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9. ABSTRACT

Contains the papers and discussions presented at a workshop held in 1976 at Fort Collins, Colorado, which brought together 50 persons from 15 countries concerned with the development of low-cost extrusion cookers (LECs). LECs are machines which can produce nutritious, low-cost foods, and the focus of the conference was on developments in the technology transfer of LECs to the developing countries for use in nutrition programs. The conference papers examine A.I.D.'s nutrition program and the part LECs play in it, LEC research and development at Colorado State University, physical and chemical evaluations of extruded food products, and manufacturers' experiences with the Brady Corp. Cooker and the Insta-Pro Extruder. The editors note that the feasibility of transferring LEC technology to LDCs has been demonstrated, and a series of the conference papers detail these developments. Extrusion equipment has been or is being tested in India, Indonesia, Kenya, Bolivia, Sri Lanka, Guatemala, and Costa Rica. Other countries interested in or developing programs include Honduras, Chile, Tanzania, Mali, Pakistan, and The Philippines. Extruded food products are being used in nutrition programs in Bolivia ("Maisoy") and Sri Lanka ("Thriposha"), and acceptability tests are underway or planned in Honduras, Ecuador, Panama, Kenya and Tanzania. The workshop served as a focus for sharing experiences and for planning future LEC program directions and needs.

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USA 80523

LOW-COST EXTRUSION COOKERS

INTERNATIONAL WORKSHOP PROCEEDINGS

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Agency for International Development
Technical Assistance Bureau
Office of Nutrition

United States Department of Agriculture
Economic Research Service
Nutrition and Agribusiness Group

Colorado State University
Department of Agricultural Engineering
Department of Food Science and Nutrition

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Fort Collins, Colorado 80523

June 2-4, 1976

The views expressed herein are those of the speakers and do not necessarily reflect official positions or policies of the agencies represented.

Preface

Agricultural and food technologists in the United States and elsewhere have been applying the extrusion technique of processing foods for animal and human consumption for several years. However, it is only very recently that investigation of extrusion equipment's applicability to mother-child nutrition programs and commercial production in less developed countries (LDC's) has been undertaken.

In order to transfer successfully to LDC environments, we recognized that the extrusion cooking system must be low cost; must require a suitable level of technological capability; must be able to process indigenous cereals or legumes; and must produce a food high in nutritional quality which is acceptable to consumers.

Accordingly, in October 1974, the Office of Nutrition of the Agency for International Development provided funds through the U. S. Department of Agriculture's Nutrition and Agribusiness Group to Colorado State University for the purpose of identifying systems meeting the requisite criteria. In less than two years these combined efforts, together with the cooperation of private voluntary organizations and industry, have resulted in a clear demonstration of the feasibility of transferring the technology to developing countries. Extrusion equipment has been or is being tested to produce low-cost nutritious foods in India, Indonesia, Kenya, Bolivia, Sri Lanka, Guatemala and Costa Rica. Other countries interested in or already developing programs include Honduras, Chile, Tanzania, Mali, Pakistan and The Philippines. Low-cost nutritious foods produced by extrusion cookers are presently consumed by nutrition program beneficiaries in Bolivia ("Maisoy") and Sri Lanka ("Thriposha"), and acceptability tests among similar groups are underway or planned in Honduras, Ecuador, Panama, Kenya and Tanzania.

In view of the interest generated by this program and the great strides made in adapting low-cost extrusion cookers to local conditions, it was fitting--indeed necessary--that AID, USDA and CSU cosponsor a workshop to serve as a forum for sharing experiences to date and planning for future activities. It is our pleasure to transmit to you herewith the formal proceedings of that workshop and to encourage your comments and questions.

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Colorado State University

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Colorado State University

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Nutrition and Agribusiness Group
USDA/ERS

Irwin Hornstein, Deputy Director
Office of Nutrition
TAB/AID

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Acknowledgment

The editors of the International Workshop on Low-cost Extrusion Cooker Proceedings would like to acknowledge the following:

1. The support and sponsorship of the work and workshop on low-cost extrusion cookers by the Agency for International Development.

2. The participants of the workshop who contributed through their papers, comments and questions to provide information on and direction to LEC activities.

3. Mrs. Phylis Sitzman for typing manuscripts and assisting with paste-up of the proceedings. Mr. Ronald Tribelhorn and Mr. Marvin Stone for preparing pictures and graphs appearing in the proceedings.

4. Mrs. Sandra Burnett, Mrs. Peggy Sweeney, Miss Lauda Fallis and Mrs. Jackie Kachel for helping make arrangements and seeing that the workshop functioned smoothly.

5. Mr. Robb Brown for assisting many of the participants with alternate travel arrangements.

Opening Remarks

I want to welcome you to the Low-cost Extrusion Cooker Workshop. I am Jud Harper, Head of the Department of Agricultural Engineering, and I have been heading a project on Low-cost Extrusion Cookers (LEC's) at Colorado State University funded by the AID Office of Nutrition through the USDA. You will meet the rest of our CSU staff who have been involved in this work as the meeting proceeds. We hope that the workshop will prove educational, informative, and helpful, and we have gathered, as you can see, people from all over the world who have an interest in LEC's. We believe LEC's to be a very important subject, and we ask you, as participants, to not only listen but to contribute extensively in the workshop discussions. There also will be ample time for people to get together formally and informally to discuss topics concerning LEC's.

Objectives of Conference

Judson M. Harper
Department of Agricultural Engineering
Colorado State University
Fort Collins, Colorado

Extrusion is believed to be an important food processing technique that can be used to produce nutritious foods for people, particularly those in developing countries. The technique could be used by local people to process indigenous grains and legumes into nutritious foods. AID and the United States Department of Agriculture have been working on these techniques and have been investigating possibilities for their application for a number of years. With their support, Colorado State University--starting with a project in October of 1974--has been working with two extrusion machines which are low-cost. Part of our objective has been to use them; to understand their operating capabilities; to examine the nutritional parameters of foods produced; and to look at the food science or functional parameters of the extruded foods. It has been an interdisciplinary project at CSU, involving faculty and staff in the Department of Agricultural Engineering and in the Department of Food Science and Nutrition.

This workshop is a focus on LEC activities done at CSU and overseas. We have brought people together to focus on those activities and to better define program directions and needs. The objective of the conference will be a two-way interchange of information. Specifically, we will be examining AID's nutrition program and the part low-cost extrusion cooker technology plays in it. We also will be discussing in detail the research program and work being done at Colorado State University. You will have an opportunity to see the LEC machines in operation, and for some of you that will be a first-time experience. Additionally, we will hear about specific countries' programs--what they are intending to do and ways they could fit this particular technology into their programs. Finally, on Friday we will divide into four working groups to discuss additional food applications of this technology that need to be investigated; further research that is required to improve the manufacturing operations; program assistance needs in order to bring LEC programs into fruition; and evaluation needs of products made by LEC's, both from the nutritional and the food science points of view. Are there any questions on procedural items of interest to the entire group? If not, let us proceed.

Welcome

A. R. Chamberlain
President
Colorado State University
Fort Collins, Colorado

It is my privilege to welcome each of you to Colorado State University and to share with you some comments on three different topics:

1. Tell you a little about the institution that is serving as your host.

2. Make a few comments in regard to the national land-grant system and its aspiration for involvement in international affairs.

3. Add a few more comments in regard to interdisciplinary research.

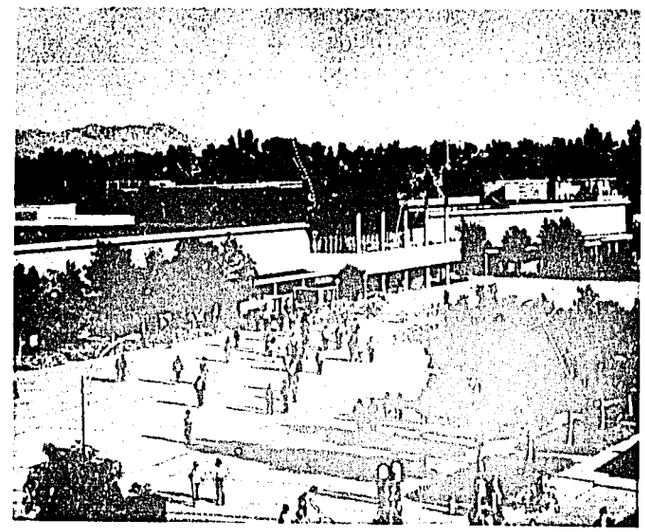
Let's take the first topic.

Colorado State University is a land-grant institution operating under a master plan that put it in a mode of controlled growth. As we went into the late 1960's, we terminated the idea that we could try to be of service to all people under all circumstances. So the university's plan encompasses a resident instruction program, the Experiment Station program, the Colorado State Forest Service, the classical Cooperative Extension Service, and then a multiplicity of private, non-profit corporations which we created for the conduct of specific activities.

Within these particular activities, we are working on the presumption that the ultimate size of the university will be 20,000 students. So all of the physical plant that you see and enjoy, and the support services linked thereto, are dedicated to permitting the university to grow only about another 2,000 students.

It may interest you to know that we have not increased the size of the freshman class at CSU in more than a dozen years, and we have no intention of changing the size of the freshman class at any time in the future. CSU is an institution, then, with a growth plan, and it is adhering to the plan in fulfillment of most of its missions.

Where does the money come from for such an institution as this? We are no longer state-supported. We are now state-assisted. What that is actually saying is that less than one-third of the university's budget comes from state taxes; more than a third comes from student tuition; and about a third comes from contract and grant resources, with a modest amount derived from private funds. The typical idea that faculty have had--that resident instruction money is hard money--is false. Across the land, the hard money now is contract money and student money--tuition. Soft money is your state money. Face up to that circumstance, because it is going on in practically every state.



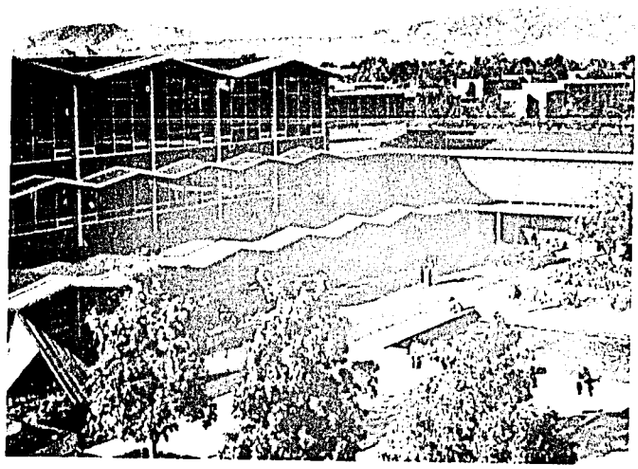
Lory Student Center Plaza

As we look forward to the future, then, institutions such as this university have to presume four primary sources of support, none of which will constitute as much as 50 percent of the whole. The system is therefore a pluralistic one, and you must keep more constituencies happier than ever before in history.

You have the private sector that is increasingly significant to the public as well as to private institutions; state support that is a decreasing percentage as a whole; your student clientele which is providing an increasing percentage as a whole; and contract and grant funding that is staying about the same as a percentage, but in absolute dollars it is increasing. I have outlined not only CSU's system but what, to some extent, is typical of the land-grant and state university system of about 138 major universities enrolling more than three million students in this country.

Let us talk specifically for a moment about the role of land-grant colleges and universities in international affairs. The role of land-grant institutions internationally, of course, made a major impetus after World War II. All of us, in one way or another, have had some involvement as institutions during that approximately 20-year period from 1947 to 1967; but I think most of us would look back and say that our successes were pretty few and quite mixed, although they presented a tremendous learning experience.

Now, in the process of international institution-building, a 20-year time frame to learn while laying the foundation for new opportunities and new ways to solve problems is not unusual. And the purposes of this conference, I suspect, will really be fully seen 15 to 20 years from now, although you will see some progress in three to five years. But the institution-building of full social acceptance of the better parts of your ideas may be 15 to 20 years in building. Well, that is also true in this arena of universities participating in international affairs.



Morgan Library

From those 20 years of learning, we have come up in this country with two major new initiatives which I believe portend a very substantial shift for the rest of this century in the role of land-grant state universities particularly, and other universities and colleges to some extent, in international affairs.

The first of these is an organization of which some of you are aware. It is the Association for International Cooperation in Higher Education and Research (AICHER). The importance of this organization is that it links together much of the higher education community in this country with the sole objective of enhancing our capacity to interact around the world, particularly in educational affairs. That it has credibility is exemplified by the fact that its chief executive is a man named Fred Harrington, a senior person with many years of experience at the University of Wisconsin, who will be supported in his role as chief executive by the Ford Foundation. So there is a Ford Foundation commitment, and there is a commitment by an experienced person.

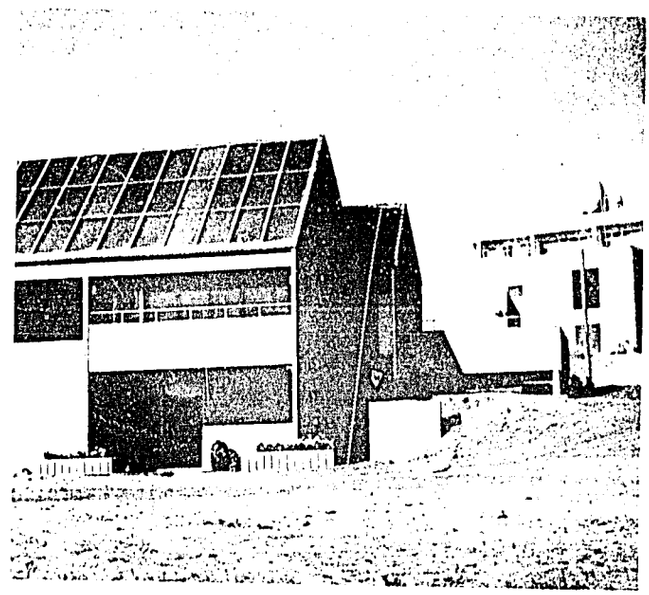
But probably of even greater significance is the so-called Title XII of the Agency for International Development (AID). Title XII to us is a new initiative because for the first time it grants major authority over a sector of federal agency funding to a university citizen governing board. The appointments to this board have been submitted to President Ford.

The importance is that Title XII permits a new form of relationship between universities in this country and either universities, colleges, departments of agriculture or ministries of agriculture, education and interior in foreign lands. This new concept will work in a way that will permit universities, for the first time, to interact with our international colleagues with a lessening of the protocol formality of the old United States Overseas Mission (USOM) and the bureaucracy that seemed, from the university's point of view, to sometimes help but many times hinder program accomplishment.

The last point of Title XII is that there appears to be real money for it. Usually, we have had grand authorizations to do things, but no funds. We think that, this time, there will be money and that we then can look forward to two new social structures, which have come into being, that will permit United States universities and colleges to play a larger role in international relationships for good and sufficient reason. And that is why the land-grant state universities and colleges have put forth all of this effort and have become involved.

I think all of us perceive that the reason for trying to create these social institutions is heavily oriented to circumstances not apparent during the first 20 years that I was alluding to, the post-World War II period. During that time span, there still was a lot of feeling that, if we in this country were to choose to do so, we could just build a wall around ourselves, go on about our business in our own bloody way and ignore the rest of the world. But in recent years, it has become abundantly clear that this course of action cannot be. It cannot be, not just for social humanistic reasons, but it cannot be for economic and technologic reasons either.

So, given that it is an interdependent world--and there is no way it can be handled otherwise--our universities have tried to step forward and increase their role on an international basis. Our high technology industry requires minerals in levels that cannot conceivably be provided within our own borders, as just one example of economic interdependence. Aside from the hydrocarbons issue--and above and beyond the social necessity, as most of use would view it, of helping with the food and population issues for the world--we are in an arena of interdependence.



Solar House on Foothills Campus

There is not going to be any energy independence, or independence in any other area, so far as I can see. What that says is that, as we go beyond AICHER and Title XII and go beyond the United Nations, we go beyond our own individual sovereignties. I think that what we will see by the turn of the century is what one might call a new planetary bargain--a new social institution that would succeed the United Nations just as the United Nations succeeded its predecessors--a new social structure that would be less predicated on the sovereignty of nationalistic pieces of geography and people and more based on the necessities of social and economic interdependence.

If that is going to happen, how are we going to promote it? One of the reasons you are here is, in effect, associated with promoting it. That is, the conduct of interdisciplinary research conveys with it, pretty near automatically, new ordering among the intellectual community across disciplines in ways which are setting the structures to accept for all of us the fact that we are an interdependent group, intellectually as well as socially and economically. On our campuses, however, that typically takes a more mundane form of interdisciplinary task groups and so on; but I would suggest to you that, as you debate among yourselves, you think about the social framework in which interdisciplinary relationships actually need to be constructed. Then you would have a framework for why you want interdisciplinary structures to be created. It is more than purely the fact that a technological problem is too complicated for a single discipline to handle typically. There are human, social institutional reasons as well.

On the campuses, typically like many others, we have used an orientation that says: Let's define a task, such as the task of this particular conference associated with your extrusion technology. Once we define the task, we then begin to construct a frame of reference for the scope of disciplines needed to carry it out. So one of the typical things we do on a campus now is to build to some extent from the management style of the space industry, to talk tasks and then select the people from economics to sociology to engineering to physics and chemistry to do them. That has opened up new doors of interchange among faculty on the campus. It is sometimes surprising what they can accomplish, but it is also sometimes revealing as to what they lay on the table--things that can't be done because of people.

Perhaps more important than the task orientation of faculty between departments on a campus is the social institutional creation of new types of consortia. All of us are acquainted with the individual consortia constructs of the last 20 years, but new ones now are coming into creation that are framed differently--bringing selected sets of institutions together, rather than thinking that they should be an amalgam of the world. These new arrangements involve the linking of whole institutions whereby two, three, five and occasionally as many as 45 or 50 are being brought together again around a specific task, rather than just because they are all nice people.

A third arrangement is the classical one of joint appointments across the disciplines. It is increasingly common to have an electrical engineer also

Engineering Building

appointed as a professor in physiology, and between the Departments of Agricultural Engineering and Food Science and Nutrition we have examples of those kinds of interactions.

But what is the driving force behind all of them? I suggest that, when we talk about interdisciplinary research activities linking international organizations, private voluntary organizations, foreign governments and United States colleges and universities, there still is one driving force, and that is the allocation of money for the accomplishment of a task. Whoever allocates the funds for the accomplishment of a task will find the intellectual community gravitating toward it to accomplish that particular task. Now, I don't know whether that suggests that we are greedy or anything of that nature; but I want to emphasize that when you want something accomplished there isn't any substitute for injecting the driving force known as allocation of money and definition of task, and then the rest of us can begin to move in and get the job done.

Let me close my welcoming remarks to you by sharing the thought that the conference--typically, perhaps even more than the subject matter itself--is a great opportunity to develop new personal relationships across both state and national boundaries. Those relationships constitute the foundation on which you can build the social institutions and the interdisciplinary management structures and through which, in many cases, you can get the financial resource allocation on an international basis that you typically would not get on a local scene.

The AID Nutrition Program

Ms. Amy Pound
Office of Nutrition
Technical Assistance Bureau
Agency for International Development
Washington, D. C.

On behalf of the Office of Nutrition, Technical Assistance Bureau, Agency for International Development, I welcome you. Our Office of Nutrition Director, Martin J. Forman, regrets that he cannot be with you this week. Our annual budget submission, congressional hearings and related activities keep him in Washington, D. C. this week. This is a critical period in our annual program and budgeting cycle.

Now to speak about our AID program. Low-income masses in the less developed countries (LDC's) usually derive most of their calories and protein from cereals such as rice, corn, wheat, sorghum, etc.; the staple is usually supplemented with legumes and an occasional portion of meat, fish or chicken. Most of these diets tend to be low in calories and protein.

Groups particularly vulnerable to protein deficiency in the diet include women of child-bearing age, infants and preschool children. AID is concerned with alleviating malnutrition in all segments of the population, but particularly in these target groups.

In carrying out our efforts we work with governments at various levels to encourage and assist them to do a better job of analyzing problems, developing plans and effectively implementing programs. In addition we work with and support the private voluntary organizations, since we recognize that they represent in some places the most effective means of impact on malnutrition problems at the grass-roots level. Most of the affected people in the LDC's are found in small rural communities and urban slums. All share a common heritage of poverty, ignorance, poor sanitation, and other conditions which tend to contribute to the problem of malnutrition and interfere with its solution.

The question then becomes: What can be done to alleviate malnutrition under the less-than-ideal conditions existing in the LDC's? One approach is to start from the food supply side and attempt to add needed nutrients into the foods consumed in LDC's, particularly those consumed by the poor.

Basically there are only a limited number of ways of building nutrients into foods: (1) the plant breeder can develop new varieties of corn, rice, wheat, etc., that have higher yields and whose protein content is both qualitatively and quantitatively improved; (2) the food technologist can add nutrients to food staples by fortification with essential amino acids, minerals and vitamins. This can be done with little, if any, detectable effect on acceptability. The food technologist can also develop low-cost, blended foods that consist of mixtures of cereals and legumes or of cereals and somewhat unconventional protein sources such as soy and oil seeds. To have any viability these must be organoleptically acceptable to the consumer.

AID has supported research and field trials in both of these areas. Neither route is free of pitfalls, and both routes have limitations.

Thus, some nutrients such as minerals and vitamins are unlikely to be bred into the "improved varieties" and, at least to date, varieties possessing improved protein quality or quantity generally give a lower yield than normal high-yielding varieties.

Fortified and blended foods may have their limitations, too; costs may be high and products may require government subsidies to be viable. Processed foods require careful quality control lest much of the "added" nutrients not be added or added improperly so that nutrients may be lost. Furthermore, processed low-cost nutritious foods may not reach the bulk of the rural poor. It is, of course, unrealistic to expect one nutrition intervention to cure all ills, and there may be conditions under which neither of these approaches makes sense. New crop varieties may reach areas that fortified foods cannot reach. The new varieties, though inferior in yields to the highest yielding varieties, may be higher in yield than the conventional regional varieties. Fortified foods can maintain nutrient quality with proper precautions, and although they may not have unlimited outreach, they can still reach the poor in urban areas and their surroundings.

AID has provided grants both to United States and LDC food companies to encourage the companies to carry out feasibility studies designed to put low-cost nutritious foods into the marketplace. The priorities in these programs include widely used staple foods such as bread, tortillas, pasta, etc., and weaning foods which can play a decisive role in helping an infant survive during the critical months during and after weaning.

AID also supports a research effort aimed at developing low-cost technologies which may in the near term have widespread application in the LDC's. Low-cost extrusion cookers fall into this category.

Extrusion cookers have been widely used in developed countries in the manufacture of cooked cereal grains. The diversity of equipment is fairly extensive and in general fairly expensive.

Low-cost extruders, lacking the versatility of their more sophisticated predecessors, were developed for on-the-farm processing of such crops as soybeans into feed. Adaptation of this technology to the preparation of inexpensive, highly nutritious foods and weaning foods is an important AID nutrition goal.

Tests to date indicate that LEC's (low-cost extrusion cookers) may have a place in LDC's for the production of extrusion-cooked products for use in food and feed.

A body of knowledge is being accumulated covering the merits and essentials of this technology. This workshop has been convened to permit those generating this new knowledge to come together to describe their experiences, the pitfalls they have encountered, the obstacles they have overcome, and their overall reactions to the values of these inexpensive extruders. We should learn from one another's experiences, and this exchange of information should shorten the time for practical application to be instituted in the LDC's.

The bottom line of the workshop--that is, the recommendations you make--will help guide AID, USDA, our colleagues at CSU, those in overseas areas, and those in private voluntary organizations make decisions regarding future programs involving low-cost extruders.

We would hope that your recommendations will provide insights into the type of research still needed and the types of operational programs that lend themselves to this type of technology.

Extrusion Cooking as a Utilizable Technology to Produce Nutritious Foods

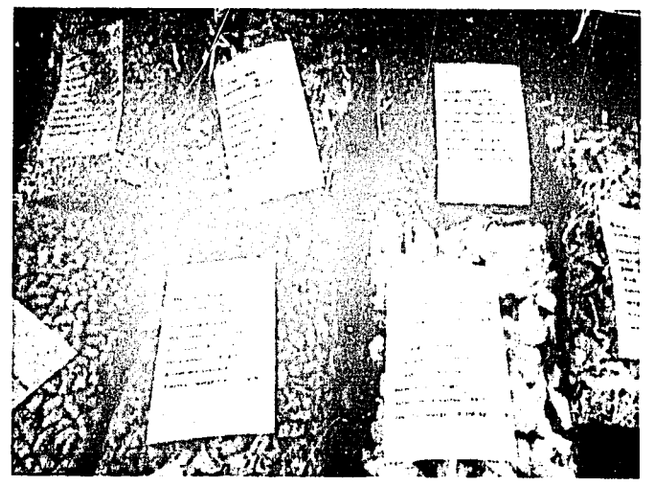
Paul R. Crowley
Nutrition and Agribusiness Group
USDA/ERS
Washington, D. C.

Reduced to the simplest terms, extrusion cooking may be thought of as a process in which materials are heated and worked mechanically while they are passing through a compression screw and extruded through a die or other restriction. When applied to foods, the extruded materials generally reach temperatures of 250-350°F in the extruder but remain at those temperatures for only a few seconds. The material generally becomes plastic during cooking and often expands or puffs when leaving the die as moisture contained in the material flashes to steam.

As those who have studied the subject know, this simple concept of the process falls short of describing the real action of extrusion cooking. Unfortunately, extrusion cooking is both a relatively new technology and a complex one. It is still not well understood. As a result, it is now practiced more as an art than as a science.

Even though it is not well understood, extrusion cooking results in changes in materials that make it a very valuable and, in some instances, a unique process. It removes the raw, uncooked flavor from food, replacing it with cooked or toasted flavors people have learned to like. It gelatinizes starch and modifies protein so that their functional properties are changed. The products become more susceptible to enzyme action. They absorb water differently. Under extreme conditions, extrusion cooking can even break down starch molecules, dextrinizing them and making the product soluble or even sweet. It can destroy the natural enzymes and prevent their adverse effects. It can rebuild products by plasticizing and reforming them in new shapes or sizes. And it can change texture by creating porous, aligned structures that are in some instances quite unique.

Extrusion cooking is now practiced widely in the manufacture of textured soy protein products which are used as low-cost meat substitutes and extenders. It is used extensively to cook cereal flours to make food ingredients like the processed corn meal used in corn-soy milk (CSM) and the gelatinized cereal flours used in oil well drilling muds and foundry core binders. It is used to make pet foods and animal feeds. And it is used widely to make snacks like the popular corn curls. Although it is a relatively new technology, it has been adopted quickly and now plays an important role in both food and industrial manufacturing. And for this reason it has been of special interest in programs in which developing countries have looked for technology to produce low-cost nutritious foods.



Samples of extruded products.

The following examples illustrate the potential use of extrusion cooking in less developed countries:

1. Textured Soy Protein--The Government of Colombia (GOC) is currently developing an integrated health and nutrition program which is intended to overcome malnutrition among children under two years of age and pregnant and lactating women in the poorest 30% of the population. One element in the program provides a subsidy for purchase of nutritious processed foods. Coupons worth about 80% of the retail price of certain foods are given to eligible persons by health workers, and the beneficiaries use these coupons to buy nutritious processed foods through normal retail outlets. Over one million beneficiaries are expected to be covered by this program when it is fully implemented. One of the foods which will be eligible for subsidy is textured soy protein. Textured soy is manufactured by two Colombian companies using large-scale extrusion cooking equipment and is now sold there commercially. One product, CARVE, is sold through retail outlets as a meat replacer or extender at a meat-equivalent price of about one-third that of animal meat. (Even greater savings can be achieved in institutional and industrial situations where textured soy can be made available at meat-equivalent prices of only 6-8 cents per pound.)

This Colombian example illustrates two major points. First, an extrusion-cooked product, namely textured soy protein, can be manufactured and sold commercially in developing countries. And second, food coupon subsidies provide a mechanism through which governments can help low-income persons increase consumption of nutritious foods. (A similar program called the Women, Infants, and Children Program (WIC) is now in operation in the United States.)

2. Blended Foods--For the past several years a variety of processed foods has been distributed in direct distribution feeding programs in schools and health centers in Colombia. Among these foods are imported processed blended foods in which cooked cereals and soy flour provide a nutritious, low-cost food suitable for consumption as a beverage, soup, or flour for baking. These foods include the CSM products furnished by the United States under P. L. 480--products which contain about two-thirds precooked corn meal made with extrusion cookers.

As has been agreed between the GOC and the food donor organizations, imported foods will be phased down over time and discontinued altogether by 1978. The process has now started. Beginning last January, Colombia started manufacturing a locally formulated blended food, Bienstarina, in three mixing plants having a total capacity of about 70,000 tons per year. In addition, plans are now being prepared for a multi-million dollar plant which is to produce 30,000 tons per year of precooked blended foods. When this plant goes into operation in 1978, it is expected that about 10,000 tons of Bienstarina will be produced for use in direct distribution programs, and most of the rest is to be sold through retail stores as a part of the food coupon program. Several proposals are now under consideration for the new plant. Use of extrusion cooking to precook the cereal fraction is being given serious attention.

The Colombian plan for production of precooked blended foods is not unique. Plans to phase down imported foods or supplement them with locally made foods have been developed in a number of countries. For example, in India a locally made blended food called Bal Ahar was developed to replace CSM. And in Costa Rica and Sri Lanka, as you will hear later in the program, plans are now in motion to manufacture precooked foods based on local raw materials.

I would like to mention one example of a similar plan which didn't work out and which illustrates a potential pitfall to avoid. I've been told that in a certain country a private company was approached by the government asking if it would manufacture a precooked CSM-type product for use in local feeding programs. The company agreed. It ordered and installed a large extrusion cooking system. Unfortunately, about that time the government changed, and the new government decided not to buy the product. The new system, which represented a considerable capital investment, therefore, sat idle. The company learned a very expensive lesson. I hope we can profit by that lesson and not expect private companies or anyone to invest without a firm and lasting commitment to use the product.

3. Snack Foods -- Snack foods which can be made by extrusion cooking are universally popular. In some places snacks are made with extrusion cookers, like the corn curl snacks made by Jack's Snacks in Costa Rica. In other places puffed snacks made by other processes are consumed in enormous quantity. For example, in India a puffed rice product called Muri is consumed at the rate of about 500,000 tons per year. Muri is made by a primitive process called sand roasting in which parboiled rice is moistened and shaken in hot sand until it puffs like popcorn. An economic analysis has shown that it can be made using modern extrusion cooking equipment and sold in competition with the traditional product, returning more than 50% on the investment. Furthermore, extrusion-cooked Muri can be fortified with protein, vitamins, and minerals and can be made with broken rice rather than whole rice to reduce the cost.

Nutritional snacks made by extrusion cooking have enormous potential, whether used in school feeding programs or sold commercially. They represent an extremely popular set of products that can be made by extrusion cooking.

4. Enzyme Inactivation--Soybeans contain a group of enzymes and growth inhibitors which must be inactivated before use as food or feed. Traditionally these enzymes have been destroyed by heating the soybeans or the solvent-extracted soybean meal. Today we know that extrusion cooking is an effective means of inactivating these growth inhibitors. Whole or dehulled soybeans processed through extrusion cookers are excellent sources of protein and energy. They can be used as an ingredient in blended foods and formulated infant foods. They might even have potential as a low-cost replacement for the expensive beans and pulses which are a part of the diets in most developing countries. Later in the program, the group from Costa Rica will outline their plans for manufacturing soybean flour with an extrusion cooker.

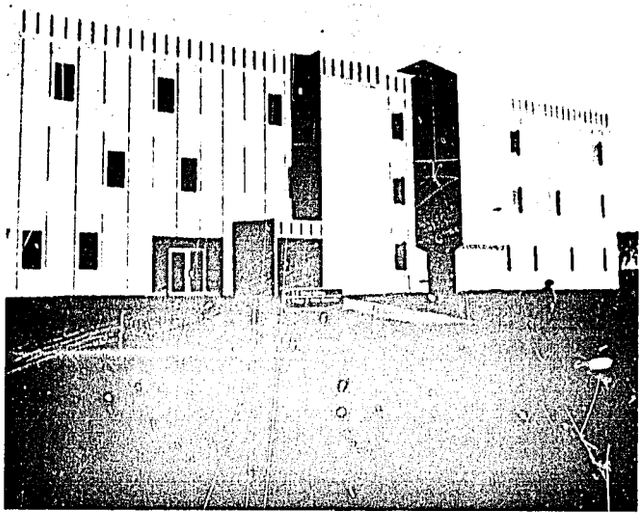
A number of different types of equipment are used to produce the various products described above. Some of the machines have been designed with specific functions in mind, such as the snack-making extruders which are most often used to make puffed corn snacks. On the other hand, some extruders which were designed for limited applications have been found to work effectively in other applications. For example, it has been found that plastic extruders can be used to make textured soy protein. At the same time, some extruders are extremely versatile and can be used to make textured soy protein, cooked cereals, soybean flour, pet foods and a wide range of snacks.

Machines range in capacity from a few pounds to several tons per hour. Some cost only a few thousand dollars, while others cost up to several hundred thousand dollars for a complete system. Some can be set up in a garage as a simple independent unit operated by an unskilled laborer with only very little training. Others require elaborate supporting equipment (steam generators, cutters, dryers, coolers, etc.) and can be operated only by extensively trained technicians. Clearly the selection of one or another of these machines for a given application is not a simple matter, but each type of extrusion cooker has a place. Every machine in the market was developed with some application in mind, and every one has been sold for some purpose.

During the course of this workshop we will be discussing a class of machines called low-cost extrusion cookers (LEC's). These are unique in that they represent a very low capital cost per unit of throughput as compared with other extruders--generally less than $5-10 per pound of throughput per hour versus $10-100 for other types of extruders. They usually cost less than $10,000 for a unit, whereas other extruders cost $20,000 and more. Except for the one

which Mark Sterner of MFM will describe at our workshop, these extruders were not developed for food use. They are inexpensive because they are mass-produced. They also appear to be simple to operate and simple to maintain.

At the same time it is likely that low-cost extrusion cookers have disadvantages and limitations compared with some other extruders and likely would be unsuitable for large-scale manufacture, such as the 30,000 ton-per-year Bienstarina plant in Colombia. They aren't designed for producing shaped pieces like snack extruders. And they likely have other limitations.



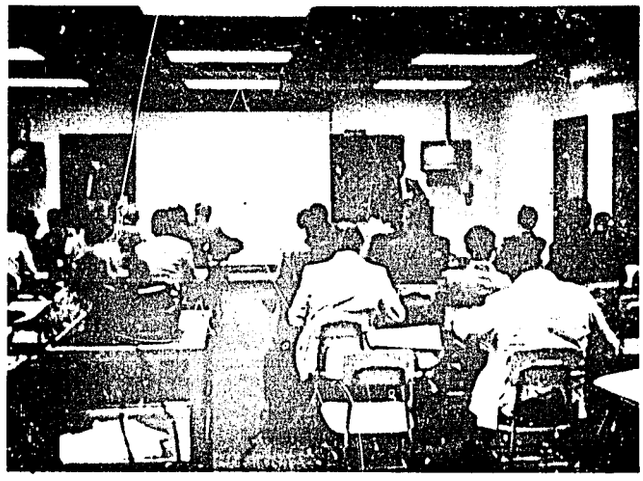
Gifford Building - site of the LEC Workshop

In this connection it is important that the workshop take note of the fact that AID and USDA are supporting work to explore LEC's as a technology which we believe might have applicability in developing countries and which would not otherwise be considered. To do this, we believe the capabilities and the limitations of LEC's must be determined and reasonable application demonstrated. It is not our purpose to promote extrusion cooking as a technology when it is not appropriate or when some other technology is better. Nor do we intend to suggest low-cost extrusion cookers or machines made by particular companies when other types are more appropriate. Our aim is simply to make available knowledge of a new technology to those who might use it to the benefit of those in need. This, as we see it, is the goal of this workshop and the activities which will follow as a result of the workshop.

QUESTION AND ANSWER SESSION

Mr. Samaan:

Could you comment on the relative desirability of mounting pilot programs as opposed to undertaking feasibility studies to determine potential effectiveness?



Participants attending a LEC Conference session.

Mr. Crowley:

To demonstrate a technology, you need assurances that equipment will not be idle and that demonstration will in fact take place long enough to produce results. Certainly the cost of the systems is low compared to many alternatives. To fund a feasibility study costs a substantial amount of money. A demonstration project also costs a substantial amount of money beyond just the equipment and an idle system cannot demonstrate application. We should know in advance that the equipment is going to be put to use, and we should be selective.

Dr. Bogyo:

One question on puffed rice which is a popular snack in India, and if I noted it correctly, a rather large quantity--500,000 pounds--was mentioned. The thought occurs that once this production is centralized, you will then face costs for packaging and distribution. I wonder whether this was included in the calculations which indicate a very good return from the production itself. Puffed snacks usually spoil in a humid area in 24 hours or less, and I wonder whether you have any answer to the packaging and distribution of such snacks.

Mr. Crowley:

The information I mentioned is the result of a study of food habits of the people of Calcutta. The study indicated that there were a number of processed foods that were consumed in substantial quantities. Muri was one of those products. The objective of that particular study was to see what kinds of changes might be made in the system, both in manufacturing and distribution, which would improve the nutrition of particularly low-income people. What we developed as an alternative was to manufacture--using the Kelldot type of snack extrusion--a product which would be fortified with vitamins, minerals and proteins; and to sell it at the same wholesale price as the unfortified product. In calculating return on the investment, we added operating time and took into account the same distribution and packaging systems for the new variation of the product.

The AID Program to Utilize LEC's in LDC's

Alfred Lachmann
Nutrition and Agribusiness Group
USDA/ERS
Washington, D. C.

INTRODUCTION

Planning and implementation of an AID low-cost extrusion cooking program--designed primarily to reduce malnutrition in low-income preschool and school children and pregnant and lactating women by providing them with nutritious foods from commodities grown and processed in developing countries--has become a complex undertaking. One of the reasons for this complexity is that implementation of such a program requires the collaboration and continuous interaction among people belonging to different countries, cultures and disciplines. In describing some of the steps necessary to implement a program, one can easily understand that many problems will have to be solved.

With the assumption that food technology would be used to provide answers to processing problems occurring during production of locally grown commodities, the first step in our program was to identify a process which is economically feasible and which can be adapted to conditions existing in the developing countries. Extrusion processes utilized for cooking of cereals were identified as likely candidates. The next step was to select the most economical equipment capable of producing extruded prod cts.

After determining on an experimental basis some capabilities of low-cost extruders, the equipment had to be shipped to foreign countries for further evaluation. There, organizations had to be found with qualified personnel to test the machine, raw materials and finished products and to distribute the food for acceptability tests in nutrition-oriented feeding programs.

In the meantime, in the United States, a systematic approach to learn more about low-cost extrusion cookers was devised in order to help answer questions arising during testing programs in foreign countries.

In addition to problem-solving of technical questions, administrative procedures had to be drawn up to permit a fair testing of the machine, processes and products.

Transfer of technology requires an almost flawless network of communications. This is not an easy task when one realizes that conditions vary from country to country and that understanding between people can sometimes become difficult. It is the need to strengthen this link of communications which AID has recognized for a long time, and which is also one of the major reasons we are assembled at CSU.

REVIEW OF PROGRAM

Following is a brief review of the overall program, i.e., its historical development; the efforts of the equipment manufacturers; the work performed by the staff of Colorado State University; the experience gained in the testing programs; and guidelines and criteria used by AID and other organizations for the selection of worthwhile programs.

Historical Review

As early as 1971 a search for low-cost extrusion equipment began. One of the extruders selected for further study was the Brady Crop Cooker Model No. 206, manufactured by Koehring Farm Division. The machine was used in the manufacture of full-fat soybean flour which was blended with other ingredients to produce nutritive feed formulations. AID became interested in this equipment and wondered if this machine would be capable of producing soybean flour from dehulled beans for use in human food products.

Later, in 1973, another low-cost extruder was located which produced flour from full-fat soybeans for use in feed formulations. It was the Insta-Pro extruder, Model 500, manufactured by Triple "F" Inc.

As a consequence, experimental work was started to test the capabilities of low-cost extruders for the manufacture of human foods. Samples of experimentally extruded soy flours were tested by Northern Regional Laboratories and ADM for their physical and chemical characteristics and for the destruction of anti-physiological factors. Kansas State University evaluated the soy flours for their suitability as protein fortifiers in the manufacture of bread and found them to be suitable for this purpose. When it became evident from other preliminary tests that this equipment might have potential not only for the manufacture of soy flour, but also for the processing of cereal-oil seed blends (such as corn-soy blends and other blended foods), AID/USDA arranged for equipment to be made available for further tests.

Equipment Testing Arrangements

The purpose of the test arrangement was to send the machine to selected foreign countries so that testing organizations could evaluate the capabilities of the equipment under in-country conditions by processing locally grown and available raw materials. Three cookers were loaned to USDA by the equipment manufacturer for a period of 30 months. Each country

which expressed an interest in studying the performance of this equipment could apply for an equipment loan to AID or USDA. If approved, the manufacturer would ship the machine and spare parts to the selected country; would pay for the transportation; and would furnish one technician for each of the first three specified countries for a period of approximately two weeks in each country. This would permit training of local operators in the operation and utilization of this equipment.

AID/USDA paid for shipping of the equipment and for expenses for training operators at the test sites. In addition, AID/USDA assumed responsibility for making all necessary arrangements for shipment between countries and for return of the machine to the manufacturer's headquarters at the end of the contract.

AID Airgram

When these arrangements had been made, the AID Office of Nutrition sent an airgram informing certain USAID Missions of the availability of low-cost extrusion equipment for testing. In this airgram AID spelled out the capabilities of the machine and included background information on experimental runs undertaken in the United States. It required investigators who would receive the equipment to collect data on processing costs of intermediate and finished foods and to determine local labor and power costs, in addition to testing of various formulations. Since the equipment produces fairly large quantities of test formulations it was suggested to use them for the initiation of small-scale acceptability tests. The circulation of the AID airgram created interest in USAID missions, private voluntary organizations and local groups. In Asia, India, Indonesia, Sri Lanka and The Philippines desired additional information; in Africa, Ghana expressed an interest; and in Latin America, Guatemala and Brazil requested more detailed background. Later, other countries showed considerable interest, such as Kenya, Tanzania and Cameroon in Africa, and Honduras and Costa Rica in Central America.

Testing Programs

The first testing of a low-cost extrusion cooker outside of the United States took place in India in 1973. In Calcutta at the United Flour Mills, a CARE-purchased Brady Crop Cooker was installed and a test program was started to look into production of foods for Asian CARE-sponsored feeding programs.

The first AID/USDA-sponsored testing program was initiated in Guatemala. In Guatemala the machine to be tested was loaned to CARE by USDA. CARE in turn selected as its testing organization the Institute of Nutrition of Central America and Panama (INCAP). A Memorandum of Understanding (MOU) was written. It defined in general terms the work to be performed by the various parties. According to the agreement, USDA would provide an extrusion cooker to CARE/Guatemala for a given period of time. (Although the usual time for testing the equipment at one place was to be 4-6 months, in the case of Guatemala it was considerably longer.) The cooker would be shipped to a selected site, and USDA would provide an engineer for the start-up operation. The engineer would stay for about two weeks to permit training of local people in the operation of this equipment. CARE and the testing organization would provide all of the necessary services required for the operation of the machine and would purchase raw materials necessary for running test formulations. One of the major requirements was that the extrusion cooker be studied as a means of manufacturing low-cost nutritious foods.

An additional agreement was signed between the East African Industrial Research Organization (EAIRO) and the AID/USDA, and another agreement is being formalized between the Philippine Women's University (PWU) in Manila and USDA.

Agreement Between AID/USDA and CSU

In 1974 it became clear that specific problems encountered in utilizing low-cost extrusion cookers required solutions, and that a systematic testing program to evaluate and analyze capabilities of low-cost extrusion equipment should be started. A research contract was signed between Colorado State University and the USDA. The University's Agricultural Engineering Department was given the task of determining the operational characteristics and capability of cooker-extruders for the production of human foods. In addition, it was asked to study plant designs and layouts, specification of equipment components related to extrusion cooking, the cost of complete extrusion cooking systems and maintenance requirements for varying processing needs in developing countries. Finally, training of personnel in the developing countries for testing program start-up and backstopping became part of CSU's responsibilities.

A year later, USDA signed a research agreement with CSU extending its role in studying low-cost extrusion cookers. In this agreement the Food Science and Nutrition Department and the Agricultural Engineering Department became involved in a new project. The general objectives of this project were to assist selected developing countries in their efforts to supplement or replace foods from international donor agencies with commodities produced locally, and to utilize food technology in related areas to improve diets of their local population.

CSU Development Activities

Since it was felt that investigation of the extrusion cookers' capabilities required also an evaluation of the complete processing system (which included preprocessing and postprocessing of the major ingredients and blends), the pilot plant at CSU was provided with ancillary equipment flexible enough to address problems which could surface in testing programs performed in the developing countries. In addition to the two extruders--the Brady Crop Cooker and the Triple "F" Insta-Pro--the pilot plant equipment consisted of a diesel tractor to serve as the power source to drive the equipment, thereby reducing intermediate product temperature, and a proportioning mill, which allowed correct proportioning of various blends.

It is not the purpose of this paper to describe the principle of extrusion. However, it is necessary to review briefly part of CSU's work in extrusion.

To understand the operational characteristics of the extruder, the staff determined how individual equipment components were affected by input and output conditions. A testing procedure for the extrusion process of cereal-oil seed blends was established. Data sheets were designed to record and analyze processing conditions and product characteristics. Procedures were developed to measure finished product characteristics. Bulk densities, puff index (measure of expansion) and viscosity became measurements for evaluating blends. Moisture determinations and screen analysis were performed.

The first experimental data were collected on blends of whole corn, whole sorghum and whole soybeans. It was found that grinding the cereals prior to extrusion improved not only the feed ratio and output, but also the homogeneity of the extrudate. The higher the oil content of the blended food derived from the addition of soybeans or other oil-bearing materials, the lower became the putting of the end product. Results also confirmed earlier observations by CARE that the addition of water to the feed improved extrusion efficiency and changed product characteristics. Uniformity of the blended product was also the result of water addition. Water applicators were designed to introduce the liquid in a constant flow. Measurements of power requirements showed that the addition of oil to cereals decreased the power requirements of the extruder. Testing of preprocessed raw materials continued with dehulled corn and soybeans and raw and toasted peanuts.

Optimum processing conditions were established for a number of blended foods, and the staff undertook calculation of operating costs for three different systems: a weaning food mixture, soy flour, and snacks.

Another important activity at CSU was the work performed at the Food Science and Nutrition Department. Their staff investigated product characteristics of intermediate blends and finished food products. They analyzed moisture, ash, nitrogen and protein percentages of corn-soy blends. Storage tests were performed for 3 and 6 months at room temperature and higher to determine shelf life. Corn-soy blends fairly similar in composition to Title II commodities were evaluated for their nutritional quality. PER determinations were run at their nutrition laboratories.

Technical Service Activities Testing Program

Technical service is another activity performed by CSU for AID/USDA. This includes outlining operational procedures for the machines; designing and specifying equipment; and training of personnel in the operation of equipment.

One of the first places where CSU provided technical backstopping was at INCAP in Guatemala. Research at this Institute centered on extruding combinations of corn, sorghum, soybeans, cottonseed and coffee pulp. Most of the blends could be produced successfully. The Institute's studies included work on the effect of extrusion cooking on the nutritional quality of cottonseed. Tests indicated that extrusion-cooked cottonseed showed nutritional improvement over uncooked cottonseed. This means that some of the gossypol present must have been detoxified by extrusion cooking or bound chemically.

Another testing program was initiated at EAIRO in Nairobi, Kenya, where white maize, a special local millet, rice and soybeans were cooked successfully. During the testing program the cooker was utilized to produce enough material of a corn-soy blend to initiate a study on the acceptability of this product as a commercial weaning food in Tanzania.

A third machine will soon be installed at the Philippine Women's University, and a testing program has been outlined in which extrusion-cooked rice will be blended with coconut, shrimp and different kinds of legumes to be distributed as a weaning food.

In Sri Lanka a cooker has been installed by CARE with auxiliary equipment provided through CSU which performs as a production unit. It is utilized for the cooking of dehulled sorghum to which a small quantity of soybeans has been added. The total production system consists of extruder and power source, conveying systems, proportioning, grinding and cooling equipment and various storage tanks. The plant has been operating since February 1976 and has had start-up difficulties like most other new plants. However, production rates of cooked sorghum are on the increase, and it is expected that the system will soon be working as a satisfactory processing plant.

In Costa Rica an electrically powered extrusion unit, furnished by CARE, is located at the Pronutre plant and has been used to demonstrate processing of whole soybeans and corn-soy blends.

In Indonesia, again with CARE's initiative, the performance of extrusion cookers will be studied at the Institut Pertanian Bogor (IPB). Combinations of cereals, legumes and oil seeds will be processed through the CARE-furnished extruder.

Experience with testing programs indicated that some problems recurred several times. They included unavailability of raw materials or ingredients for collection of processing data; and difficulties in preblending combinations of food ingredients, such as cereals and oil seeds or blends of legumes. Solutions to these problems are important for the success of the testing program. A thorough analysis of the results is necessary, because it affects the decision whether or not the next phase of the program--the production phase--should be planned and initiated. Without accurate data it would be difficult to make a decision.

FUTURE ACTIVITIES

It is hoped that the capabilities and limitations of low-cost extrusion cookers can be better defined. Systematic studies on a variety of important cereals such as cassava and many legumes have not been completed. Simplification of operating procedures to further improve the economics without deteriorating the products' quality should be researched.

GUIDELINES AND CRITERIA FOR FINANCING PROJECTS RELATED TO LOW-COST EXTRUSION COOKING PROGRAMS

AID/USAID Assistance

Certain kinds of technical assistance are available through AID, USDA and CSU. For clarification, the needs for assistance can be divided into (a) financial aid for purchase of equipment required for the production of nutritious extruded food products; (b) financial aid for purchase of raw materials, ingredients and finished products to be used in the manufacture and distribution of low-cost nutritious foods; (c) guidance and technical assistance in suggesting, selecting, designing and specifying processing equipment and/or ingredients for extrusion food production; (d) technical assistance in the solution of processing problems (e.g., establishment of operating conditions, cost calculations, and maintenance problems); (e) technical assistance in the solution of problems related to product quality (e.g., raw materials, ingredients, finished product, quality control, shelf life, sensory evaluation, packaging, storage, and plant sanitation); (f) assistance in the evaluation

of the nutritional qualities of extruded foods; (g) technical and financial assistance in the solution of marketing problems such as consumer surveys, and market research (e.g., promotion, advertising, mass media, and packaging design).

In general, the Office of Nutrition, AID Washington, does not fund equipment purchases for low-cost extrusion systems. However, in limited cases it may consider funding to demonstrate the soundness of the principle of such a production system. The demonstration plant should show that the principle and technology of the extrusion process can be adopted by other plants located around the world without major modifications. It should furthermore be demonstrated that the process is a practical and economical one.

If it were decided that equipment funding for a demonstration project could be considered by AID, additional criteria should be met, including:

1. Assurance that once the equipment is installed it would be utilized to produce weaning foods or other nutritious foods which could help alleviate malnutrition.

2. The plant should produce foods which are used in nutrition-oriented applications for a reasonable length of time.

Major expenses to implement food manufacturing are, in general, raw materials and ingredients costs, and costs related to processing, distribution and management of the finished food products. Therefore, assurances should be given either by host government agencies, PVO's or other bona fide recognized organizations that funds will be obligated to guarantee a production and distribution program lasting approximately two to three years.

AID and USAID missions have other programs which might provide funding for manufacturing food. Accelerated Implementation Grants (AIG), Development Program Grants (DPG) and Operational Program Grants (OPG) are some of the more common grants provided by AID and USAID.

DPG's are, in general, grants made to PVO headquarters to assess planning, evaluation and management of projects. They are, therefore, not applicable for consideration in field-oriented programs.

OPG proposals should complement overall mission and host country government program objectives. They should focus on reaching sizable numbers of poor people and include involvement of PVO's and host country agencies.

Grants are broken down into functional areas such as Food and Nutrition, Health and Family Planning, and Education and Human Resources.

The usual procedure to apply for OPG grants is for a PVO to consult with the AID mission or the Washington regional bureau, as appropriate. Draft proposals are reviewed by the regional bureau, and PVO and Mission representatives are invited to participate at the review session. If the proposal submitted is acceptable, final approval of a grant can be given from AID's regional offices or sometimes directly from the USAID. If, on the other hand, answers are required to questions raised during the review session, the proposal will be referred to the PVO for reply.

Some criteria for considering proposals are:

1. a definite interest of the host government in the project and its approval

2. technical feasibility of the project

3. commitments of both host government and PVO

4. products of the project should reach the poorest majority of the population

5. results from the project can be replicated

Projects should be reasonable in scope, and average expenditures should be between $100,000-$200,000.

In fiscal year 1975, $6.2 million were spent on funding OPG's. It is estimated that for fiscal year 1976 approximately $7 million will be used for funding them. From a total of 38 projects funded in 1975, 20 belonged to the group related to Food and Nutrition. OPG grants can be used for the purchase of materials and equipment and for salaries of personnel.

Assistance by International Organizations

Agencies connected to the United Nations Development Program (UNDP) or independent United Nations agencies such as FAO, UNESCO, and UNICEF have funded programs connected with food and nutrition. UNIDO (United Nations Industrial Development Organization) has funded equipment purchases for laboratories, pilot plants and plant operations. The rationale has been that installation of a food plant in a member country will help in the industrial development of that particular country, thereby raising the living standard of its population. The food plant can be used to manufacture products for domestic utilization or export.

The host government representative will approach the local UNDP representative, who will contact either the local UNIDO representative or forward the request to UNIDO headquarters. In the case of UNIDO, the decision-making process will involve the host government, UNDP and UNIDO.

Criteria are fairly similar to those requested by United States Government agencies. They include interest of host government in the project; specific commitments by the host government in the form of personnel, materials, equipment or buildings; and availability of counterpart personnel working together with the United Nations experts.

Expenses for equipment, materials and personnel can be funded by UNIDO to develop industrial activities within the host country.

UNICEF also funds the purchase of equipment for food and nutrition projects. However, its present policy seems to have shifted from support of large-scale projects to those that are related to intermediate and village-level technology.

The overall criteria of UNICEF are similar to those mentioned for UNIDO. All criteria are subject to change and are adapted to conditions existing in each individual case. UNICEF requires that the finished food products processed with UNICEF-donated equipment be made available to preschool children in feeding programs. Raw material sources should be local. Donated foods such as Title II commodities

cannot be processed with UNICEF-donated equipment. Both private and public sectors can apply for grants.

There appears to be only one agency in the United Nations system which will consider purchase of raw materials and ingredients required for large-scale food processing plants. It is the World Food Program (WFP), an agency connected with UNDP.

If capital for procurement of raw materials is temporarily unavailable in order to start worthwhile projects, WFP can consider funding for a period of about two years. Income from the sale of the finished foods would be used to build up the capital and for the purchase of additional ingredients.

As an example, WFP has provided raw materials, [i.e., butter and nonfat dry milk solids (NFDM)], to milk plants built with UNICEF-donated equipment to produce reconstituted milk either for sale or distribution in feeding programs. A weaning food plant in Egypt requested donation of wheat flour and dry skim milk to get its processing started. The procedures for approaching WFP are similar to those outlined earlier for UNIDO.

Other potential sources for funding include the International Bank for Reconstruction and Development (IBRD), the Organization of American States (OAS), the Pan American Health Organization (PAHO), and the Organization of African Unity (OAU).

Assistance by International and National Private Voluntary Organizations

In developing countries where national or international PVO's have programs (e.g., Caritos, CARE, Church World Service, Catholic Relief Services, etc.), food and nutrition funds are sometimes available. Program priorities, criteria and funds available vary by organization, and persons or governments seeking funding should determine these on an individual basis by contacting local representatives.

Assistance by National Organizations

Projects to assist developing countries in their search for financial help to provide food to local needy people are also underwritten by many national organizations, such as the Canadian International Development Agency (CIDA) and the Swedish International Development Agency (SIDA), to name just two of them. Most of the West European countries have agencies which will consider assistance to the developing countries, and some of the oil-producing countries also provide funds for such purposes. Individual agencies or embassies should be approached to determine procedural steps for consideration of projects.

Assistance by Foundations

Foundations exist which are interested in assisting developing countries in specific cases. For example, Oxfam (Oxford Group Against Famine), with headquarters in Great Britain and an office in Boston, underwrites funding of small programs related to famine relief. Compilation of a listing of foundations specifically interested in international food and nutrition programs is projected as a task to be undertaken in FY 1977 by USDA/CSU.

Technical Assistance

Funding for equipment and the purchase of raw materials to produce nutritious foods has been discussed. Other technical assistance and guidance are provided by United States organizations such as AID, USDA, and CSU. Special consultants can be selected to assist host governments, private voluntary organizations, foreign research institutes and private industries in the solution of technical problems related to food and nutrition programs to combat malnutrition. Criteria for assisting in the solution of these problems are closely related to those described earlier.

From what has been said so far, it can be seen that the AID program--which has as it goal the narrowing of the gap between unavailability and availability of local food resources--is indeed a multifaceted program. It requires the assistance and collaboration of people from many countries, many cultures and many disciplines in order to bring it to a successful completion.

It is hoped that all of us at this workshop can contribute to identifying some of the problems observed in the implementation of the low-cost extrusion cooking program and to suggest solutions. By so doing, we may be able to make more nutritious food available to those people who need it so desperately.

Goals and Activities of the Colorado State University LEC Program

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INTRODUCTION

Extrusion processing has been discussed for a number of years as a technology which has significant capability in processing foods to meet the food and nutritional needs of the world's poorest people living in developing countries.

Interestingly, with all of this rhetoric concerning the extrusion process, the literature and other standard sources of information are almost universally devoid of good information about it. Consequently, this may be a good and just reason why we at Colorado State University have undertaken the activity of looking into, particularly, low-cost extrusion cookers and their role in the feeding of the world's poor.

Smith (1969) summarized the advantages of using an extruder to precook mixtures of cereal with legumes or oil seeds. They were:

1. Thermal deactivation of heat-liable growth inhibitions in legumes or oil seeds.

2. Gelatinization of cereals to improve digestibility and acceptability, and to reduce cooking time.

3. Destruction of bacteria and insects to insure a sanitary product.

4. Shelf-stable products without refrigeration because of their low moisture content.

5. Control and variation of product characteristics to improve their acceptability and marketing.

de Muelenaere and Buzzard (1969) pointed to the versatility of extruders in producing foods for world needs because of their versatility, high capacity, flexibility and the wide variety of products they can manufacture.

Extensive work has been published on the production and utilization of full-fat soy flour. The work of Mustakas et al. (1964, 1970) was instrumental in establishing extrusion as a viable alternative for nutritious human foods. Little specific work has been published on the use of cooker extruders in producing blended foods, nutritious snacks, weaning foods, precooked gruels or beverage bases, etc., which could find value in feed and processing programs in developing countries.

In order for extrusion cookers to be effectively applied to the food and nutrition problems of the LDC's, they must have the following characteristics:

1. Low cost--Processing system cost must be less than $75,000/ton/hour capacity. To achieve these costs the extruder needs to cost less than $20,000/ton/hour capacity.

2. Moderate production rate--Production rate ranging between 500 and 2,000 pounds/hour.

3. Simple operation--Requires little sophisticated technical capability to operate.

4. Minimal auxiliary equipment--To the greatest possible extent the system should not require auxiliary boilers, dryers or pre- or post-process conditioning equipment that will increase cost and can lead to product contamination.

5. Versatile--Process should handle a wide variety of cereals in combination with protein-rich legumes or oil seeds.

6. Maintenance--System should be easily maintained and should utilize locally available parts and equipment to the greatest possible extent.

7. Sanitary--Equipment must be cleanable and suitable for human food products.

Work has been underway at Colorado State University with the support of AID through USDA since October 1974, to evaluate low-cost extrusion cookers (LEC's). To date the following extruders have been examined extensively:

1. Brady Crop Cooker (#206)
   Koehring Farm Division
   Ankeny, Iowa 50021

2. Insta-Pro Extruder (#500)
   Triple "F", Inc.
   Des Moines, Iowa 50322

These two extrusion machines meet the criteria listed above. A multifaceted testing evaluation and operational program has been undertaken to determine their operating parameters and the extent to which they can be used to extrude cereal grains with or without the presence of oil seeds or legumes. Each of these extruders was originally designed for the cooking of whole soybeans to thermally deactivate naturally occurring antigrowth and nutritional factors present in raw soybeans. Therefore, the operating conditions for processing other food combinations must be determined. A summary of the use and capabilities of these two LEC's has been published by Tribelhorn et al. (1975).

GOALS

The goals of the LEC Program at CSU are as follow:

1. Set up a test facility to determine the capabilities and limitations of LEC's.

2. Evaluate the nutritional and physical characteristics of extruded materials.

3. Develop nutritional specifications of new products.

4. Provide technical backstopping for existing programs and other users.

5. Assist in the application and implementation of LEC technology.

DISCUSSION

Test Facility and Testing Procedures

In order to evaluate the capability of the LEC to process a wide variety of cereals in combination with protein-rich ingredients (legumes or oil seeds), a pilot facility was designed and installed at the Agricultural Engineering Research Center on CSU's Foothills Campus. Every effort was made to provide flexibility in the system so that a wide variety of ingredients and processing conditions could be tested. In this system it is essential to provide equipment for bulk raw materials' storage and handling, blending and grinding, and conveying.

A number of experiments have been conducted on the LEC's to determine the operating characteristics, limitations and process requirements. On the extruders themselves, many operating variables can be adjusted which drastically alter the extruder's operations. These are:

1. Feed ingredient combinations
2. Feed rate
3. Granulation before extrusion
4. Water or oil addition to dry ingredients
5. Discharge openings and/or screw configurations
6. Speed of extruder

To obtain suitable operating data it was necessary to run an extruder for 2 to 4 hours and required about 1 to 2 tons of raw ingredients. The following variables were measured during our testing program.

1. Feed rate
2. Moisture content of dry ingredients
3. Moisture additions
4. Extrusion power
5. Granulation of feed
6. Extrusion temperatures

A simple data sheet summarizing these variables is shown in Figure 1.

Ingredients and Operating Conditions

A wide variety of raw ingredients has been tested and extruded on both extruders. A complete list of raw ingredients tested is shown in Table I. Extensive work has been done on corn, sorghum, wheat and rice, normally in combination with soybeans. To a lesser extent, work has been done on other combinations, some of them in LDC test locations using ingredients not normally available in the United States.

Table I. Ingredient Combinations Tested

Legumes/Oil Seed	Cereals	Range of Cereals, %
Whole soybeans	corn	0 - 100
	sorghum	0 - 100
	wheat	0 - 100
	rice	0 - 100
	millet	0 - 100
Peanuts (raw and roasted)	corn	0 - 100
Navy beans	corn	0 - 100
Defatted soy (44% protein)	whole soy	20 - 100
Dried peas		0
Cottonseed[1]	corn	70

[1]Tested at overseas test locations.

Table II gives a comparison of the two LEC's tested on products where extensive data were taken. Several important generalizations can be drawn from these summaries.

1. To date all raw ingredients evaluated have been extruded successfully. In other words, the operating conditions can be varied and controlled sufficiently to accomplish successful extrusion.

2. When extruding cereal grains with less than 30% whole soy, the addition of water or oil directly to the dry ingredients mixture is necessary to control temperature and/or excessive product expansion which tends to block the outlet of the machine.

3. Grinding raw feed grains prior to extrusion improves extrudate uniformity and reduces power required.

4. Extrusion of cereal grains normally requires 320-350°F barrel temperatures to achieve proper cooking. Extrusion temperatures of 280°F for soybeans is sufficient to deactivate thermally liable constituents.

5. Corn, sorghum and rice extrude similarly and handle well in both extruders. Wheat and millet require large quantities of power and/or the addition of water or oil. Navy beans must have added oil to extrude successfully.

6. Work to date on texturizing vegetable proteins has been inconclusive. Modifications to the extruders need to be made to facilitate feeding of high-protein flours before their capabilities can be determined.

7. The Brady Crop Cooker requires slightly less energy per kilogram of product than does the Insta-Pro extruder. Because of the greater power addition in the Insta-Pro, high cereal formulations are difficult to extrude without overheating unless 5-8% water is added.

Because of its larger size, the capacity of the Brady is about double that of the Insta-Pro Model 500. The discharge nozzles on the Insta-Pro make it particularly suited to manufacturing shaped pieces used as snacks or cereals.

Suitability of LEC

These studies on the two LEC's tested have shown them to be suitable for the production of nutritious human foods in LDC's. Their operating flexibility allows them to use a wide variety of ingredients so that indigenous nutritious food products can be manufactured in LDC's, taking advantage of local raw ingredient availability. Extensive experience to date has set guidelines on the operating conditions, plant requirements, maintenance requirements, and costs to manufacture a variety of products. Additional work is underway in the following areas:

1. methods of fortification
2. finished product enrobing and coating
3. packaging
4. analysis of nutritional characteristics
5. determination of product properties--physical and chemical

Designing, Implementing and Evaluating Feeding Programs

To complement the work on evaluating the operating characteristics of the LEC's, the CSU project has developed the capability to assist in planning, implementing and evaluating feeding programs built around the LEC technology. Foods to be manufactured on the LEC's need to be designed to meet the specific nutritional needs of the local country, to be acceptable to the target group, and to fit the food delivery or distribution patterns existing in the country. Working with local counterparts, PVO's, governmental agencies, etc., assistance in product formulation to meet nutrient needs using indigenous cereals and protein sources can be provided. Teams of nutritionists, food scientists and engineers can provide on-site assistance in product formulation, manufacturing requirements, cost estimates, quality control requirements, and product evaluation, based on the experiences of these studies to date. Efforts have been focused on manufacturing a CSB replacment made on LEC's as an important illustration of the capabilities of LEC's and of the range of work required to produce locally manufactured nutritious foods with the LEC technology.

Technical Backstopping

Prior to the initiation of Colorado State University's LEC project, Brady crop cookers had been supplied to INCAP in Guatemala, EAIRO in Kenya and Bogor Institute in Indonesia by the USDA/ERS with funds provided by AID. In addition, Brady extruders have been purchased in Costa Rica and Bolivia. In all of these cases, project personnel have assisted directly with consultation and training of local personnel so that they could test and apply the extruder in the production of nutritious human foods. The status of these specific projects will be discussed in this workshop by representatives from these institutions to better define the interest in LEC's and their application to food processing in LDC's.

A significant amount of planning and preparation needs to be done before a successful feeding program on new nutritious food can be introduced. This is the case also when a new LEC project is undertaken. The CSU project stands ready to provide a broad range of backstopping service to qualified projects.

Operating Programs

To date one LEC installation is operational. A Brady #206 is being used to cook locally grown dehulled sorghum in Sri Lanka which is mixed with WSB to extend the imported product. Developed in conjunction with CARE/SL, the project was implemented as part of a three-phase program which will eventually lead to the larger scale production of a locally manufactured weaning food (Thriposha).

In the Sri Lanka situation, CSU has provided help with LEC plant design, equipment selection and purchase, plant installation and start-up. The plant was in operation 8.5 months after initial planning was completed and has operated 2.5 months. Like all new operations, production is increasing with time, and normal start-up problems are being resolved. Prior to start-up of the process, CSU had participated in the evaluation of LEC sorghum products and conducted sample infant feeding trials.

Currently, discussions are being held with Tanzanian officials concerning the development of a LEC project which would produce a CSB-like product.

SUMMARY

Extensive testing of LEC's has shown them to be versatile and capable of extruding a wide variety of cereals with legumes or oil seeds. CSU has developed the capability of providing a broad spectrum of technical assistance associated with LEC technology.

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Table I. Summary Data Sheet

A. INPUT AND EXTRUDER CHARACTERISTICS

Sample Number	Proportions of Ingredients														Feed Moisture Content	Ground/Unground G or U	Water Added (GPH)	Feed Auger Setting	Cone Clearance (turns out)	Torque (ft/lb)	RPM	Horsepower	Input Feed Rate (lb/hr)	Output Rate (lb/hr)	Temperatures			
	Cereals						Legumes					Minor																
	Corn	Milo	Wheat	Rice			Soybean	Nut																	T_1	T_2	T_3	T_4

Comments:

Table I. Summary Data Sheet (continued)

B. OUTPUT PROPERTIES

1. Sample Number _____
2. Moisture Content _____
3. Bulk Density _____
4. Density _____
5. Urease Activity _____
6. Solubility _____
7. Kjeldahl Nitrogen _____
8. Fat Content _____

9. Appearance

____ a. Roped ____ c. Puffed ____ e. Erose
____ b. Flaked ____ d. Smooth ____ f. Porous

10. Texture

____ a. Hardness
____ 1) Soft ____ 2) Firm ____ 3) Hard
____ b. Brittleness
____ 1) Crumbly ____ 2) Crunchy ____ 3) Brittle
____ c. Chewiness
____ 1) Tender ____ 2) Chewy ____ 3) Tough
____ d. Gumminess
____ 1) Short ____ 2) Mealy ____ 3) Pasty ____ 4) Gummy
____ e. Adhesiveness
____ 1) Sticky ____ 2) Tacky ____ 3) Gooey
____ f. Particle Size and Shape
____ 1) Gritty ____ 2) Grainy ____ 3) Coarse
____ g. Other Characteristics
____ 1) Dry ____ 2) Moist ____ 3) Oily ____ 4) Greasy

11. Taste

____ a. Raw ____ b. Cooked

12. Flavor

____ a. Bland ____ c. Toasted ____ e. Cooked with some uncooked particles
____ b. Roasted ____ d. Burned

13. Constituent Flavors--What flavor is prevalent?

____ a. Soybean ____ c. Rice ____ e. Wheat ____ g. Other
____ b. Corn ____ d. Milo ____ f. Nut

14. Flavor Score _____

0 — dislike flavor; 5 — no flavor; 10 — like flavor very much

15. Odor--What constituent odor is prevalent?

____ a. Soybean ____ c. Rice ____ e. Wheat ____ g. Other
____ b. Corn ____ d. Milo ____ f. Nut

15. Odor Score _____

0 — Putrid; 5 — No odor; 10 — Agreeable

17. Color Score--mark appropriate box

Yellow — Brown — Black

18. Color Consistency

____ a. homogeneous
____ b. homogeneous, except for dark (or light) spots
____ c. nonhomogeneous, but one color dominates
Which color? _____
What is the other color(s)? _____
____ d. nonhomogeneous

Table I. Summary Data Sheet (continued)

C. STORAGE PROPERTIES

1. Sample Number _____ 3. Humidity Stored _____
2. Package Type _____ 4. Length of Storage _____

5. Appearance

___ a. Roped ___ c. Puffed ___ e. Erose
___ b. Flaked ___ d. Smooth ___ f. Porous

6. Texture

___ a. Hardness
___ 1) Soft ___ 2) Firm ___ 3) Hard
___ b. Brittleness
___ 1) Crumbly ___ 2) Crunchy ___ 3) Brittle
___ c. Chewiness
___ 1) Tender ___ 2) Chewy ___ 3) Tough
___ d. Gumminess
___ 1) Short ___ 2) Mealy ___ 3) Pasty ___ 4) Gummy
___ e. Adhesiveness
___ 1) Sticky ___ 2) Tacky ___ 3) Gooey
___ f. Particle Size and Shape
___ 1) Gritty ___ 2) Grainy ___ 3) Coarse
___ g. Other Characteristics
___ 1) Dry ___ 2) Moist ___ 3) Oily ___ 4) Greasy

7. Taste

___ a. Raw ___ b. Cooked

8. Flavor

___ a. Bland ___ c. Toasted ___ e. Cooked with some uncooked particles
___ b. Roasted ___ d. Burned

9. Constituent Flavors--What flavor is prevalent?

___ a. Soybean ___ c. Rice ___ e. Wheat ___ g. Other
___ b. Corn ___ d. Milo ___ f. Nut

10. Flavor Score ___

0 dislike flavor — 5 no flavor — 10 like flavor very much

11. Odor--What constituent odor is prevalent?

___ a. Soybean ___ c. Rice ___ e. Wheat ___ g. Other
___ b. Corn ___ d. Milo ___ f. Nut

12. Odor Score ___

0 Putrid — 5 No odor — 10 Agreeable

13. Color Score--mark appropriate box

Yellow — Brown — Black

14. Color Consistency

___ a. homogeneous
___ b. homogeneous, except for dark (or light) spots
___ c. nonhomogeneous, but one color dominates
Which color? _____
What is the other color(s)? _____
___ d. nonhomogeneous

Table II. Summary of Results

Test Parameters	Percent Cereal 50% Insta-Pro	50% Brady	70% Insta-Pro	70% Brady	80% Insta-Pro	80% Brady	100% Insta-Pro	100% Brady
I. Corn/Soybean Combinations								
A. Average feed rate (kg/h)	232.5	451.7	227.5	474.9	281.5	471.3	325.1	449.5
B. Average water added (m^3/h)	0.0	0.0	0.0073	0.0	0.0432	0.0051	0.0454	0.0083
C. Temperature cooked (°C)	152.8	166.1	154.4	165.6	167.2	165.6	173.9	175.6
D. Horsepower	31.0	58.0	32.0	61.0	39.0	64.0	42.0	61.0
E. Specific energy (hp-h/kg)	0.13	0.128	0.141	0.128	0.139	0.136	0.129	0.136
F. Consistometer (diameter, cm)	22.9	21.8	22.9	19.7	22.2	19.1	23.5	19.1
G. Bulk density (g/cm^3)	0.53	0.24	0.51	0.16	0.86	0.13	0.35	0.13
H. Puff index (g/cm^3)	0.42	0.36	0.25	0.23	0.44	0.19	0.34	0.15
I. Urease activity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
II. Sorghum/Soybean Combinations								
A. Average feed rate (kg/h)	287.8	341.9	261.5	381.4	328.7	411.3	294.2	385.9
B. Average water added (m^3/h)	0.0	0.0	0.0318	0.0085	0.0409	0.0085	0.0454	0.0090
C. Temperature cooked (°C)	162.8	166.7	172.2	172.8	171.1	171.1	176.7	178.3
D. Horsepower	52.0	51.0	49.0	46.0	52.0	54.0	50.0	57.0
E. Specific energy (hp-h/kg)	0.181	0.149	0.187	0.121	0.158	0.131	0.170	0.148
F. Consistometer (diameter, cm)	25.4	20.3	19.7	15.2	16.5	12.7	15.2	11.4
G. Bulk density (g/cm^3)	0.55	0.39	0.44	0.22	0.43	0.18	0.39	0.195
H. Puff index (g/cm^3)	0.51	0.51	0.40	0.41	0.37	0.28	0.33	0.28
I. Urease activity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
III. Wheat/Soybean Combinations								
A. Average feed rate (kg/h)	305.5	419.5	256.1	467.6	267.0	470.3	291.0	517.8
B. Average water added (m^3/h)	0.0	0.0	0.0091	0.0	0.0091	0.0	0.0273	0.0076
C. Temperature cooked (°C)	160.0	165.6	164.4	173.9	165.6	168.3	160.0	165.6
D. Horsepower	52.0	50.0	49.0	61.0	56.0	56.0	59.0	53.0
E. Specific energy (hp-h/kg)	0.170	0.119	0.191	0.130	0.210	0.119	0.203	0.102
F. Consistometer (diameter, cm)	25.4	25.4	16.5	24.1	15.2	21.0	12.7	13.3
G. Bulk density (g/cm^3)	0.51	0.43	0.36	0.37	0.23	0.36	0.31	0.25
H. Puff index (g/cm^3)	0.55	0.35	0.32	0.42	0.21	0.41	0.31	0.33
I. Urease activity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table II. Summary of Results (continued)

Test Parameters	Percent Cereal 50% Insta-Pro	50% Brady	70% Insta-Pro	70% Brady	80% Insta-Pro	80% Brady	100% Insta-Pro	100% Brady
IV. Rice/Soybean Combinations								
A. Average feed rate (kg/h)	231.0	349.2	228.0	449.7	N.T.	N.T.	N.T.	435.6
B. Average water added (m^3/h)	0.0091	0.0	0.0136	0.0026				0.043
C. Temperature cooked (°C)	151.6	162.8	154.4	173.9				165.6
D. Horsepower	26.8	63.0	23.0	62.5				58.9
E. Specific energy (hp-h/kg)	0.116	0.180	0.101	0.139				0.135
F. Consistometer (diameter, cm)	25.6	21.6	22.2	12.7				7.62
G. Bulk density (g/cm^3)	0.58	0.429	0.48	0.261				0.136
H. Puff index (g/cm^3)	0.49	0.352	0.41	0.379				0.164
I. Urease activity	0.0	0.0	0.0	0.0				0.0
V. Whole Corn/Dehulled Soybean Combinations								
A. Average feed rate (kg/h)			324.8	294.9				
B. Average water added (m^3/h)			0.0068	0.0				
C. Temperature cooked (°C)			148.9	171.1				
D. Horsepower			30.7	52.1				
E. Specific energy (hp-h/kg)			0.095	0.177				
F. Consistometer (diameter, cm)			25.4	20.3				
G. Bulk density (g/cm^3)			0.472	0.180				
H. Puff index (g/cm^3)			0.425	0.280				
I. Urease activity			0.0	0.0				
VI. Corn Grits/Whole Soybean Combinations								
A. Average feed rate (kg/h)			323.7	324.0			N.T.	292.3
B. Average water added (m^3/h)			0.0057	0.0				0.0043
C. Temperature cooked (°C)			146.1	170.0				173.9
D. Horsepower			36.5	40.3				69.7
E. Specific energy (hp-h/kg)			0.113	0.124				0.239
F. Consistometer (diameter, cm)			30	19.[illegible]				10.16
G. Bulk density (g/cm^3)			0.484	0.21				0.13
H. Puff index (g/cm^3)			0.425	0.29				0.12
I. Urease activity			0.0	0.0				0.0

Table II. Summary of Results (continued)

Test Parameters	Percent Cereal							
	50%		70%		80%		100%	
	Insta-Pro	Brady	Insta-Pro	Brady	Insta-Pro	Brady	Insta-Pro	Brady
VII. Dry Bean Combinations								
A. Average feed rate (kg/h)							N.T.	404.9
B. Average oil added (kg/h)								5.68
C. Average water added (m^3/h)								0.0
D. Temperature cooked (°C)								146.1
E. Horsepower								48.0
F. Specific energy (hp-h/kg)								0.119
G. Consistometer (diameter, cm)								14.0
H. Bulk density (g/cm^3)								0.497
I. Puff index (g/cm^3)								0.492
J. Urease activity								0.0
VIII. Peas (dried)								
A. Average feed rate (kg/h)							N.T.	333.3
B. Average oil added (kg/h)								5.68
C. Average water added (m^3/h)								0.0
D. Temperature cooked (°C)								165.6
E. Horsepower								47.0
F. Specific energy (hp-h/kg)								0.141
G. Consistometer (diameter, cm)								25.4
H. Bulk density (g/cm^3)								0.547
I. Puff index (g/cm^3)								0.410
J. Urease activity								0.0
IX. Dehulled Soybeans								
A. Average feed rate (kg/h)							N.T.	300.0
B. Average water added (m^3/h)								0.0
C. Temperature cooked (°C)								115.0
D. Horsepower								39.5
E. Specific energy (hp-h/kg)								0.132
F. Consistometer (diameter, cm)								12
G. Bulk density (g/cm^3)								0.25
H. Puff index (g/cm^3)								0.34
I. Urease activity								0.0

Manufacturers' Experiences with LEC's - the Brady Crop Cooker

Marvin Van Peursem
Koehring Farm Division
Des Moines, Iowa

The Crop Cooker soybean extruder was developed by the Brady Operations of the Koehring Farm Division during 1969 and 1970. The principal objective was to manufacture and market a machine suitable for heating soybeans sufficiently to destroy the trypsin growth inhibitor. The resulting processed material would be used by farmers for livestock rations fed primarily on farms in the United States and Canada.

At the outset, we established the following basic design parameters:

1. Utilization of rotating shaft power from a variety of commonly used United States on-the-farm tractors.

2. Portability for multi-farm use or at different soybean storage locations on the owner's farm.

3. Relative simplicity of operation compared to other grain conditioning or processing implements that a United States farmer is acquainted with.

4. Realization of the critical machine price-to-performance expectation relationship which exists in the U. S. farm machinery industry. During the design phase of the Crop Cooker, anticipated costs of manufacturing were continually reviewed. Our objective was to minimize the machine cost in line with the established cost performance relationship.

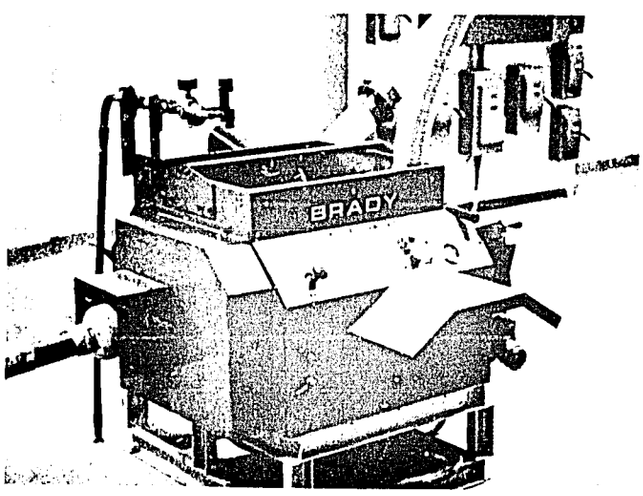

Figure 1. Brady #206 Crop Cooker.

I might add that several of you know Gerry Williamson, our chief engineer, who headed this project, and we feel he did a very good job in meeting these design parameters. The final design includes three key features:

1. An approximate 15-cm-diameter, 1-meter-long extruder directly connected by a standard power take-off output shaft to the farm tractor. The extruder rotor is assembled from shaft, cylinder tube and replaceable coil (flighting) components with a minimum amount of costly machining labor.

2. The machine includes a self-contained oil hydraulic system with a hydraulic pump, oil reservoir, control valve and hydraulic motor. This motor turns a small auger which meters the grain from the machine's hopper into the inlet of extruder. With the control valve, the metering auger speed may be varied from 0 to 50 revolutions per minute. This, in turn, regulates the volume of soybeans or other grains metered into the extruder. The valve setting helps control the cooking temperature and operating capacity depending on available tractor horsepower.

3. From the inlet, the grain in the extruder chamber is moved by the extruder rotor (turning at 500 to 1,200 rpm, depending on the horsepower size of the tractor or power unit) to the discharge end. The grain temperature rises upon approaching the discharge. The discharge end consists of a replaceable, linear adjustable, 16-cm-diameter cone with approximately 3-cm-face surface that matches a replaceable fixed cup. By means of a simple crank, while the machine is in operation, the clearance between the rotating cone and fixed cup can be varied to change the extruding temperature. The extrudate is discharged in no predetermined shape from around the periphery of the 16-cm-diameter rotating cone.

Generally, for satisfactory operation, because of the adjustable cone turning within the fixed cup at the discharge, the material being extruded should include some lubricant such as oil within the soybean. In other words, on combinations of materials which get below 30% soybean you need some type of lubricant.

Over 300 Brady Crop Cooker extruders have been put into service. Some are powered by 100 horsepower electric motors, some by gear and clutch equipped diesel power units and many by approximately 65 to 130

horsepower farm tractors. Most of the units are in use on United States farms, extruding soybeans for livestock feed ration ingredients. A number of units are in use outside of the United States extruding various mixtures.

Normal operating maintenance includes:

1. Lubricate the front bearing assembly and its adjustable housing with multi-purpose type grease at the recommended 5 and 10 hour intervals. Generally, the life of this bearing assembly properly lubricated exceeds 1,500 U.S. tons.

2. Check for adequate oil level in the hydraulic oil reservoir and proper belt tension for the hydraulic pump drive, which is required to operate the metering auger.

The principal wearing components on the Crop Cooker extruder are the replaceable processor cone and mating cup. Depending on the mixtures, types of grain and condition of the grain, the life of these components may vary as much as from over 500 tons down as low as 10 tons. Excessive dirt, sand or stones in the soybeans being processed cause rapid wear. Generally, non-oil seed grains do cause faster wear. This wear is evident when it becomes extremely difficult to maintain desired operating temperatures by the normal operating adjustments.

The rotor will also slowly wear, the greatest wear being near the discharge end. Eight short agitator bars welded to the rotor at the discharge may need replacement or build-up by weld after extended service. The full length, or a portion, of the spiral flighting welded intermittently on the rotor can also be replaced when worn to improve machine performance. The complete rotor can be easily replaced, also.

Our company desires to meet the needs of the most potential users whether on United States farms or in less developed countries. We believe that our basic, original design parameter remains important; that is, to minimize the machine cost in line with the broadest, potential user performance expectation. With this general policy, we realize that our machine will not meet all specialized user requirements. For instance, we cannot change discharge dies to make different shaped products.

We seek to build and market a general purpose extruder in sufficient high quantity to insure the most economical manufacture. This means a standardized design for purchasing the necessary required components and manufacture in our factory in large quantity production lots. We are interested in following successful new uses and user adaptations of our Crop Cooker extruder. To insure low cost, we do not plan to manufacture modifications of our general design until we can prove the justification for most potential users.

To summarize, the Brady Crop Cooker extruder is a low-cost extrusion cooker developed initially for use on farms in the United States. We are pleased that it may also meet a need in other areas of the world, especially in those less developed countries seeking to fulfill protein food requirements.

Manufacturers' Experiences with LEC's ' the Insta-Pro Extruder

Leroy J. Hanson
Triple "F" Feeds
Des Moines, Iowa

Today, I would like to explain what led to the development of the Insta-Pro Extruder and also, review for you the development of the soybean.

Originally, soybeans were raised in the United States and around the world for their oil content. Soybeans were brought to the United States as ballast for ships and were grown as a legume for hay. During World War II, the price of fat became very high and we started extracting oil from the soybeans. Thus, for approximately the past 20 years, the soybean was raised primarily for its oil content.

However, during the 30-year period from the early 1940's, the price of oil fluctuated from 40 to 50 cents down to a low of 7 cents per pound. When oil is low in price, the meal or protein fraction of the soybean must carry the major portion of the soybean cost. In the late 1960's, the farmer was raising soybeans, selling them to a processor who removed the oil and then buying back the meal with the oil removed for more than he originally received for them. Transportation costs have also become a more significant cost, in addition to shrink.

In 1961, Triple "F", Inc. decided to do something about what appeared to be an inequity to the farmer. We thought about it, watched the oil price, and developed supplemental products to use with high-energy soybeans, but it wasn't until 1964 that work started with the infrared process, now called the dry roasting process.

Dry roasting involves a process where beans are roasted whole with no mechanical processing such as grinding. We worked with that process for five years on the premise that if you ground the soybean it would turn rancid. Later, it was found that if the oil cells are ruptured they release a phospholipid known as lecithin, which acts as a natural antioxidant and keeps the bean from turning rancid.

In 1969, Mr. Wayne Fox, President of Triple "F", thought of the idea of dry extrusion, and we built an extruder for soybeans and began selling a commercial soybean extruder in the fall. The soybeans did not turn rancid because in the extrusion process enough lecithin was released from the oil to keep that from happening.

The reason that high-energy soybeans are so good for livestock is that the oil is used for energy, thus improving the animals efficiency significantly, usually about 10%. Not only do whole soybeans contain 38% protein, but they also contain 18-20% oil. The lecithin is present in the oil fraction at approximately 4% of the oil.

Recent work at the University of Georgia by Dr. M. E. McCullough has shown a synergistic effect when whole extruded soybeans are fed with the whole corn plant. This work is in its infancy, but it indicates that when whole soybeans are fed with corn silage, the response is greater than the apparent energy contribution of the ration. This is very important from an economic standpoint for livestock production. Phospholipids are also important for human nutrition, because they have to do with uptake of fat in the intestinal tract and are contained in all living cells.

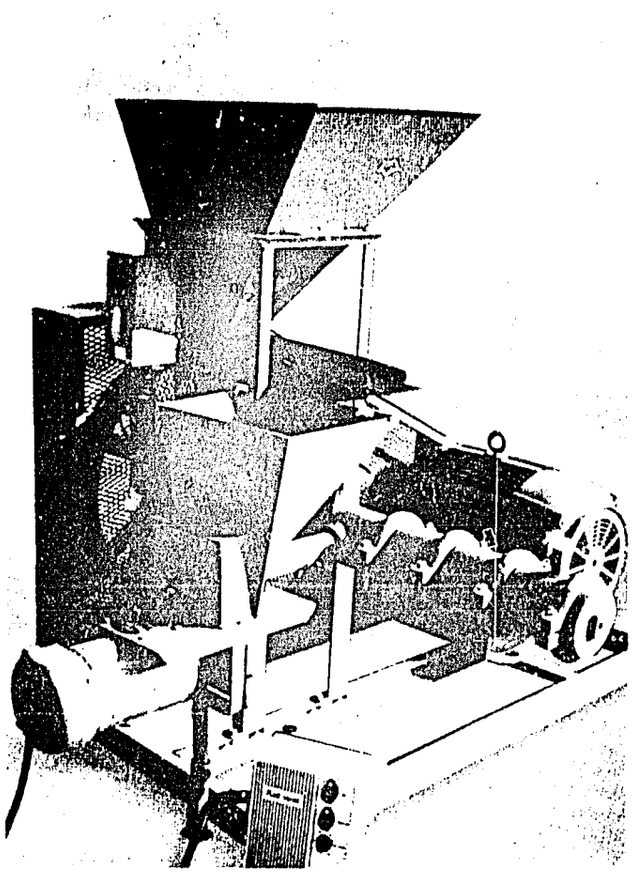

Figure 1. The Insta-Pro Extruder.

Our company now has several hundred extruders in 13 countries throughout the world. There is a great interest in the extrusion concept since soybeans must be heated before they can be consumed by livestock or humans. There are many areas of the world that can raise soybeans, but none have a low-cost means of processing them. The Insta-Pro Extruder allows the beginning of an industry on a small-scale basis without huge capital investments.

One of the basic objectives in developing the Insta-Pro Extruder was to find a way to develop heat by friction. Bear in mind that we went through five years of testing different types of processing methods. One of the problems with the live flame method of heating is the danger of explosions and fires. Soybeans, characteristically, have trash in them--hulls, leaves and stems which are very flammable.

With the Insta-Pro Extruder, the machine converts horsepower to heat through the use of friction so there is no fear of fire. The heat is needed to destroy the trypsin inhibitors and the urease activity in the soybean.

Another objective was to mechanically grind the soybean and to develop sufficient pressure so that when the product was released to the atmosphere the oil cell would rupture. In addition, a simplified process that would avoid the necessity for both preprocessing or post-processing auxiliary equipment was required. We wanted to develop a low-cost machine which could be powered by any type of power that was available, whether it was diesel, tractor or electric. We have concentrated with the Insta-Pro method on the stationary concept, developing methods of adding liquids directly into the barrel as well as shaping and cutting the product upon its release.

Another objective was to reduce material handling costs to a minimum. We wanted a machine small and inexpensive enough to be placed in strategic locations to avoid high freight costs in shipping the soybeans or whatever is being extruded. Controlling the wear of disposable parts was also critical. With friction converting horsepower to heat, wear results, so with the Insta-Pro Extruder, wear is confined to those parts that are the least costly to replace.

Lastly, we wanted to simplify the operation and maintenance so that relatively untrained people could operate the extruder. The more sophisticated extruders on the market require highly trained people, while training someone to operate the Insta-Pro Extruder takes a few days, as long as the person has some mechanical aptitude.

The next subject is the basic design: how is the machine constructed, and how does its construction affect the operation. Basically, the extruder starts with a cylindrically shaped tube designed in sections. There are four sections, so you can imagine a round tube, with four sections hooked together. Within each section is a screw and a restriction which is needed to build pressure and heat. As the product passes through the tube by means of the screw, each section increases the pressure by means of the restriction. As the product works against itself, it creates heat and when it nears the tube end, the restrictions get smaller and smaller so the heat increases. In this regard, each section has a thermometer so that the heat buildup can be monitored and the right amount of heat can be produced. The degree of heat can be altered by regulating the size of the restriction and the throughput in the tube.

A liquid injection system has recently been added so liquids can be injected directly into the barrel. Liquids act as a lubricant and can expand greatly the type of products that can be extruded, including products with low oil contents, such as grains.

Also, the Insta-Pro Extruder is available with a multiple-head die. This makes it possible to vary the size and shape of the product. A knife-type cutter which fits on the multiple-die head also makes it possible to alter the length of the pieces.

The basic restrictions are varied in our machine according to the product and the amount of heat needed. In other words, different sizes of steam locks or restrictors, are changed depending on whether you are processing soybeans or corn. A disposable wear ring surrounds this restriction, which can be entirely worn out by placing washers either before or after it, or by reversing it. Materials can be put into the extruder from either of two locations: they can be force-fed into the side of the machine with a screw, or they can be put into the top of the barrel with a vibratory feeder. The latter is the way we originally started with soybeans, because it let us do two things: first, a way to extract any metal in the soybeans--by the use of a magnet in the throat; and second, a method to separate the rocks and trash that were bigger than the soybeans. Soybeans or any other product should be cleaned prior to putting it through the extruder to reduce abrasion. To maintain the maximum utilization of the energy being changed to heat by friction, a modulator in the electrical system which interrupts the electrical flow to the feeders momentarily was added. This device prevents overloading the motor and provides a somewhat semiautomatic operation so as to maximize the use of energy.

With regard to present applications of our extruder, it is still primarily used as originally designed--for organic products. With this type of low-cost extrusion using friction as a source of heat, oil or fat at a minimum level must be present. You can operate at a minimum of about 8%, based on our experience. At that level you might want to add some moisture to reduce the horsepower requirements, or you can use water. We routinely cook corn with water as the only source of additional lubricant. Products can also be extruded when an ingredient is added to the product which melts after it gets hot. One of the products used in this way is urea, a dry synthetic form of nitrogen which melts and acts as a lubricant. In this case, the machine is preheated with an oil seed.

Needs vary depending on the product. However, extrusion is not recommended unless you do something to the product to improve it. Effective extrusion denatures the enzymes and ruptures the fat cells. Expansion can be important in some products. Gelatinization of the starch can be important. An as-yet unanswered question is the importance of complexing. Some of the literature indicates that by extrusion of fat products, oil seeds with starch products, results in complexing of the starch and the oil or the fat which could be important nutritionally. Putting products into different forms can also be important such as improving palatability, sterilizing and encapsulating.

One of the major areas of application of our machine is that of producing pet foods. Others include processing grain and protein combinations for livestock feed; manufacturing a product using urea

complexed with starch to slow down the release of ammonia for ruminant animals; and gelatinizing starch for baby pigs.

The University of Wisconsin is doing some interesting work in the area of extracting juice from alfalfa--heat steaming the juice, coagulating the protein and then extruding the coagulant with starch sources to make the product palatable. Since alfalfa protein concentrate is a quality source of protein, that could be an important source of protein for the future. Other universities are working on heat processing of all types of protein for ruminants to accomplish a rumen bypass so that bacteria do not degrade the protein in the paunch. A final example of the many possible applications of the machine is that of using it to capture waste products.

The chief limitations of the machine are two. One is that you need lubrication to control the heat. The other is that you get excessive wear with dirty products, although we have learned how to control the wear. As for maintenance and durability, the machine is designed to create heat with pressure and friction, and the attrition will cause parts to wear. Therefore, maintenance is important to produce a quality product. It is important to have a magnet in the machine to remove the metal. It is also important that the dust or dirt and sand be removed by cleaning the product prior to extrusion. There are simple ways of doing this, for example, I saw recently on a farm an auger with the bottom cut out and a screen underneath. As the product passed up the auger the sand fell through the screen. Then the soybeans fell through another screen while the chaff went over the top. That kind of cleaning mechanism costs almost nothing and is very effective.

The parts in the extruder are made of special steel and are built to stand a great deal of abrasion, but the machine should be kept in good repair. Parts should be replaced when needed, and we recommend that when the machine is shut down, the equipment be cleaned, because oil and meal will become caked on the shaft if left to harden.

Our approach to machine modifications has been one of modifying the machine to fit the need, although the basic principle of the machine hasn't changed since its introduction in 1969--the conversion of friction to heat. We have changed the machine with respect to some of the ingredients processed. For instance, for the urea product a volumetric feeder to feed the material into the side of the machine was added. The modulator to prevent surging in the machine, and an expanded number and size of steam locks are now used for more flexibility. For grain products we have developed the water injection system, and for pet food the multiple-head die was developed so that the product can be shaped. With the Insta-Pro Extruder, it is possible to configure the machine to commercially process any organic type of ingredient on a consistent and quality basis.

Colorado State University Extrusion Facilities and Systems

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Fort Collins, Colorado

INTRODUCTION

The initial possibility of using low-cost extrusion cookers (LEC's) in LDC's has been investigated thoroughly by the USDA (Crowley, 1973). Results from this survey and research indicated that LEC's can play a substantial role in food programs and will help LDC's become less dependent on donated food items from the United States.

Two LEC's, the Brady #206 Crop Cooker and the Insta-Pro Model 500 extruder have shown potential utility in processing foods. Technology on these two extruders has been limited primarily to processing whole soybeans for use as livestock feed.

The requirements for a food product processed by these extruders for use by humans rather than by livestock are considerably different. Initial investigation of the two extruders revealed that there was not sufficient information on their operation using high percentages of cereals and cereal kinds. This need resulted in the USDA's initiating a cooperative agreement funded by AID with the Department of Agricultural Engineering, Colorado State University, to investigate the two extruders and determine their utility with various grains in combination with legumes or oil seeds to produce a variety of human foods.

OBJECTIVES

A research plan, along with the necessary equipment to carry out this plan, was designed. The system was built around the following objectives:

1. To demonstrate and evaluate the suitability of LEC's to produce blended foods.
2. To determine the operational characteristics and product capabilities of LEC's for the production of low-cost human foods.
3. To serve as a model for use in designing LEC installations to meet varying processing needs in LDC's.
4. To provide training and backstopping for existing or new LEC-users in less developed countries.
5. To serve as a United States facility for LDC visitors with interest in LEC's.

TEST PARAMETERS

The test facility designed and constructed at the Agricultural Engineering Research Center at CSU permits the control of the following extrusion parameters

1. Moisture
2. Granulation of feed
3. Temperature
4. Orifice opening
5. Cooling of finished product
6. Input rate
7. Output rate
8. Water added
9. Torque
10. Rotor speed (rpm)

Additionally, the extruded products made under various processing conditions are evaluated for the following:

1. Physical characteristics
2. Gelatinization - consistometer
3. Urease, where applicable
4. Storage stability

EXTRUSION FACILITY

The CSU extrusion facility was designed to permit the greatest versatility possible and yet be simple. The system has the capability of feeding the individual extruders from one to six ingredients at a time. The system consists of the following equipment:

1. John Deere 4020 diesel tractor (90 hp, 540 rpm PTO)
2. 4 - Read bulk tanks (capacity of 10 tons each)
3. 1 - Modern Mill Model 600 (proportioner/grinder)

4. 1 - Brady #206 Crop Cooker

5. 1 - Insta-Pro Model 500 extruder

6. Miscellaneous augers and spouting (incoming)

7. 1 - 6-inch extruded product auger

8. 1 - transport truck

9. 1 - Model A12 BLH torque sensor

10. 1 - tach-generator (speed determination)

Figure 1 gives the floor plan of the facility. The arrangement of the equipment permits optimum utility by providing easy equipment interaction. Figure 2 gives the flow of the system in block diagram form. The major equipment is discussed below to aid in understanding the test facility.

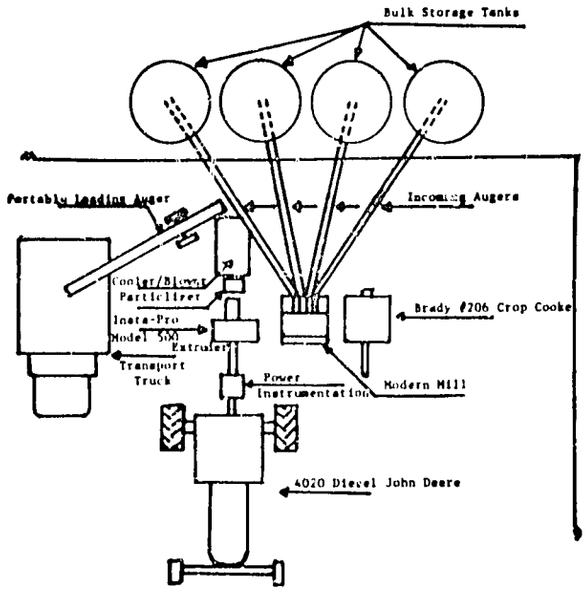

Figure 1. Floor plan of extruder test facility.

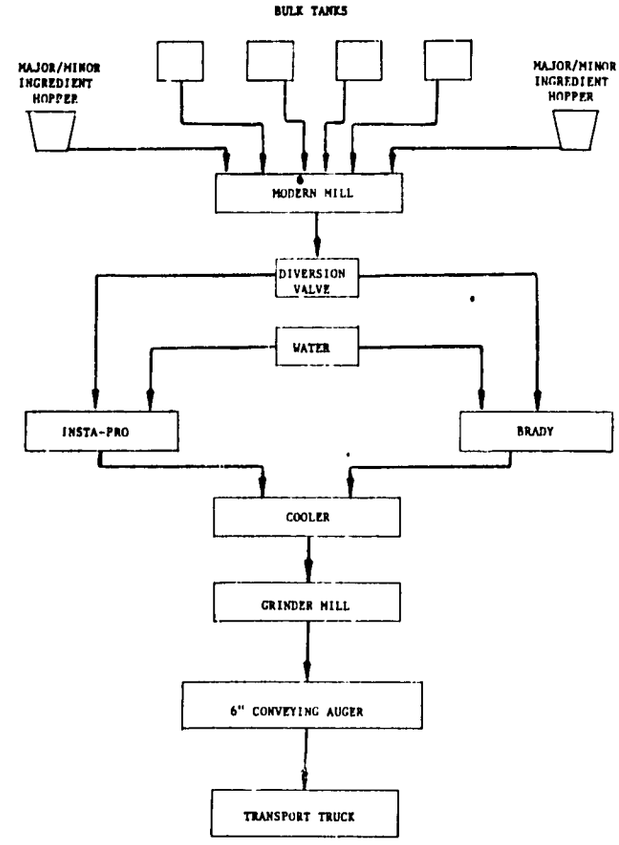

Figure 2. Flow diagram of CSU test facility.

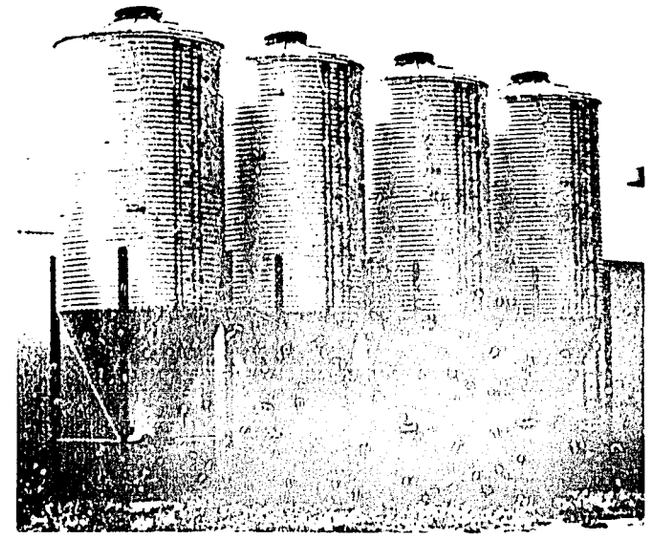

Figure 3. Read bulk tanks.

BULK TANKS

Four Read bulk tanks (Fig. 3), each with a capacity of 10 tons, are used in the system as storage for major input grains. The tanks currently contain soy, corn (maize), wheat, and sorghum.

MODERN MILL

The Modern Mill Model 600 (Fig. 4) is used to pre-process the grain before extrusion. The mill is a hammer mill with interchangeable screens that can be used to vary the particle size of the food materials for the extruder. Additionally, the mill has the capability of six inputs, four major and two minor. The four major inputs have control hoppers which maintain a constant flow of material from the bulk tanks. Two hoppers are mounted on the mill for the addition of minor ingredients or two more major ingredients. The mill also has a variable speed control on the metering unit which allows the matching of material flow into the extruders (an important feature to insure proper water addition).

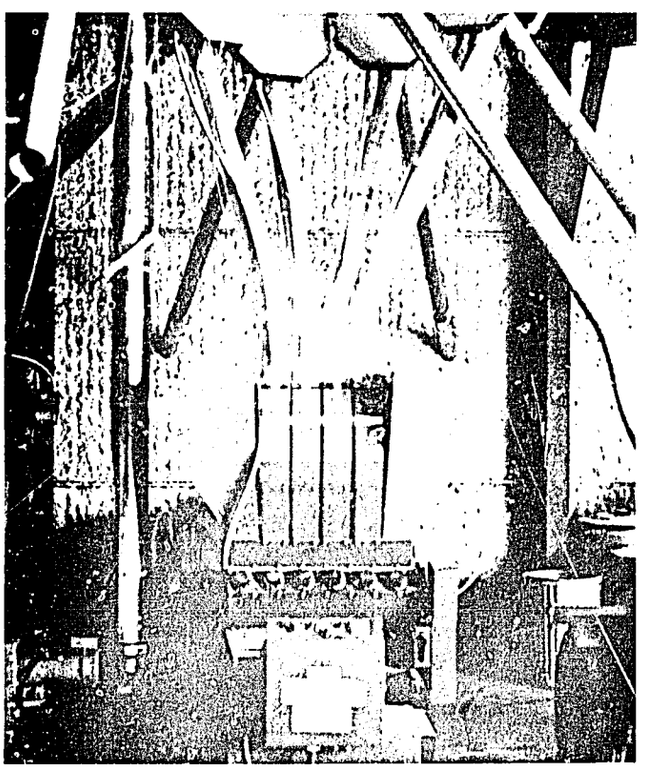

Figure 4. Modern Mill Model 600

The metering unit on the Modern Mill has dials which, when adjusted, will combine any number of grains in any combination. Calibration curves have been determined for the mill in this facility. The combination of metering unit settings and variable speed control allows the control of input feed ingredients in any desired ratio. Throughput rates are measured by collecting the grain flowing to the extruder in a tared container.

POWER MEASUREMENT

The Model A12 Baldwin-Lima Hamilton torque sensor and a tach-generator (electrical generator with signal proportional to speed) are used to measure the power required to operate each extruder (Fig. 5). These two items are built into a single unit that can be interchanged with each extruder.

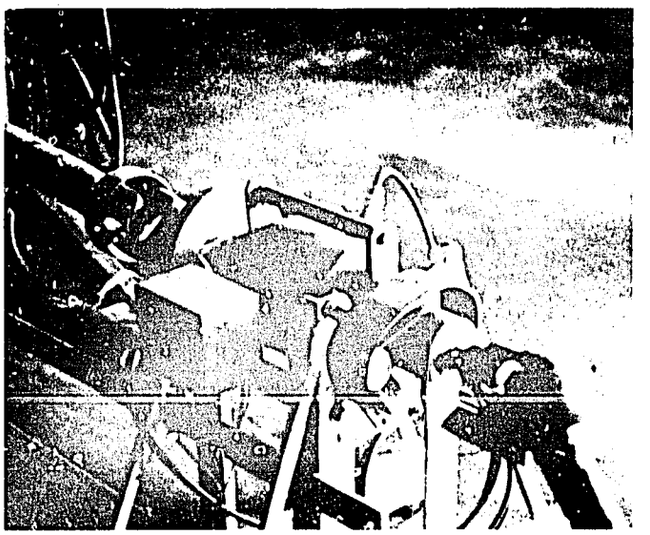

Figure 5. BLH Model A12 torque sensor and assembly.

The use of this equipment permits determination of the torque and speed (rpm) which are essential in determining horsepower. Both the torque and speed are permanently recorded on a brush recorder, then planimetered to determine their average values. With the throughput known, the specific energy (hp-h/lb or kW-h/kg) can be determined and used to predict the power necessary for a potential application.

The above equipment is required because of the diesel power source. If an electric motor were used to drive the extruders, an amperage and power factor would suffice.

AUXILIARY EQUIPMENT

Two additional pieces of equipment are being installed for this system (Fig. 2). One is a simple cooler which is made of large tubing with internal lifting flights. This is used in line after extrusion to cool and dry the product prior to grinding or packaging.

The second piece of equipment is a hammer mill. This is quite different from the Modern Mill in that it is versatile and can grind the extruded product from a grit size to a flour size. The Fitz Mill being purchased has the capability of internal configuration variability. In other words, the mill hammers and/or screens can be changed with only a small time and expense requirement. This mill will permit the sizing and configurations required for potential application in LDC's.

EXTRUDERS

A brief discussion of each extruder is given below, along with an outline of proper operating procedures concerned with warm-up, operating, and shutdown. Reference is made to existing reports from CSU (1975-1976) to obtain more detailed information.

Brady #206 Crop Cooker

Figure 6 shows the Brady Crop Cooker and its controls. Two controls are available for regulation of the extruder temperature or product consistency. The first is the cone adjustment handle which regulates the cone/race clearance at the discharge. One complete revolution of this adjustment handle represents a clearance change of 0.051 cm. Such adjustments change the area of the discharge opening, which controls product residence time and energy input from the engine.

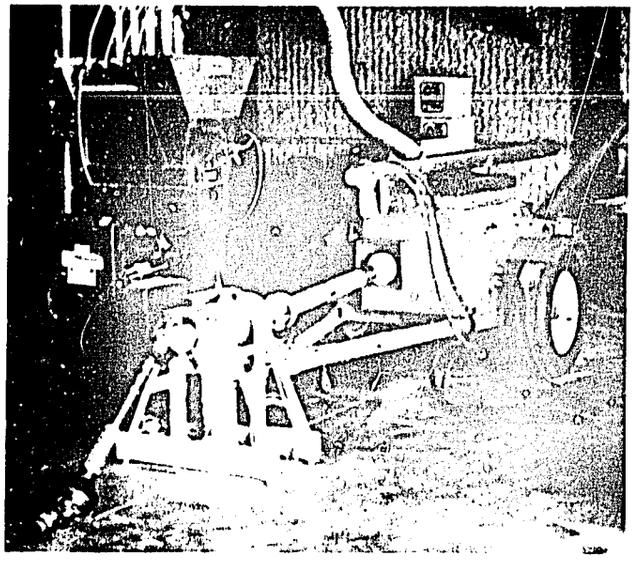

Figure 6. Brady #206 Crop Cooker showing feed input controls and cone adjustment.

The second control adjusts the feed rate into the extruder. A hydraulic valve is used to adjust the speed of the feed auger to the extruder screw.

Operation--Operation of the Brady consists of a warm-up procedure with soybeans until operating temperature is achieved. This is followed by a gradual switching of cereal/legume combinations. Warm-up is accomplished by slowly reducing the cone/race clearance from an initial orifice opening at a moderately low feed rate. Under these conditions the extruder temperature increases to 138°C which is sufficient to completely cook whole soybeans.

The Brady's extrusion screw measures 12.7 cm diameter by 86.4 cm in length. The screw has a constant pitch of 3.81 cm and fits into the barrel equipped with three breaker bars. With soybeans, the extruder produces 435.8 kg/h with 53 horsepower input.

Shut-down of the Brady is very simply done by introducing soybean into the machine. The cone is opened to its maximum position and the temperature is allowed to decrease. This allows the dry soybeans to flow through and clean the extruder. The extruder does not require disassembling to clean, but normal sanitation precautions need to be taken at the end of each run to sweep away accumulated dry flour adhering to the equipment.

Insta-Pro Model 500 Extruder

The Insta-Pro extruder is shown in Figure 7. It has internal adjustments which are not possible on the Brady and which must be set prior to any extrusion process. Control of the extruder is accomplished in three ways.

1. Variable-sized restrictions termed "steam locks" are placed in three locations down the barrel. The size of these restrictions greatly affect the operation of the extruder. The steam locks are manufactured in various diameters. To change the locks, the barrel section and screw must be disassembled.

2. Cone clearance at the discharge is done by controlling the number and size of orifices to vary the final temperature in the last section of the extruder barrel. Unlike the Brady, this cone clearance acts only as a final trim on temperature rather than the primary control.

3. The volumetric feed mechanism, which is used to feed the extruder during runs, can be used to control the throughput and thus the temperature. This mechanism has an SCR-controlled DC motor connected to a screw conveyor and injects feed directly into the barrel of the extruder.

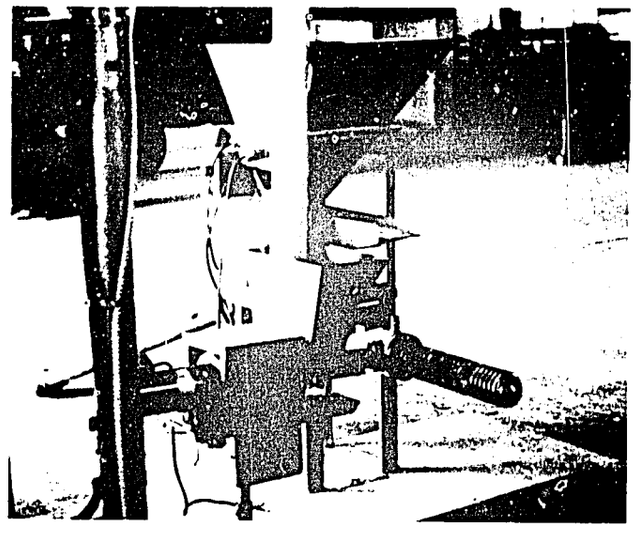

Figure 7. Insta-Pro Model 500 extruder showing feed input mechanisms and controls.

Operation--Temperature regulation is accomplished primarily by interchanging or replacing the steam locks. The use of these steam locks is entirely dependent on the material that is to be extruded. The temperature along the barrel is dependent on the gap between the steam lock and the barrel wear ring. It is desirable to use a configuration which results in an approximate linear temperature increase along the length of the barrel. Such a configuration is accomplished by having the steam locks increase in diameter from the inlet to the discharge end with the outlet orifice size used to obtain the final processing temperature.

An auxiliary vibratory feeder and hopper is on the machine and is primarily used for feeding whole soybeans to warm-up, shut-down, and clear the machine after operation problems are encountered during testing.

The Insta-Pro's extrusion screw measures 9.4 cm diameter by 71.1 cm length. The screw has a constant pitch of 3.49 cm. With soybeans, the extruder produces 232.5 kg/h with 31 horsepower input.

Warm-up is accomplished by feeding a small amount of soy to the machine and virtually starving the extruder. When the temperature begins to rise, the feed rate is increased until approximately 272.7 kg/h is reached.

Shut-down requires running soybeans through the machine until all cereal is cleaned out and the temperature is decreased. The machine is disassembled to clean remaining materials from the barrel and screw.

Both extruders can be adjusted to arrive at a desired product temperature and consistency. Adjustment of the throughput, orifice opening, and amount of water added have been shown to extensively affect horsepower required, temperature, and final product consistency.

TESTING PROCEDURE

The extrusion procedure is outlined below. Some test conditions required small deviations from this outline.

1. Warm-up extruder with whole soybean.
2. Begin gradual switch over to desired combination to be tested.
3. When desired composition of products is achieved, adjust any or all of the following extruder controls to maintain the desired temperature:
   a. cone clearance
   b. feed rate
   c. amount of water added
4. Adjust proportioner mill rate to correlate with input into extruder, thus establishing equilibrium feed rate conditions.
5. Record the following test data:
   a. temperatures
   b. feed mechanism control setting
   c. cone clearance
   d. input feed rate
   e. output rate
   f. amount of water added
   g. torque input
   h. angular speed
6. Take samples for further testing.

Steps 5 and 6 are repeated for each test condition or run made. General observations were also recorded as they occurred.

COMPARING THE EXTRUDERS

The operating principles of the two extruders are substantially different. Control of the Brady lies essentially in the adjustment of the discharge cone clearance. Control of the Insta-Pro 500 requires proper presetting of the steam locks on the screw so that an even temperature rise down the barrel occurs. These differences make experimental adjustments easier on the Brady, but once operational parameters are fixed for a specific product, adjustment of either extruder should not have to be made.

Because the Brady has an annulus for a discharge, products come out in flat flakes of irregular size. The Insta-Pro has a multiple-holed die with cutters which is ideal for making shaped pieces. The system's end use will dictate the machine choice.

Operating experience to date indicates that the Brady requires less water addition to extrude 100% cereal mixtures. Further work on the Insta-Pro extruder may result in methods to reduce water addition.

MANUFACTURING PROCEDURES

Extensive work with the extruders and results achieved have opened up the specificity of proper manufacturing procedures for potential applications. These items are discussed below.

Corn-Soy Blend

Corn-soy blend (CSB) has been used by various countries to supply food to their people. The mixture specified by USDA (1973) combines 70% corn and 30% soybean with vitamin-mineral premixes. Use of the extruders makes the corn-soy combination instant, which in many cases is desirable.

Specific processing conditions for a CSB product are given below.

1. Materials required
   a. corn or corn grits
   b. dehulled soy
   c. vitamin premix
2. Processing temperature range: 149-171°C (depending on extruder used and the amount of gelatinization required)
3. Input granulation: 40 mesh
4. Final particle size: 40-60 mesh
5. Approximate throughput: 273-546 kg/h

Dehulling and cleaning are necessary for the soybeans and grains to reduce the fiber in the final product and to minimize wear on the extruder. The product must be ground to a particle size of at least 40 mesh before extrusion to reduce power requirements and to insure a more homogeneous product.

Depending on the extruder used, the recommended temperature and throughput rate will vary. Generally speaking, the Insta-Pro has temperatures and throughputs in the lower end of the ranges given above. The Brady temperature and throughput ranges are toward the upper limit mentioned.

After extrusion the material must be cooled. This serves two requirements: to allow any moisture to evaporate (down to an optimum of at least 8% moisture content); and to cool the product to prevent excessive heat buildup in the final grinding of the extruded product.

The CSB is generally used with a large particle size (60 mesh) which makes it different from flours (100 mesh). Grinding requirements are easier to meet with this product due to the larger particle size.

Finally, some type of packaging to control the amount of contamination during storing and transporting is required. The package size should be determined by the intended use to meet the processing rates that would exist. Combinations of 1-5 kg paper or polyethylene bags packed by hand appear feasible.

Soy Flour

Soy flour is generally used as a high protein supplement in breads, meats, etc. Extrusion processing of whole soy to denature naturally occurring anti-nutritional factors is necessary. Production of a fine flour may be difficult because of the high oil content in the finished product. Specific processing conditions are given below.

1. Material required: dehulled soy
2. Processing temperature range: 127-138°C (depending on extruder used)
3. Input granulation: whole or ground to a 40 mesh size
4. Final particle size: 100 mesh or smaller
5. Approximate throughput: 296-636 kg/h

Again, as in the previous system, the soy must be dehulled and cleaned. This reduces the amount of fiber in the final product. Additionally, wear on the extruder will be minimized when soy is cleaned and dehulled.

Depending on the extruder that is used, the above temperature range has been shown to have destroyed all naturally occurring anti-nutritional factors. The Brady must be at the higher temperature to destroy these factors, and the Insta-Pro can be used from the lower 127°C and higher. Essentially, both extruders have shown excellent capabilities for extruding soy. Throughputs are higher for a given power source than for, as an example, CSB production systems. Thus a higher throughput or a smaller power source can be used.

Input to the extruder can range from whole to ground soybeans. If the beans are dehulled, they probably will be broken, and further size reduction may not be required. If whole soy is used, the input does not need to be ground to extrude; however, grinding is highly recommended to reduce power consumption of the extruder.

The product must be cooled to a temperature of at least 40°C to reduce heat buildup in the final milling process. Additionally, this cooling operation will allow time for the product to dry. The ultimate moisture content for grinding is 8%. Generally, the high heat from extrusion will flash off moisture down to the 8% level, but ambient conditions will have to be considered.

Final particle size must be 100 mesh or smaller to obtain a product for mixing with other flours. An attrition or pin mill will be required for producing fine flours. More coarse grinds, however, may be used depending on the final product use.

Sorghum

When extruding a cereal, expansion of the grain occurs due to the high percentage of starch and to the low concentration of oil which suppresses puff. Because the oil level is low, water addition is required to lubricate the extruder and to reduce required power.

Although for this system, the cereal used will be sorghum, similar processing will be required for other grains. The required processing conditions are given below.

1. Material required: whole grain sorghum (dehulling is optional)
2. Processing temperature: 163-171°C (depending on extruder used and gelatinization required)
3. Input granulation: 40 mesh
4. Water addition required: 1-2%
5. Final particle size: 40-60 mesh and smaller
6. Approximate throughput: 455 kg/h

Whole grain sorghum can be extruded. The ultimate use will determine whether the sorghum must be pearled to reduce the fiber content. Processing temperature has been determined to be between 163-171°C to achieve a fully cooked, highly gelatinized product.

Two important conditions in this system are the input granulation and water application. Unlike the previous two systems which have a high oil input (6-10%), the oil content is very low (less than 1%). Thus the extruder must be lubricated. Water addition has shown to be a very good lubricant when using a cereal such as sorghum. Water is added to sorghum (with its inherent moisture) to bring the total moisture content up to 12-14%. Generally, the water needs to be applied at a rate of 1-2%.

Grinding of the sorghum before extrusion is advantageous because the power required is reduced; the sorghum is cooked more thoroughly; and the final product is more homogeneous. The extruded sorghum must be cooled to a temperature of 40°C or lower to reduce heat buildup in the final milling process and to remove excess moisture from the extruded product.

Depending on the ultimate use, final granulation is variable. It is recommended that the final product be ground to at least 60 mesh for infant and young child feeding. Smaller grinds may be suitable when the product is to be used as a substitute for all-purpose flour.

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Colorado State University. 1975-76. Quarterly Reports--January 1975, April 1975, July 1975, October 1975, January 1976 and April 1976. Agricultural Engineering Department, Colorado State University, Fort Collins, Colorado.

Crowley, P. R. 1973. Evaluation of LEC for Use in Less Developed Countries. Report TA/N, AID, Washington, D. C.

United States Department of Agriculture. 1973. Purchase of Corn-Soy Blend for Use in Export Programs. Announcement CSB-1. September.

QUESTION AND ANSWER SESSION

Dr. Bressani:

I would like to ask a question of Mr. Tribelhorn. You indicated that the input granulation size was 40 mesh. How did you arrive at this particular size? What parameters did you use?

Mr. Tribelhorn:

We experimented with the Modern Mill in our facility using different screen sizes. We reduced the particle size of the feed to obtain the most uniform product while maintaining the ability to feed the extruder.

LEC Systems and Costs

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INTRODUCTION

The economics of LEC systems must be considered before they can be judged feasible. As illustrative cases, the costs of three example systems have been outlined in detail. These examples may be used in developing the costs for other similar systems.

The costs may then be used to set a value for the products manufactured by the plant and/or determine how production rate affects the product value. This value can be used as an index of the economic feasibility of the system in comparing LEC's to alternative systems.

The most common systems which may be used in LDC's were chosen as examples. The three systems included plants that would produce: (1) cooked flour/grit; (2) snack foods; and (3) full-fat soybean flour. An outline of the necessary equipment for each system was made. This was used to set the total fixed costs for the systems. The manufacturing cost of the products was also calculated.

The systems are presented below, first in diagram form and then with a cost analysis. The assumptions used in developing these analyses can be found in Attachment I.

SYSTEM I - AN EXTRUDED FLOUR/GRIT PRODUCTION FACILITY

A diagram of the system is shown in Figure 1. This facility is similar to the system that has been installed in Sri Lanka. A pearling device is provided in the system to remove hulls from incoming grains. Three storage bins are provided to accommodate two days' storage for bulk raw materials. The materials can be conveyed into the plant and into a proportioning mill where the ingredients are proportioned, mixed, and pre-ground before extrusion. After extrusion, the product is conveyed to a cooler-dryer where the moisture in the product is allowed to evaporate, pre-conditioning it for subsequent grinding. After the product is cooled, it is ground. The grit system is presented, but a flour system would require a pin mill instead of an inexpensive hammer mill. The additional cost for the pin mill would be approximately $30,000. After grinding, the product is conveyed and packaged by hand.

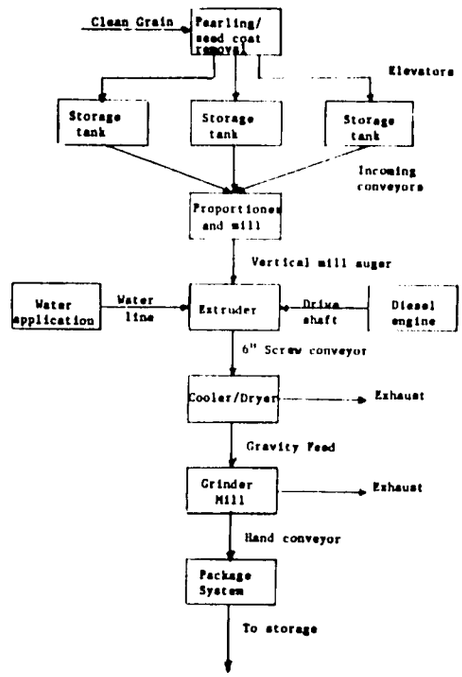

Figure 1. Block diagram of System I.

This system was designed to produce flours or grits that can be used to make gruel and other products in the home. An 80% maize/20% soybean product was chosen for the specific example presented. A summary of the capital costs for System I is shown in Table I. The total capital costs, including working capital, will be presented later.

Table I. Capital Costs for System I

A. Purchased Equipment		
Pearler	$ 4,500	
Vertical conveyor	300	
Storage tanks	2,025	
Incoming conveyors	900	
Proportioner mill	2,900	
Extruder	4,500	
Water application kit	125	
Diesel engine	8,500	
Product conveyor	600	
Cooler/dryer	7,200	
Product grinder	3,000	
Electrical equipment	1,600	
Packaging equipment	350	
Total		$36,500
B. Equipment Transporting Costs		
Crating	$ 1,200	
Freight	1,000	
Shipping	3,500	
Total		5,700
C. Installation Costs		
Labor	$ 800	
Supplies	500	
Total		1,300
D. Services (assumed to be present)		-0-
E. Building		24,500
F. Land		500
		$68,500
G. Contingency (20% of fixed cost)		13,700
Total capital costs less working capital		$82,200

Table II. Manufacturing Costs* for System I--a Flour/Grit Production Facility

Direct Production Costs			
Raw Materials			
Grains	$ 65.00		
Credit for dehulling waste	- 1.80		
		$ 63.20	
Packaging materials		37.83	
Labor		5.30	
Utilities			
Electrical	1.80		
Fuel	3.50		
		5.30	
Maintenance		1.65	
General supplies		.25	
Shipping costs		3.00	
Total direct production cost			$116.53
Direct Manufacturing Costs			
Payroll overhead		.80	
Laboratory costs		.25	
Total direct manufacturing cost			$ 1.05
Indirect Manufacturing Costs			
Depreciation		2.20	
Interest on borrowed capital		6.08	
Total indirect manufacturing Cost			$ 11.28
Total Manufacturing Costs			$129.38

*Costs given in $/hr

The manufacturing costs for the system were also calculated (Table II). The costs are presented on an hourly production basis so that their influence on the cost of the product can be seen directly.

The working capital necessary for operation of the plant for two months can be calculated from the total manufacturing costs, and for this system it will be $47,440. This value is over half of the equipment costs and indicates that the facility is a low-cost system.

SYSTEM II - A SNACK FOOD FACILITY

This system is designed to produce a nutritious cereal snack that can be eaten from small bags without further processing. The raw materials used to produce the snack are maize and soybean in a 70% cereal/30% oil seed ratio. After extrusion the product is enrobed in an oil-spice-salt solution to improve its flavor.

The equipment used for this system is similar to the extruded flour-grit facility. A diagram of the system is shown in Figure 2. No pearling equipment is provided, and the raw materials are charged directly to the bulk storage. The raw materials are processed in the same way as at the flour/grit facility, and a proportioning mill is necessary for mixing the raw materials, as well as for pregrinding to achieve good product uniformity. The cooler/dryer is also used in this system to separate the fine materials for reprocessing. After the product is cooled it is enrobed and packaged. Two form-fill packaging machines are utilized at considerable expense, although at the rate of production chosen, a hand packaging system appears to be slightly more expensive.

A summary of the capital costs for the snack food production facility is shown in Table III. The working capital can be calculated from the manufacturing costs presented in Table IV. The working capital for a two-month period for System II would be $70,710, which is less than half of the capital costs previously calculated. This reflects the higher investment in packaging equipment for this system.

The manufacturing costs are again presented on an hourly cost of production basis. The influence of the high costs of packaging materials can be seen to substantially increase the direct production costs. The high capital investment due to packaging machinery costs also largely affects increasing manufacturing costs.

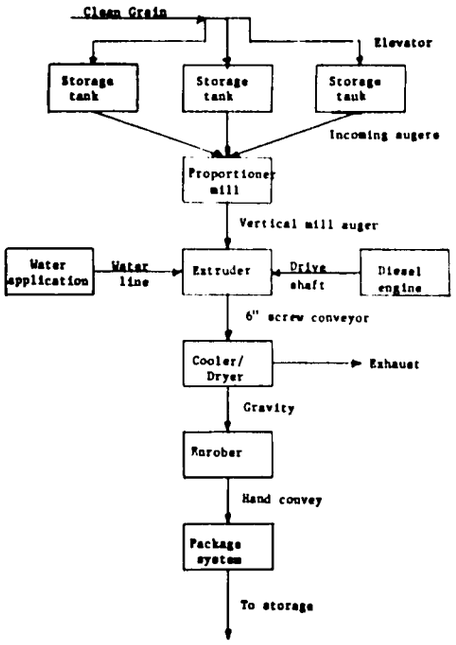

Figure 2. Block diagram of System II.

Table III. Capital Costs for Snack Food Production Facility

A. Purchased Equipment		
Vertical conveyor	$ 300	
Storage tanks	2,025	
Incoming conveyors	900	
Proportioner mill	2,900	
Extruder	4,500	
Diesel engine	8,500	
Water application kit	125	
Product conveyor	600	
Cooler/dryer/separator	7,200	
Enrober	2,000	
Packaging machinery	114,000	
Electrical equipment	1,400	
Total		$144,450
B. Transportation Costs		
Crating	$ 1,000	
Freight	1,000	
Shipping	3,800	
Total		5,800
C. Installation Costs		
Labor	$ 1,150	
Supplies	400	
Total		1,550
D. Services to Facility		-0-
E. Building		29,500
F. Land		500
		$181,800
G. Contingency (20% of fixed cost)		36,360
Total capital costs less working capital		$218,160

Table IV. Manufacturing Costs* for System II--a Snack Food Production Facility

Direct Production Costs			
Raw Materials			
Grains	$ 55.70		
Enrobing ingredients	25.20		
		$ 80.90	
Packaging Materials		65.50	
Labor		5.10	
Utilities			
Electricity	1.20		
Fuel	3.50		
		4.70	
Maintenance		2.68	
General supplies		.25	
Shipping costs		4.50	
Total direct production cost			$163.63
Direct Manufacturing Costs			
Payroll overhead		.42	
Laboratory		.25	
Total direct manufacturing cost			$ .67
Indirect Manufacturing Costs			
Depreciation		7.17	
Interest on borrowed capital		21.35	
Total indirect manufacturing cost			$ 28.52
Total Manufacturing Costs			$192.82

*Costs given in $/hr

SYSTEM III - A FULL-FAT SOY FLOUR PRODUCTION FACILITY

This system is much simpler than the other two, as only one raw ingredient is required. This eliminates two storage bins and incoming conveyor systems. Ingredient preportioning is not necessary, and enough pre-grinding of the raw material will be accomplished in dehulling, eliminating the need for the proportioner mill. A simpler cooler/dryer is also installed and reduces the equipment costs. The final product grinder, a pin mill, is the most complex item in the plant and is necessary to grind the oily extruded product into a flour. After grinding, the product is packaged into large cloth bags for storage. The large bags are sufficient, since the flour will probably be used by bakeries or institutions in the bulk form.

A diagram of the plant (Fig. 3) illustrates the simpler plant design. The capital costs for the full-fat soy flour facility are shown in Table V. The table illustrates the low cost of the system, although the final product mill has a high cost.

Table VI emphasizes the high proportion of manufacturing costs represented by raw materials and packaging. The working capital for this system for a two-month period would be $47,430, and, as in System I, it represents over one-half of the other capital costs.

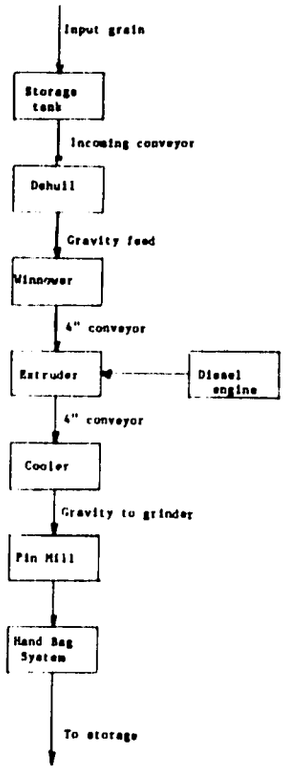

Figure 3. Block diagram of System III.

Table V. Capital Costs for System III

A. Purchased Equipment		
Vertical conveyor	$ 300	
Storage tanks	675	
Incoming conveyors	300	
Dehuller	3,000	
Winnower	850	
Conveyor	300	
Extruder	4,500	
Diesel Engine	6,400	
Conveyor	300	
Cooler	2,500	
Pin Mill	28,000	
Bagging equipment	450	
Electrical equipment	1,850	
Total		$49,425
B. Equipment Transporting Costs		
Crating	$ 900	
Freight	3,300	
Shipping	950	
Total		5,150
C. Installation Costs		
Labor	$ 650	
Supplies	400	
Total		1,050
D. Services		-0-
E. Building		19,000
F. Land		500
		$ 75,125
G. Contingency (20% of fixed cost)		15,025
Total capital costs less working capital		$ 90,150

Table VI. Manufacturing Costs[a] for System III--a Full Fat Soy Flour Production Facility

Direct Production Costs			
Raw Materials			
Grains	$ 82.80		
Credit for dehulling waste	-1.80		
		$ 81.00	
Packaging Materials		21.80	
Labor		2.80	
Utilities			
Electricity	1.20		
Fuel	2.80		
		4.00	
Maintenance		2.37	
General supplies		.25	
Shipping costs		3.60	
Total direct production cost			$115.82
Direct Manufacturing Costs			
Payroll overhead		.42	
Laboratory		.25	
Total direct manufacturing cost			$ .67
Indirect Manufacturing Costs			
Depreciation		2.69	
Interest on borrowed capital		10.16	
Total indirect manufacturing cost			$ 12.85
Total Manufacturing Costs			$129.34

[a]Costs given in $/hr

A summary of the important statistics of all three systems is shown in Table VII. It includes the total capital required and the value of the product as a basis for comparison of these LEC systems to other processing systems.

Table VII. Summary of the Important Economics Statistics of Three Example LEC Systems

Statistic	System I	System II	System III
Capital Required			
Fixed capital less working capital	$ 82,200	$218,160	$ 90,150
Working capital	47,440	70,710	47,430
Total	$129,640	$288,870	$137,580
Manufacturing Costs ($/hr)			
Direct production costs			
Raw materials	$ 63.20	$ 80.85	$ 81.00
Packaging materials	37.83	65.50	21.80
Labor	5.30	5.15	2.80
Other	10.20	12.13	10.22
Manufacturing costs	12.85	29.19	13.52
Total	$129.38	$192.82	$129.34
Production Rate (lb/hr)	1000	1000	1200
Product Value ($/lb)	$0.13	$0.19	$0.11

DISCUSSION

Several important observations can be made from these costs analyses:

1. Ingredient and packaging costs approximate 80% of the finished product costs in all cases.

2. Systems discussed in these analyses would be classified as low cost, because total capital is less than $100,000 except for systems with expensive pouch packaging.

3. Systems studied would have a lower capital cost per kg by putting in multiple extruders for much of the service, and auxiliary equipment would serve two extruders.

4. Depreciation can be reduced to about one-half (from 4% to 2%) by increasing production with a second shift.

On the basis of these figures, it is concluded that the capital and manufacturing costs associated with these extruder systems are low, making them suitable for the production of nutritious human foods in LDC's.

ATTACHMENT I

GENERAL ASSUMPTIONS USED IN CALCULATING COST FOR LEC SYSTEMS

The general assumptions used in calculating the system costs are that:

1. The equipment for the plants will be purchased in the United States and shipped to the plant site duty free.

2. Grain received by the plants will arrive every other day in bags and will need no further cleaning.

3. Straight-line depreciation will be used: a 10-year life expectancy will be given to the equipment; and a 50-year life expectancy to the building.

4. Maintenance costs will be 10% of the value of the purchased equipment per year.

5. The plants will operate at full production for 2,200 hours per year.

6. No property taxes or insurance costs will be incurred.

7. A simple interest rate of 10% will be used to calculate costs of borrowed capital.

8. Payroll overhead costs will be 15% of operating labor costs.

9. Raw material costs will be:

maize	0.05 $/lb
soybean	0.06 $/lb
salt and spices	0.60 $/lb
oil	0.15 $/lb

10. Utility costs will be:

fuel	$0.70/gallon
electricity	$0.06/kW-hr

11. Building costs will be $10.00 per square foot.

12. Two months' working capital will be required.

13. Dehulling wastes will have a value of $0.01/lb.

14. The facilities will be financed over a 10-year period.

Additionally, the assumptions made in Table VIII are not necessarily the same for each of the systems.

Table VIII. Assumptions used in Developing Economic Analyses of the Three LEC Systems

	System I	System II	System III
I. Raw Ingredients			
Ratios	80% maize/ 20% soybean	70% maize/ 30% soybean	100% soybean
Amount purchased (% of production)	125	105	115
Amount reduced to waste during dehulling (% of production)	18	-0-	15
II. Packaging			
Type of bag	paper/ polyethylene	polyethylene	cloth
Bag size	450 g.	60 g.	25 kg.
Cost per bag	$0.022	$0.003	$1.00
Cardboard case size	24 bags	48 bags	- - -
Cost of case	$0.38	$0.38	- - -
III. Labor Costs			
Number of:			
Supervisors @ $1.00/hr	1	1	1
Extruder operators @ $0.50/hr	2	2	1
Packaging equipment operators @ $0.50/hr	- - -	2	2
Laborers @ $0.30/hr	10	6	- - -
Janitors @ $0.30/hr	1	1	1
IV. Shipping Costs			
Maximum truck load (tons)	12	4.8	12
Shipping rate ($/ton-mile)	$0.20	$0.30	$0.20
Avg shipping distance (mi)	30	30	30
V. Production Rate (lb/hr)	1000	1000	1200
VI. Utility Usage			
Electrical (kw-hr)	25	20	20
Fuel (gal/hr)	5	5	4

Physical and Chemical Evaluation of Extruded Products

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SAMPLE IDENTIFICATION

Samples of corn (degerminated corn grits or whole corn), dehulled or whole soybeans, and blends of these products were extruded on the Brady either separately or together at temperatures listed in Table I. Following extrusion the samples were ground in a hammer mill (Wiley), and those samples of corn and soy extruded separately were dry-blended in a Hobart A-200 mixer (Fig. 1) in the proportion of 70 parts corn and 30 parts soy, by weight. The AID vitamin and salt mixes (for Title II CSB) were obtained from Hoffman LaRoche and Mallingrodt, respectively.

Batches of 500 grams were prepared. The vitamin and mineral mixes were dry-blended for 30 minutes into the corn-soy samples in the amounts specified for Title II CSB. All products were stored at 40°F.

Table I. CSB Sample Characteristics

CSB Samples Extruded on Brady Cooker

Sample	Extrusion Temperature (°F)
1. Whole corn-dehulled soybeans (70:30)	340
2. Whole corn-dehulled soybeans (70:30)	310
3. Whole corn	340
4. Whole corn	312
5. Dehulled soybeans	280
6. Corn grits-whole soybeans (70:30)	308
7. Corn grits-whole soybeans (70:30)	338
8. Corn grits-dehulled soybeans (70:30)	307
9. Corn grits-dehulled soybeans (70:30)	340
10. Corn grits	345
11. Whole soybeans	280

CSB Samples Used for Physical and Chemical Evaluations[1]
(after grinding, combining extruded samples and nutrient additions)

Sample	Extruded Sample No.
1. Whole corn-dehulled soybeans (70:30)	1
2. Whole corn-dehulled soybeans (70:30)	2
3. Whole corn	3
4. Whole corn	4
5. Corn grits-whole soybeans (70:30)	6
6. Corn grits-whole soybeans (70:30)	7
7. Corn grits-dehulled soybeans (70:30)	8
8. Corn grits-dehulled soybeans (70:30)	9
9. Corn grits	10
10. Whole corn-dehulled soybeans (70:30)	3 + 5
11. Whole corn-dehulled soybeans (70:30)	4 + 5
12. Whole soybeans + corn grits (30:70)	11 + 10
13. Dehulled soybeans + corn grits (30:70)	5 + 10
14. Bolivia (whole soybeans + dehulled corn (30:70)	commercial sample
15. Corn-soy blend (30:70)	commercial sample

[1]Samples 1-9, 14 cooked together
Samples 10-13 cooked separately
Samples 14, 15 commercial samples
Sample 14, no vitamins and minerals added

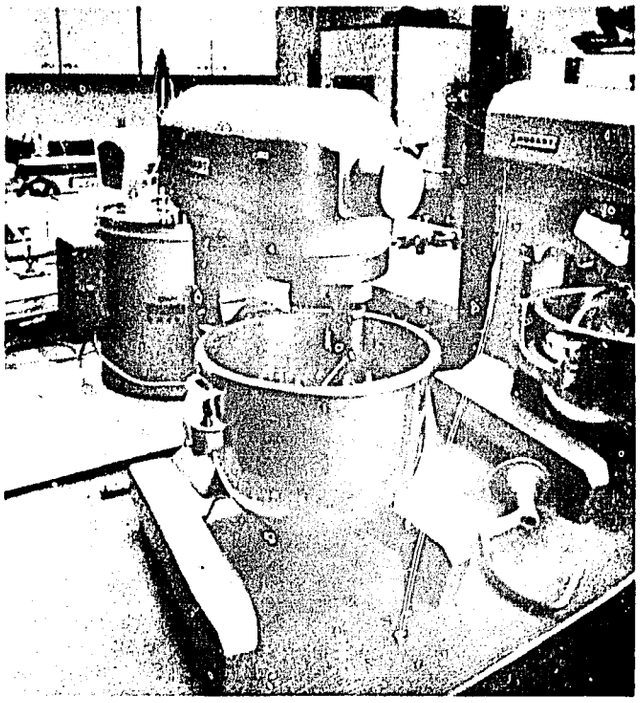

Figure 1. Mixer used to blend separately cooked products.

MATERIAL AND METHODS

Moisture, protein, ash and fat were determined using the Association of Official Agriculture Chemists (AOAC) methods. Mesh size was determined by shaking 100 grams of each product for 15 minutes on a Model RX-24 portable sieve shaker. The amount of material on U.S. standard #10, 20 and 60 sieves, as well as the amounts through a #60 sieve, were determined.

Consistency was measured with a Brookfield viscosimeter (Fig. 2) rather than with a Bostwick consistometer, which was not available. In this case the Brookfield made it possible to differentiate between samples better than the Bostwick, since some samples were very viscous. The samples were prepared as outlined under Methods of Analyses for the Commodity Specifications of CSB with minor modifications.

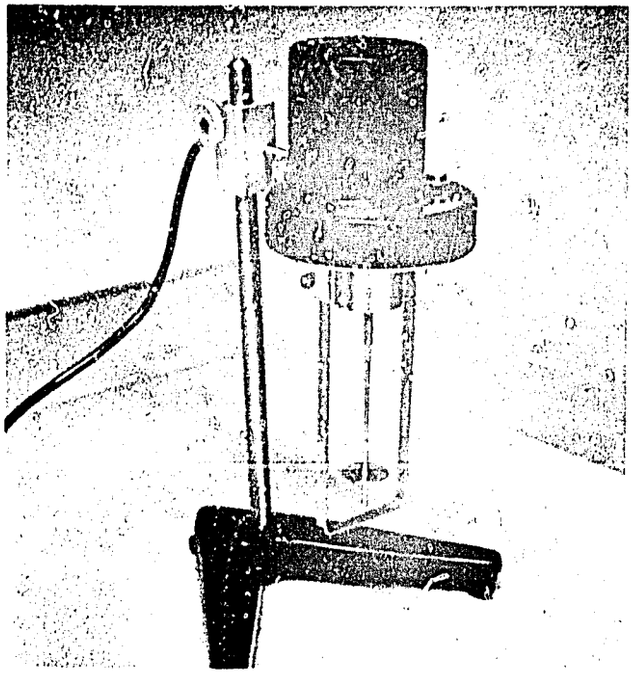

Figure 2. Brookfield viscosimeter.

The viscosity of the uncooked material was determined by placing 100 ml of water at 25°C in a 150 ml beaker, adding 37 grams of the test sample while stirring vigorously with a spatula. Gentle stirring was continued for 3 minutes to smooth any lumps that may have formed. Brookfield viscosity then was measured as mentioned above.

The viscosity of the cooked material was determined by adding 23 grams of the test sample to 175 ml of boiling water in a 250 ml beaker, stirring vigorously with a fork. Boiling was continued for 2 minutes. The cooked slurry was removed from the hot plate and held in a 30°C water bath for 10 minutes. The beaker was placed on a scale, and water was added to a total slurry weight of 200 grams to compensate for water loss due to evaporation. The slurry was then held at 30°C for 1 hour before making viscosity measurements.

All uncooked viscosities were higher than the control commercial sample. This was believed to be caused by the fact that the corn in the commercial sample is extruded under rather low temperature conditions and is not fully gelatinized. To extrude samples on the Brady with the same low uncooked viscosity, the extrusion temperature would have to be decreased and the amount of water increased.

RESULTS AND DISCUSSION

Results of the proximate analyses of the extruded samples are shown in Tables IIA and IIB. Values for ash, fat and protein are expressed on a dry basis, which was arbitrarily selected. The CSB specifications indicate a maximum moisture content of 10% and minimum requirements of 16.7% and 6.0% for protein and fat, respectively, but do not state the moisture basis for these requirements. Of the samples which were cooked together, all but the whole soybean-corn grits samples cooked at 338°F, met the specifications as seen in Table IIA. We believe that a blending problem with the Brady cooker was responsible for the lower value, since the same blend cooked at 308°F met the specification. The fat values of some of the blends are just slightly below the 6% level specified. The ash values for the blends are essentially identical. It has to be realized that these relatively high values are due to the addition of the mineral mix after extrusion.

Table IIA. Proximate Analyses of Samples--Products Cooked Together

Ingredients	Cooking temp. (°F)	Moisture (%)	Ash[1] (%)	Fat[1] (%)	N (%)	Protein[1] (%)
Dehulled soybeans and whole corn	340	5.2	4.4	5.1	2.97	17.6
Dehulled soybeans and whole corn	310	5.7	4.3	5.6	2.93	17.5
Whole corn	340	5.5	3.9	2.2	1.45	9.6
Whole corn	312	6.9	4.0	2.2	1.38	9.2
Whole soybeans and corn grits	308	4.9	4.3	6.0	2.69	17.7
Whole soybeans and corn grits	338	5.6	4.3	5.1	2.38	15.8
Dehulled soybeans and corn grits	307	4.9	4.3	6.1	2.59	17.0
Dehulled soybeans and corn grits	340	5.1	4.3	5.8	2.60	17.1
Corn grits	345	4.4	3.0	0.2	1.38	9.0

[1]On a moisture free basis; Protein = N x 6.25

Table IIB. Proximate Analyses of Samples--Products Cooked Separately and Commercial Samples

Ingredients	Cooking temp. (°F)	Moisture (%)	Ash[1] (%)	Fat[1] (%)	N (%)	Protuin[1] (%)
Dehulled soybeans and whole corn	280/340	5.5	5.0	7.7	2.60	17.2
Dehulled soybeans and whole corn	280/312	6.2	5.1	7.7	2.66	17.8
Whole soybeans and corn grits	280/345	4.8	4.4	5.9	2.59	17.0
Whole soybeans and corn grits	280/345	4.5	4.4	5.9	2.70	17.7
Bolivia (commercial sample)		4.6	5.0	7.4	3.00	19.7
CSB (commercial sample)		8.9	4.2	8.8	2.64	18.1

[1]On a moisture free basis; Protein = N x 6.25

Proximate analyses of blends for which the soybeans and corn were cooked separately are shown in Table IIB. All blends met the protein specifications. The fat values are just slightly below the specified amounts of 6.0 when corn grits were used instead of whole corn.

The commercial samples, Bolivian and CSB, were slightly higher than the experimental blends in protein. CSB was higher in fat than any other sample analyzed.

The particle sizes of the blends are given in Table III. The CSB specifications state that a minimum of 99% should pass through a U.S. #6 screen. All blends meet this specification. There are, however,

Table III. Mesh Sizes and Brookfield Viscosities of Samples

Ingredients	Cooking temp. (°F)	Mesh Size (% of sample) on #10	on #30	on #60	through #60	Brookfield Viscosities Cooked (CPS)	Uncooked (CPS)
Dehulled soybeans and whole corn	340	0.1	78.1	21.0	0.2	1370	95600
Dehulled soybeans and whole corn	310	0.0	91.1	8.0	0.5	2767	64600
Whole corn	340	0.2	17.3	59.1	22.5	360	64730
Whole corn	312	0.2	16.0	62.1	20.9	790	83330
Whole soybeans and corn grits	308	0.8	71.6	26.9	0.5	2670	17530
Whole soybeans and corn grits	338	0.2	84.9	13.9	0.5	1435	53330
Dehulled soybeans and corn grits	307	0.3	89.9	8.5	0.7	2960	12330
Dehulled soybeans and corn grits	340	0.3	87.6	10.8	0.7	2140	35400
Corn grits	345	0.0	6.3	41.7	51.2	625	90000
Dehulled soybeans and whole corn	280/340	0.0	70.8	28.4	0.3	155	32800
Dehulled soybeans and whole corn	280/312	0.0	74.2	23.9	1.8	230	34800
Whole soybeans and corn grits	280/345	0.0	34.8	51.4	13.3	155	59600
Dehulled soybeans and corn grits	280/345	0.2	29.4	59.2	10.8	150	45400
Bolivia (commercial sample)	-355	0.2	89.4	9.8	0.1	960	136260
CSB - control		0.3	85.5	13.7	9.8	2145	1000

differences in mesh size as seen in the table. Average particle size appears to be smaller when the soybeans and the corn were cooked separately. When a CSB process is specified, the method of grinding must correspond with processing conditions to assure the correct particle size.

Examination of the product viscosities indicated that samples extruded at lower temperatures had a higher cooked product viscosity. Higher extrusion temperatures may cause breakdown of the starch which results in the lower viscosity. Samples where the corn and the soy were extruded separately and combined in the correct proportion had much lower cooked product viscosities. Based on these data, a CSB product should be extruded with the raw corn and soy blended together prior to extrusion.

The uncooked viscosities of the extruded product with the Brady varied extensively from sample to sample. The resulting viscosity appears to be a function of extrusion temperature, particle size and sample manufacturing process. Samples extruded at higher temperatures tended to have higher uncooked viscosities. In these cases, the product was expanded to a greater extent allowing it to hydrate quickly and produce a high viscosity. Extrusion of raw ingredients separately results in products with moderately high viscosities. The higher the temperature of extrusion on the corn, the higher the viscosity.

Physical, Chemical and Sensory Evaluation of Extruded Products

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TOTAL PLATE COUNT

Standard methods were employed to analyze the extruded and/or blended products along with the commercial domestic and Bolivian samples. As seen in Table I, all products were below the maximum level of 50,000 colonies per gram. All CSU samples, except number 12, had counts lower than 500 per gram and thus would indicate that raw product quality and extrusion and/or blending conditions present no microbiological problem.

Table I. Product Total Plate Count

	Product	Processing Temp. (°C)	Processed Separately	Processed Together	Colonies/ gram
1.	Krause CSB	-	-	-	10,100
2.	Whole corn	155	+		330
3.	Whole corn	171	+		380
4.	Corn grits	171	+		51
5.	Dehulled soy	137	+		325
6.	Whole soy	137	+		145
7.	Whole corn/dehulled soy	155		+	255
8.	Whole corn/dehulled soy	155/137	+		250
9.	Whole corn/dehulled soy	171		+	225
10.	Whole corn/dehulled soy	171/137	+		85
11.	Corn grits/dehulled soy	155		+	300
12.	Corn grits/dehulled soy	171		+	16,700
13.	Corn grits/dehulled soy	171/137	+		63
14.	Corn grits/whole soy	155		+	70
15.	Corn grits/whole soy	171		+	405
16.	Corn grits/whole soy	171/137	+		330
17.	Bolivian CSB	-	-	-	1,155

DENSITY

The density of all products was taken by recording and averaging the weight of 100 cc of each product for three replicates (Fig. 1). These averages are summarized in Table II and, as can be seen, significant differences do exist. None of the products had significantly higher densities than the domestic commercial control. However, certain products had significantly lower densities. It should be noted that increasing processing temperature from 155 to 171 degrees resulted in smaller density changes as compared to sample 1. Also, processing the grain and legume together produced a smaller density change than processing the same products separately. Thus it would appear that various CSU products (7, 8, 9, 11, 12, 14, and 15) had densities similar to the domestic commercial sample and therefore should present no packaging problem on a weight-to-volume basis.

Figure 1. Density samples being weighed.

Table II. Processed Product Densities

	Product	Processing Temp. (°C)	Processed Separately	Processed Together	Density (g/cc)	% Change From Sample 1
1.	Krause CSB	-	-	-	0.516	-
2.	Whole corn	155	+		0.406	-21.4
3.	Whole corn	171	+		0.318	-33.4
4.	Corn grits	171	+		0.196	-62.0
5.	Dehulled soy	137	+		0.514	- 0.4
6.	Whole soy	137	+		0.507	- 2.8
7.	Whole corn/dehulled soy	155		+	0.532	+ 3.1
8.	Whole corn/dehulled soy	155/137	+		0.454	-27.0
9.	Whole corn/dehulled soy	171		+	0.524	+ 1.5
10.	Whole corn/dehulled soy	171/137	+		0.364	-29.5
11.	Corn grits/dehulled soy	155		+	0.548	+ 6.2
12.	Corn grits/dehulled soy	171		+	0.547	+ 6.0
13.	Corn grits/dehulled soy	171/137	+		0.232	-55.1
14.	Corn grits/whole soy	155		+	0.547	+ 6.0
15.	Corn grits/whole soy	171		+	0.528	+ 2.3
16.	Corn grits/whole soy	171/137	+		0.214	-58.6
17.	Bolivian CSB	-	-	-	0.414	-19.8

UREASE ACTIVITY

Specifications for urease activity as determined by increase in pH, as measured in AACC method 22-90, for defatted soy flour is 0.05 to 0.15 units, while for full-fat soy flour the range is 0.05-0.50 pH units. As a matter of record, urease activity measurements were performed on all samples even though most of them contained only 30% soy. As seen in Table III, the soy product (5 and 6) were both within range. It should also be noted that apparently corn can also contribute to urease activity.

Table III. Product Urease Activity

Product	Processing Temp. (°C)	Separately	Together	Increase in pH
1. Krause CSB	-	-	-	0.09
2. Whole corn	155	+		0.05
3. Whole corn	171	+		0.02
4. Corn grits	171	+		0.03
5. Dehulled soy	137	+		0.11
6. Whole soy	137	+		0.11
7. Whole corn/dehulled soy	155		+	0.06
8. Whole corn/dehulled soy	155/137	+		0.09
9. Whole corn/dehulled soy	171		+	0.03
10. Whole corn/dehulled soy	171/137	+		0.05
11. Corn grits/dehulled soy	155		+	0.04
12. Corn grits/dehulled soy	171		+	0.03
13. Corn grits/dehulled soy	171/137	+		0.02
14. Corn grits/whole soy	155		+	0.07
15. Corn grits/whole soy	171		+	0.02
16. Corn grits/whole soy	171/137	+		0.06
17. Bolivian CSB	-	-	-	0.05

WATER ABSORPTION

An indirect measurement of product functionality in a food system can be obtained by measuring the amount of water a product will absorb with higher levels indicating a greater degree of functionality. The specific procedure involves dissolving 5 grams of powder in 40.00 ml of water, followed by centrifugation and measurement of the amount of free water remaining. As seen in Table IV, the domestic commercial sample has the lowest rate at 15.6% while corn grits had the highest level. Also, it is apparent that products processed at 171 degrees absorbed more water than those processed at 155 degrees, and that whole soybeans had higher values than dehulled soybeans. Lastly, blending separately absorbed more water than the corresponding products processed together. Thus it is apparent that all CSU products should exhibit more functionality in food systems than the current domestic commercial sample. If it is necessary to produce an exact duplicate of commercial CSB, these data indicate that a lower temperature extrusion for the corn would be directionally correct. Further tests need to be run to determine the precise condition.

Table IV. Percent Water Absorption

Product	Processing Temp. (°C)	Processed Separately	Processed Together	% Water Absorption
1. Krause CSB	-	-	-	15.6
2. Whole corn	155	+		33.8
3. Whole corn	171	+		36.0
4. Corn grits	171	+		56.0
5. Dehulled soy	137	+		24.8
6. Whole soy	137	+		25.4
7. Whole corn/dehulled soy	155		+	23.2
8. Whole corn/dehulled soy	155/137	+		27.8
9. Whole corn/dehulled soy	171		+	27.2
10. Whole corn/dehulled soy	171/137	+		31.6
11. Corn grits/dehulled soy	155		+	26.0
12. Corn grits/dehulled soy	171		+	28.2
13. Corn grits/dehulled soy	171/137	+		38.0
14. Corn grits/whole soy	155		+	26.4
15. Corn grits/whole soy	171		+	29.8
16. Corn grits/whole soy	171/137	+		39.0
17. Bolivian CSB	-	-	-	34.6

COLOR DIFFERENCES - PROCESSED PRODUCTS

Samples of each flour were evaluated for color properties using a Hunter Lab Model D25D2 Color Difference Meter. These data are summarized in Table V in the forms of L (total lightness), A (+ = red, - = green), B (+ = yellow, - = blue), and ΔE (total color difference). The closest blend in color to the domestic commercial sample was product 11. As expected, the lower the processing temperature, the lighter the color. Likewise, corn grits gave lighter-colored products than whole corn, while dehulled soy resulted in lighter-colored products than whole soy. Also, a lighter color resulted when the blends were processed together, as compared to physical blending after processing. Thus it is apparent that blends can be extruder-processed that have comparable color properties to the current commercial product.

Table V. Color Differences Among Processed Products

Product	Processing Temp. (°C)	Processed Separately	Processed Together	Color Properties[1] L	A	B	ΔE
1. Krause CSB	-	-	-	70.9	+1.0	+26.4	-
2. Whole corn	155	+		71.1	-0.1	+27.5	1.55
3. Whole corn	171	+		71.4	-0.6	+29.0	2.17
4. Corn grits	171	+		75.8	-1.3	+27.3	2.85
5. Dehulled soy	137	+		58.9	+1.5	+23.6	4.15
6. Whole soy	137	+		55.9	+1.3	+23.1	4.29
7. Whole corn/dehulled soy	155		+	68.1	-0.6	+27.4	2.32
8. Whole corn/dehulled soy	155/137	+		67.8	-0.6	+25.6	2.35
9. Whole corn/dehulled soy	171		+	66.2	-0.4	+26.3	2.49
10. Whole corn/dehulled soy	171/137	+		64.9	-1.2	+23.0	3.41
11. Corn grits/dehulled soy	155		+	71.3	+0.1	+27.7	1.61
12. Corn grits/dehulled soy	171		+	71.4	-0.4	+28.4	1.97
13. Corn grits/dehulled soy	171/137	+		73.2	-1.5	+25.7	2.35
14. Corn grits/whole soy	155		+	71.7	-1.8	+26.8	2.00
15. Corn grits/whole soy	171		+	68.8	+0.0	+.9.2	2.41
16. Corn grits/whole soy	171/137	+		67.5	-0.6	+29.6	2.49
17. Bolivian CSB	-	-	-	68.6	-0.6	+23.2	2.66

[1]Yellow standard No. C2 - 3865: L 78.2, A -2.4, B +21.9

COLOR DIFFERENCES - GRUELS

As a matter of interest, the same color measurements as described above were performed on 11.75% gruels from each product and, as seen in Table VI, there was a darkening of most products in the gruel form as compared to the flours. Also, none of the CSU products was as yellow (B value) as the control. Perhaps this could be explained on the basis of raw material differences. This color difference was not perceived as critical in the manufacturing of CSB.

Table VI. Color Differences Among Product Gruels

Product	Processing Temp. (°C)	Processed Separately	Processed Together	Color Properties L	A	B	ΔE
1. Krause CSB	-	-	-	69.9	-2.1	+32.6	-
2. Whole corn	155	+		67.7	-3.4	+27.9	4.18
3. Whole corn	171	+		67.8	-4.0	+28.1	4.27
4. Corn grits	171	+		71.0	-4.5	+28.7	4.01
5. Dehulled soy	137	+		61.0	+0.3	+26.1	4.91
6. Whole soy	137	+		56.6	+1.5	+23.9	4.18
7. Whole corn/dehulled soy	155		+	66.7	-2.9	+30.0	4.48
8. Whole corn/dehulled soy	155/137	+		65.1	-3.0	+24.8	4.10
9. Whole corn/dehulled soy	171		+	66.3	-2.6	+25.9	4.01
10. Whole corn/dehulled soy	171/137	+		65.3	-2.8	+28.2	4.46
11. Corn grits/dehulled soy	155		+	69.7	-4.9	+30.9	4.48
12. Corn grits/dehulled soy	171		+	69.2	-5.0	+30.6	4.50
13. Corn grits/dehulled soy	171/137	+		70.0	-3.7	+25.5	3.61
14. Corn grits/whole soy	155		+	69.1	-4.9	+30.5	4.49
15. Corn grits/whole soy	171		+	68.3	-4.0	+30.3	4.48
16. Corn grits/whole soy	171/137	+		69.2	-3.5	+25.8	3.74
17. Bolivian CSB	-	-	-	62.4	+0.1	+22.9	4.45

Table VII. Product Nitrogen Solubility Indexes

Product	Processing Temp. (°C)	Processed Separately	Processed Together	NSI
1. Krause CSB	-	-		14.35
2. Whole corn	155	+		7.03
3. Whole corn	171	+		5.54
4. Corn grits	171	+		[illegible].30
5. Dehulled soy	137	+		9.17
6. Whole soy	137	+		9.13
7. Whole corn/dehulled soy	155		+	8.63
8. Whole corn/dehulled soy	155/137	+		7.44
9. Whole corn/dehulled soy	171		+	8.13
10. Whole corn/dehulled soy	171/137	+		7.46
11. Corn grits/dehulled soy	155		+	5.73
12. --				
13. Corn grits/dehulled soy	171/137	+		7.33
14. Corn grits/whole soy	155		+	6.15
15. Corn grits/whole soy	171		+	5.70
16. Corn grits/whole soy	171/137	+		6.98
17. Bolivian CSB	-	-	-	2.66

NITROGEN SOLUBILITY INDEX (NSI)

NSI has been correlated to protein functionality and, in general, the higher the NSI, the more native the protein. Specifications call for defatted soy flour to have an NSI ranging from 10-30%, whereas the range for full-fat soy flour is 10-40%. As a matter of record, NSI tests were performed on samples as outlined in the AACC method 46-23 (Fig. 2). As seen in Table VII, the commercial CSB had the highest NSI value, while the Bolivian CSB had the lowest. Dehulled and whole soy processed at CSU were at the low ends of the suggested NSI ranges described above, thus suggesting that from the NSI standpoint, a lower processing temperature may be appropriate. The influence of processing temperature on NSI can be seen by comparing samples 2 vs. 3 and 7 vs. 9, where the higher temperatures resulted in a decrease in NSI.

Although the NSI values for the CSU samples appear to be low, it should be noted that these samples were essentially "cooked" during extrusion, whereas the commercial CSB was not.

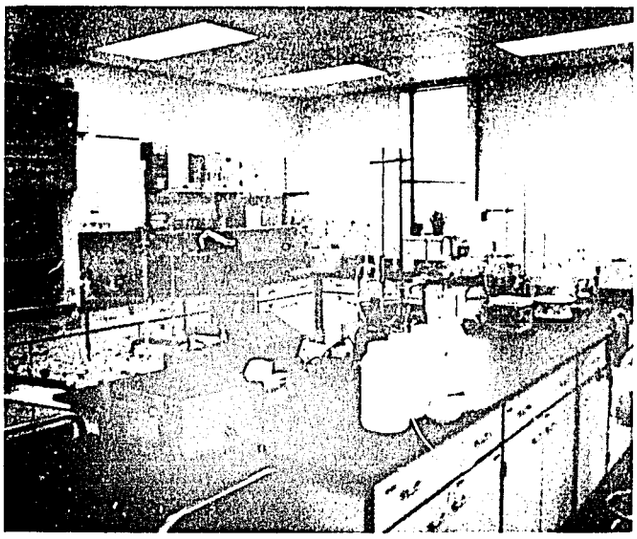

Figure 2. Food science laboratory used in sample analyses.

FLAVOR PROPERTIES - STORAGE

The sensory properties of representative samples were evaluated using the flavor profile analysis technique, whereby a highly trained four-member panel is used to describe and quantitate the aroma, flavor, and aftertaste associated with a product. An 11.75% gruel, prepared as described in the current CSB specifications, was used for all sensory evaluations. The flavor profile analysis data for five samples are summarized in Table VIII. As can be seen, most products had similar profiles with only order of detection varying. Processing the grain and legume together gave a product with a more pleasing profile than blending after processing. Also, a starch note appeared in the flavor of the CSU samples, probably due to the cooking during extrusion. In addition, the flavor notes in commercial CSB were all at threshold levels, whereas with CSU samples these notes had increased to a slight level thus resulting in a more flavorful product.

After processing, representative samples weighing approximately 0.5 kilogram were placed in the following storage conditions: (1) -18°C in 30 mil polyethylene bags, (2) 23°C in either 30 mil polyethylene or Kraft flour bags at 20% relative humidity (RH), and (3) 27°C in 30 mil polyethylene or Kraft flour bags at 80% RH. Flavor profile analysis data were obtained as described above after one month of storage under each condition. Their sensory properties will again be evaluated after a total of six months of storage has elapsed.

Changes that had occurred after one month of storage are summarized in Table IX. As seen, minor changes occurred at 27° and 80% RH for most products, with the most common change being a decrease in the sweet flavor note. Also, more changes occurred with products stored in flour bags as compared to polyethylene.

Table VIII. Initial Flavor Profile Analysis Data on Selected Sample Gruels

Krause CSB	Whole corn/ dehulled soy (155°)	Whole corn/ dehulled soy (155°/137°)	Corn grits/ whole soy (155°)	Bolivian CSB
Aroma: 2 1 Sour)(Green)(Corn	Aroma: 1 1 Corn	Aroma: 2 1 Corn 1 Green)(Starch	Aroma: 1)(Sour 1 Green 1 Corn	Aroma: 1 1 Corn)(Green
Flavor: 1)(Sweet)(Corn)(Green)(Bitter	Flavor: 1 1 Sweet)(Corn 1 Starch)(Green)(Bitter)(Astringent	Flavor: 1 1 Starch)(Corn 1 Sweet)(Green)(Bitter)(Astringent	Flavor: 1 1 Sweet)(Corn 1 Starch)(Bitter	Flavor: 1 1 Starch)(Sweet 1 Corn)(Green)(Astringent)(Bitter
Aftertaste:)(Bitter)(Astringent	Aftertaste:)(Astringent)(Bitter	Aftertaste: 1 Bitter 1 Astringent	Aftertaste:)(Astringent	Aftertaste:)(Astringent)(Bitter

)(: Detected at threshold level
1: Slight
2: Moderate

Table IX. Summary of Major Sensory Differences as Influenced by Storage Time and Conditions (based on data from Table VIII)

Product/Storage Condition	Change
Krause CSB:	
1. -18°	None
2. 23°/20% RH polyethylene	None
23°/20% RH flour bag	None
3. 27°/80% RH polyethylene	Loss of sweet note in flavor
27°/80% RH flour bag	Sour aroma note increased to 2, loss of sweet note in flavor
Whole corn/dehulled soy (155°):	
1. -18°	None
2. 23°/20% RH polyethylene	None
23°/20% RH flour bag	None
3. 27°/80% RH polyethylene	Threshold green aroma note appeared
27°/80% RH flour bag	Threshold green aroma note appeared, sweet flavor note decreased to threshold
Whole corn/dehulled soy (155°/137°):	
1. -18°	None
2. 23°/20% RH polyethylene	None
23°/20% RH flour bag	None
3. 27°/80% RH polyethylene	None
27°/80% RH flour bag	Sweet flavor note decreased to threshold
Corn grits/whole soy (155°):	
1. -18°	None
2. 23°/20% RH polyethylene	None
23°/20% RH flour bag	None
3. 27°/80% RH polyethylene	Sweet flavor note decreased to threshold
27°/80% RH flour bag	Corn aroma note decreased to threshold, sweet flavor note decreased to threshold
Bolivian CSB:	
1. -18°	None
2. 23°/20% RH polyethylene	None
23°/20% RH flour bag	None
3. 27°/80% RH polyethylene	None
27°/80% RH flour bag	Sweet flavor note lost

Nutritional Evaluation of Extruded Products

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RATIONALE OF LEC PROGRAM

A good place to start a discussion of the nutritional evaluation of extruded products would be to restate the rationale for a low-cost extrusion cooker (LEC) program. Simply stated, it is to provide low-cost nutritious food using relatively simple technology utilizing indigenous food crops, and to introduce the resulting foods into a child or maternal feeding program with the intent of achieving a nutritional impact. The nutritional impact hoped for includes reducing the mortality and morbility, and increasing the growth and well-being of children, especially those in the preschool years.

The potential payoff of feeding programs is a nutritional one and therefore, nutritional evaluation becomes a key factor against which the costs of various programs are being judged. It goes without saying that the products must be well-accepted by the target group to achieve any kind of nutritional impact. This paper will, however, deal only with strictly nutritional aspects. Nutrition is involved at three levels in LEC programs as follow: (1) nutritional specification of products, (2) nutritional evaluation of products, and (3) nutritional evaluation of feeding programs.

ISSUES IN PROTEIN AND ENERGY NUTRITION

Before discussing the nutritional specifications of extruded products, there are several issues dealing with protein and energy nutrition that should be considered.

Protein Quality-Quantity Relationships

This topic has been considered in more detail previously by Jansen (1974). Protein quality times the protein quantity determines the net protein value of a diet. In other words, it is possible to compensate for poor quality by increasing the amount consumed, within certain limits, and vice versa. Protein quality refers to the attributes of a protein that determine how efficiently it is utilized for growth and maintenance. The two most important attributes are: (1) the amino acid composition, especially the amount of the amino acid most deficient compared to a reference standard, i.e., the limiting amino acid; and (2) the digestibility of the protein. The difficulty in evaluation results from the fact that the amino acid pattern required for growth differs from that required for body maintenance. Briefly, essential amino acid needs are higher for growth than maintenance. The difference is especially striking for lysine which is the amino acid most limiting in cereal diets. The lysine need for growth is high because of the high lysine content of new protein synthesized, whereas the lysine need for maintenance is much lower because of a considerable conservation of body lysine in the adult. There is at present no better method for protein quality evaluation than the growth of the weanling rat (Fig. 1). In extrapolating rat growth data there are several important points to be kept in mind. The human infant grows at a slower rate than does the rat and consequently can grow very well on proteins containing a lower percentage of total essential amino acids. The human doesn't synthesize as much body hair as the rat and consequently needs less methionine. Finally, the rat practices coprophagy and consequently digestibility is less of a problem in the rat than it is in human infants and young children. In Table 1, the amino acid requirements for infants, children and adults, as estimated by the FAO/WHO Expert Committee (1973), are compared with their suggested provisional amino acid pattern.

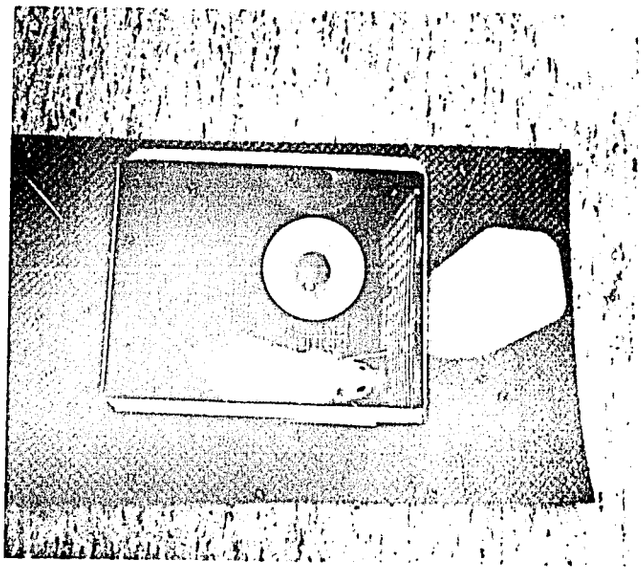

Figure 1. Rat in feeding chamber.

Table 1. FAO/WHO Amino Acid Patterns[1] (mg/g of protein)

Amino acid	Infant	10-12 years old	Adult	Provisional scoring pattern
Histidine	14	--	--	--
Isoleucine	35	37	18	40
Leucine	80	56	25	70
Lysine	52	75	22	55
Methionine + cystine	29	34	24	35
Phenylalanine + tyrosine	63	34	25	60
Threonine	44	44	13	40
Tryptophan	8.5	4.6	6.5	10
Valine	47	41	18	50

[1]Energy and Protein Requirements. World Health Organization Technical Report Series 1973, No. 522, Geneva, 1973.

Protein-Energy Relationships

An important nutritional issue that impinges on defining the specifications for a weaning food is the current controversy about protein-energy relationships. The establishment of the Protein Advisory Group (PAG) of the United Nations was based on the supposition that protein was the dietary constituent available in the least adequate amounts. The development of many high-protein weaning foods over the last 40 years was based in part on this supposition. Recently this supposition has been severely questioned. Harper et al. (1972) suggested that protein deficiency is not likely to be the prime cause of malnutrition even where cereals are the staple foods. Gopalan et al. (1973) have also shared this view, and McLaren (1975) has referred to the efforts at protein improvement that have been carried out over the past 20 years as "The Great Protein Fiasco."

There is no doubt in my mind that McLaren has overstated the case. As has been reviewed (Jansen and Verburg, 1976), there are many studies reported in the literature where protein of higher quality was used more efficiently even when food intake was restricted. We have carried out several experiments in this regard. In the first (Jansen and Verburg, 1976), weanling rats were fed diets of white bread, bread plus lysine, or bread plus lysine plus threonine at food intakes ranging from 55 to 100% of [illegible], with weight gain and net protein ratio (NPR) plotted as a function of food intake. The results, shown in Figures 2 and 3, indicate very clearly that improvement of protein quality increases growth and nitrogen utilization even when food is restricted.

In the second experiment (Jansen and Monte, 1976) pregnant rats were fed from conception until weaning diets of bread, bread plus lysine, or bread plus lysine and threonine at three energy levels. At weaning the offsprings were killed and their brains analyzed for DNA and protein. The results summarized in Table II demonstrate that protein quality improvement of the maternal diet clearly enhanced brain development of the offspring even when food intake was inadequate.

A reasonable assessment of the present situation would be as follows: deficiency of total food supply is clearly the most crucial nutritional problem in less developed countries today. Cereals combined with small amounts of legumes can meet the protein needs of most individuals. However, such diets are very marginal and leave little--if any--margin of safety. It is unlikely that they meet the nutritional needs of all vulnerable groups. It seems likely that protein improvement of such diets would be of nutritional advantage. It also seems likely that protein improvement programs are of value even when total food consumption is somewhat below need. It is obvious that the greater the deficit of food intake, the less value protein improvement will have.

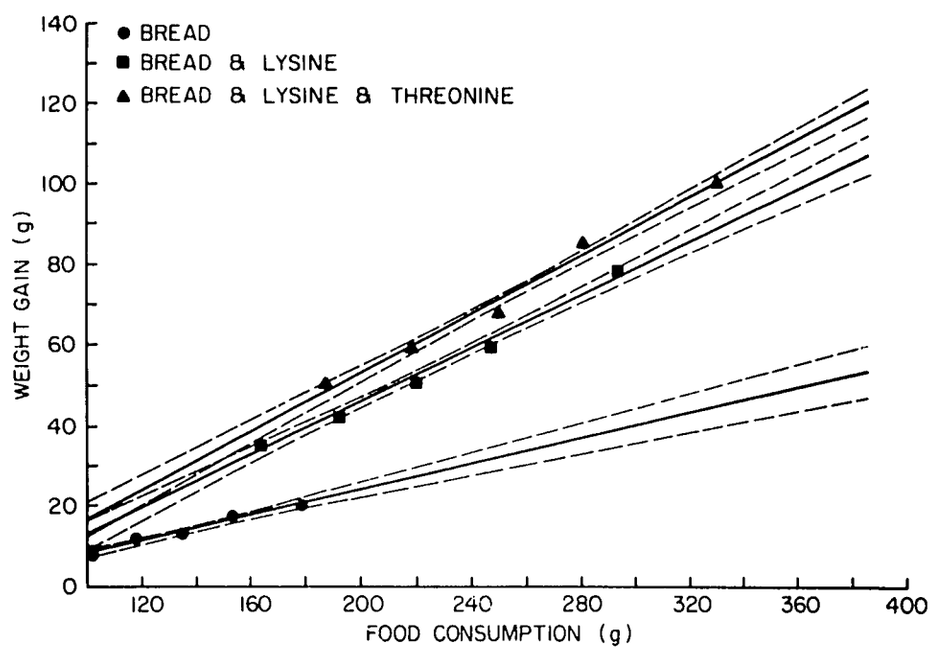

Figure 2. Weight gain vs. food consumed as affected by protein quality (experiment 2). The regression line with 95% confidence intervals for each diet are shown (n = 40).

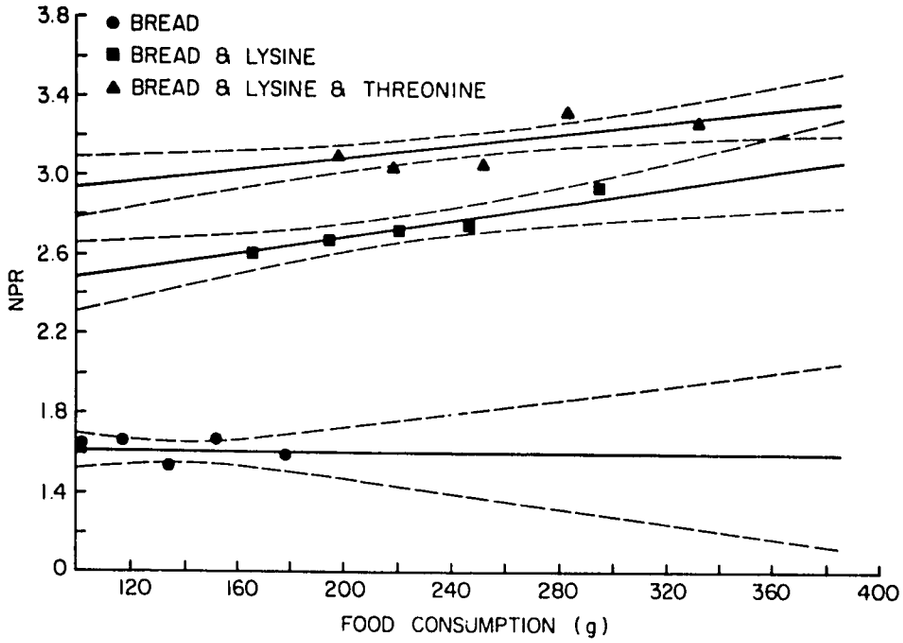

Figure 3. NPR vs. food consumed as affected by protein quality (experiment 2). The regression lines with 95% confidence intervals are shown (n = 40).

Table II. Amino Acid Fortification of Bread Fed to Pregnant or Lactating Rats at Different Energy Levels[1]

Group	1	2	3	4	5
Diet	Bread	Bread + Lysine	Bread + Lysine	Bread + Lysine + Threonine	Bread + Lysine + Threonine
Level of Feeding[2]	100%	100%	70%	100%	70%
Food consumption-pregnancy (g/day)	16.8 ± 1.3[3]	20.4 ± 0.5	14.5 ± 0.5	19.9 ± 0.5	14.6 ± 0.8
Food consumption-lactation (g/day)	31.4 ± 1.4	36.5 ± 1.7	26.3 ± 0.9	38.5 ± 0.9	27.2 ± 0.1
Weaning weight (g)	16.8 ± 0.4	26.4 ± 0.2	21.4 ± 0.2	38.8 ± 0.4	28.8 ± 0.3
Brain weight (g)	1.235 ± 0.010	1.322 ± 0.008	1.256 ± 0.007	1.491 ± 0.008	1.344 ± 0.012
Cerebellum weight (g)	0.148 ± 0.003	0.155 ± 0.001	0.154 ± 0.001	0.177 ± 0.001	0.159 ± 0.001
Cerebrum weight (g)	0.847 ± 0.012	0.894 ± 0.008	0.843 ± 0.007	0.966 ± 0.010	0.882 ± 0.008
Brainstem weight (g)	0.202 ± 0.004	0.208 ± 0.004	0.218 ± 0.005	0.235 ± 0.002	0.213 ± 0.002
Cerebellum protein (mg)	11.90 ± 0.20	14.38 ± 0.13	12.70 ± 0.10	16.34 ± 0.10	14.26 ± 0.08
Cerebrum protein (mg)	71.16 ± 0.99	78.13 ± 0.72	70.31 ± 0.56	81.12 ± 0.86	77.14 ± 0.70
Brainstem protein (mg)	16.23 ± 0.33	19.20 ± 0.36	17.28 ± 0.39	19.49 ± 0.13	18.22 ± 0.14
Cerebellum DNA (mg)	1.023 ± 0.019	1.136 ± 0.012	1.080 ± 0.009	1.467 ± 0.010	1.144 ± 0.007
Cerebrum DNA (mg)	0.922 ± 0.016	0.975 ± 0.010	0.927 ± 0.012	1.088 ± 0.014	0.973 ± 0.013
Brainstem DNA (mg)	0.231 ± 0.005	0.264 ± 0.005	0.247 ± 0.006	0.281 ± 0.002	0.258 ± 0.002

[1]Data from Jansen, G. R. and Monte, W. C. 1976. Amino acid fortification of bread fed at varying energy levels during gestation and lactation. (Submitted for publication)

[2]Percentage of *ad libitum* consumption.

[3]Mean + standard error.

Protein Improvement of Cereal Diets

The improvement of net protein value resulting from addition of legumes to cereal diets is well known and has been summarized elsewhere (Jansen, 1972). Since most plant protein mixtures used in child-feeding programs are cereal-legume mixtures, it is appropriate to look at least briefly at the changes in net protein value that result from the addition of soy to a variety of cereals. As shown in Table III, addition of more than 16 parts by weight of soy flour (50% protein) to any of the cereals listed is not likely to provide much advantage in protein quality improvement, but it does increase net protein value because of the additional protein added. If it were economically advantageous to reduce the amount of soy in the mixture, this would likely be acceptable nutritionally if the product were to be used in a community where cereals were the dietary staples.

Table III. Supplementation of Cereals with Graded Levels of Soy Flour Containing 46% Protein (N x 5.70)

Cereal	Parts soy 100 parts cereal	Soy protein (% of total)	Chemical score	Protein value	Limiting amino acid
Ragi millet	0	0	39	2.9	Lysine
	8	33	59	6.1	Lysine
	16	50	70	8.9	Lysine
	32	67	76	12.7	Methionine
White wheat flour	0	0	45	4.1	Lysine
	8	28	68	8.1	Lysine
	16	45	78	11.2	Lysine
	32	62	79	14.3	Methionine
Bulgur	0	0	62	6.9	Lysine
	8	25	76	10.5	Lysine
	16	40	84	13.5	Lysine + methionine
	32	57	78	15.3	Methionine
Corn	0	0	49	4.7	Lysine
	8	28	67	8.2	Lysine
	16	43	71	10.3	Methionine
	32	61	69	12.6	Methionine
Sorghum	0	0	38	3.8	Lysine
	8	27	50	7.5	Lysine
	16	42	66	10.0	Methionine
	32	59	66	12.4	Methionine
Rice	0	0	69	4.7	Lysine
	8	36	77	7.4	Methionine
	16	52	74	8.9	Methionine
	32	69	71	11.5	Methionine

NUTRITIONAL SPECIFICATIONS OF PRODUCTS

Specifications have been established for all Title II blended foods currently used in feeding programs, including CSB, CSM, WSB, and WSDM. Basically these specifications involve setting minimums for protein and fat, a maximum for fiber, and specifying the composition of the vitamin and mineral mix that should be added. Since the blended foods that are being made or will be made on low-cost extrusion cookers are intended to be used in a similar manner as these Title II foods, it would seem appropriate to use these same specifications in the absence of strong reasons to change. It is therefore not our intention to establish new specifications for blended foods, but rather to review the nutritional issues involved in the light of current knowledge.

Proximate Analysis and Calorie Density

The proximate analyses of Title II commodities are listed in Table IV. The percentage of calories supplied by protein and fat is also compared to the corresponding values of breast milk.

Table IV. Proximate Analyses of Title II Foods[1] (grams/100 grams)

Commodity	Kcal	Protein	Fat	Carbo	% Calories from Protein	% Calories from Fat
CSM	373	19.0	6.0	62.0	20.4	14.5
CSB	374	16.7	6.0	63.0	17.9	14.4
WSB	360	20.0	6.0	60.0	22.2	15.0
WSDM	435	20.0	20.0	50.0	18.4	41.4
Breast milk					6.0	54.0

[1] Maximum fiber levels allowed: WSB 2.5%; CSB 2.0%; CSM 2.0%; WSDB 1.5%

Major nutritional issues involved are the calorie density of the food and the protein-energy ratio. Since protein and carbohydrate each yields 4 kilocalories per gram, compared to values of 9 and 0 for fat and fiber, respectively, it is apparent that variations in the latter two constituents are major determinants of calorie density. In most LDC's the weaning process involves a change from a high-fat, high-calorie food to a low-fat, low-calorie food. Although there are no data available on satisfactory feeding of infants with diets where fat supplied less than 30% of calories, for post-weaning children the relatively low fat level in most Title II foods would not appear to be a serious limitation, since such a fat level is likely to be closely similar to the indigenous diet. It would appear to be desirable, however, to raise the fat level and hence calorie density of a blended food if this can be accomplished within the economic constraints and in a way that would enhance acceptability.

Protein-Energy Ratio

The desirable protein-energy ratio will clearly depend on the quality of the protein and its digestibility. Extrapolation from rat growth studies (Fig. 4) is very helpful, but digestibility can be quite different in a human infant than in a weanling rat. Therefore, as will be discussed below, studies in human infants are needed when major changes in processing or ingredients are made. Considering the higher protein needs of infants, the Committee on Nutrition of the American Academy of Pediatrics (1976) recommends that an infant formula should supply 1.8 grams of protein with a PER equal to that of casein per 100 kcal. With a PER equal to 75% of that of casein, the recommendation is to adjust the protein level upward to 2.4 grams per 100 kcal. In the latter case, with an adjusted PER of 1.9 (casein = 2.5), protein should supply 10% of calories. This specification would appear to furnish a reasonable margin for safety.

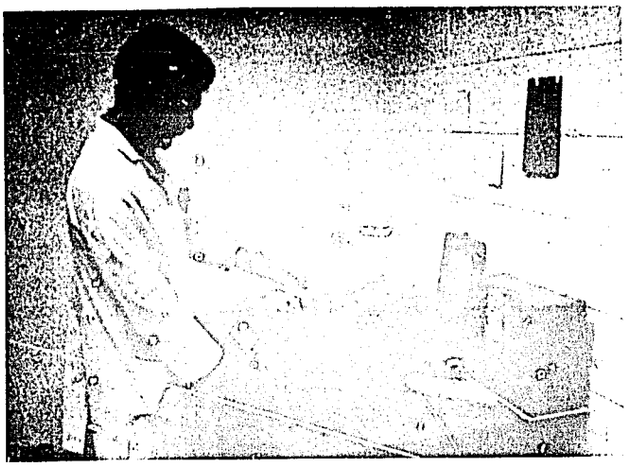

Figure 4. Determination of rat weight gain for PER.

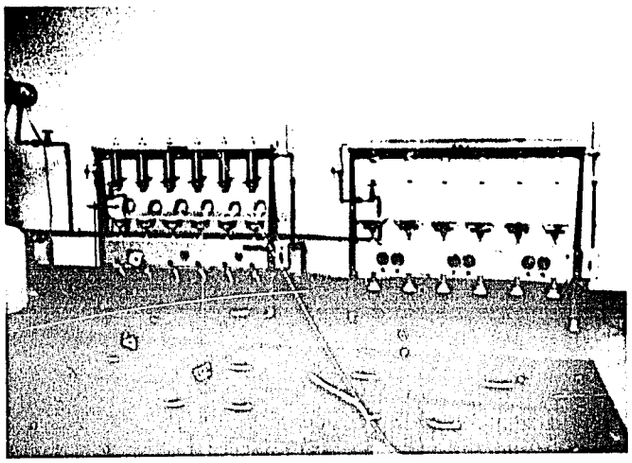

Figure 5. Crude fat and fiber determination apparatus.

The protein-energy ratio needed in a blended food used in supplementary feeding programs will depend on the nature of the usual diet. As discussed in more detail elsewhere (Jansen, 1974), in most LDC's cereals are the dietary staples. In these cases the protein deficit is more related to protein quality than quantity. In the fewer cases where cassava furnishes a significant portion of dietary energy, a quantitative deficit in protein also is likely to be present.

The following suggestions are made in regard to the protein component of blended foods: if the product is to be used in a community where cassava or plantain is consumed to a significant extent, the current specifications are most appropriate. However, in those cases where children are consuming primarily cereals with small amounts of legumes, it is suggested that the protein level could safely be reduced to 12% of calories if the PER were at least equal to 80% of casein, and digestibility were adequate as determined in human infants.

Fiber

Maximum fiber levels currently allowed in Title II foods are in the range of 1.5 to 2.5%. These levels refer to chemically defined fiber, as determined by acid and base hydrolysis (Fig. 5). Such a determination usually greatly underestimates the amount of biological fiber which reflects primarily the carbohydrate portion of a food that is not digested. There are several potential disadvantages to raising the allowable fiber level in a blended food. First, as the fiber level goes up, both the bulk density and the calorie density of the food go down. This could make it difficult for young children to consume the desirable level of protein and calories. Second, a high fiber level may reduce mineral availability to unacceptably low levels; and finally, high fiber diets may produce an unacceptably high stool volume. However, if whole cereal grains and/or legumes could be used, a considerable economic advantage might result from the reduced ingredient and processing costs. It would appear desirable to carry out the necessary studies to determine whether the resulting higher fiber products can be used successfully in child-feeding programs. It may be that adjustment of the protein and fat levels and the vitamin-mineral fortification levels would result in an acceptable product. Considerable evidence has accrued in recent years of the nutritional advantages of higher levels of dietary fiber (Trowell, 1976).

Vitamin and Mineral Levels

Title II foods are required to be fortified with a complete vitamin and mineral supplement, as shown in Table V. It would be highly desirable to use these supplements in LEC-produced foods, rather than attempting to tailor-make a food to fit the individual situation. There are several aspects of vitamin and mineral fortification that need particular attention in the LEC program. First, the availability of minerals, especially iron and zinc and perhaps copper, needs to be studied in human infants to make certain that processing or higher fiber levels do not reduce availability unduly. It may be desirable to increase the amount of minerals added. If the vitamin mix was blended in after extrusion, there would be no difficulty in insuring that the desired level of vitamins was present in the final product. From a cost and product safety standpoint, it would be desirable if the product being extruded could be packaged for ultimate use, rather than handling it a second time under possibly unsanitary conditions. It will be necessary to study the effect of extrusion on vitamin retention and then possibly to adjust the fortification level accordingly.

NUTRITIONAL EVALUATION OF PRODUCT

Considerable work over the last 30 years has been devoted to the evaluation of plant protein mixtures in human feeding (Dean, 1953; Waterlow and Stephen, 1957). In 1969, the Protein Advisory Group (PAG) of the United Nations (1975) published guidelines for the human testing of supplementary food mixtures. These guidelines are pertinent to the LEC program. Nutritional evaluation can be divided into a pre-clinical and a clinical phase. Prior to human testing, the product should be tested sufficiently to establish its proximate composition, ingredient formulation, the nutritive value of its protein by rat growth study, freedom from toxic constituents of any type (Fig. 6). The clinical phase should include: (1) acceptability and tolerance tests, (2) growth tests, (3) nitrogen balance measurements, and (4) other criteria such as maintenance of plasma albumin.

Table V. Vitamin and Mineral Fortification Levels for CSM

Mineral Premix:		Amounts/2,000 lbs
Tri-calcium phosphate		40.00 lb
Zinc sulfate hydrated		0.08 lb
Ferrous fumarate		0.92 lb
Iodized salt (0.007% I_2)		13.00 lb
	Total	54.00 lb

Vitamin Antioxidant Premix:		Amounts/2,000 lbs
Thiamin mononitrate		2.5 g
Riboflavin		3.5 g
Pyridoxin hydrochloride		1.5 g
Niacin		45.0 g
Calcium D-pantothenate		25.0 g
Folacin		1.8 g
Vitamin B_{12}		36.0 mg
Vitamin A palmitate		15 x 10^6 I.U.
Vitamin D		1.8 x 10^6 I.U.
Alpha-tocopherol acetate		68,000 I.U.
Butylated hydroxy anisole		20.0 g
Butylated hydroxy toluene		20.0 g
Ascorbic acid		364.0 g
Soy flour or starch		q.s. 2 lb
	Total	2.0 lb

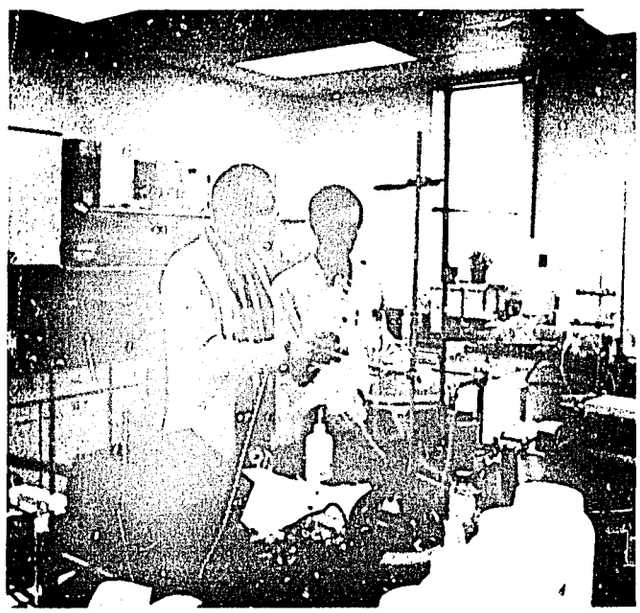

Figure 6. Kjeldahl apparatus being prepared for analyses.

In considering the need for clinical testing, the PAG Committee realized there was a real danger that excessive and unnecessary testing of minor variations in formulation, using previously tested ingredients or processes, could needlessly impede progress. They divided food mixtures into the following three categories:

Proteins and processed protein concentrates previously not considered in the WHO/FAO/UNICEF programs, or products previously considered but manufactured by new processes or by major changes in established processes--especially if these changes in processing raise any suspicions as to nutritional or toxicological properties of the product--must pass testing procedures of the type recommended (Waterlow and Stephen, 1957).

Mixtures of well-known staples and protein sources which have already received favorable consideration should be accepted without insistence on clinical testing beyond acceptability and tolerance trials, if there is no further processing which could cast a doubt on their safety. It would be advisable, however, to ascertain by animal experimentation the nutritional value of the final product (PER or NPU).

In case of severe or unconventional processing of mixtures--even of well-known staples and protein sources--the products should be accepted for tests in man only after they have satisfied the necessary laboratory analysis and animal testing for protein quality. Clinical testing, although not mandatory in this case, may be helpful in ascertaining the value of some of these food mixtures in children's supplementary feeding.

These suggestions are pertinent to the LEC program. Since relatively little clinical experience has been obtained with products made completely by low-cost cooker extruders, it is desirable that initial products receive adequate clinical evaluation. As more experience is gained it will become increasingly possible to rely on chemical and animal studies. It will, however, be important to establish a battery of quality control tests to be used to keep product quality within acceptable limits. These tests should include chemical and microbiological tests on ingredients and final products to insure product safety, wholesomeness and the nutritional efficacy of the blended foods.

BIOLOGICAL EVALUATION OF THRIPOSHA AND CSB

The initial products made at CSU with the Brady Crop Cooker have been of two types. The first was a product called Thriposha. This product was made by dry blending 80% WSB with 20% pearled sorghum imported from Sri Lanka and extruded in a Brady Crop Cooker. The second product is a corn-soy blend (CSB) made entirely in the Brady.

Thriposha

In Thriposha, only the sorghum was extruded. In Table VI the vitamin and mineral fortification levels in the final product, based on the mixture of 80 parts WSB and 20 parts sorghum, are compared to the FAO standards for 4-6 year old children. With the exceptions of pyridoxine and zinc, the resulting nutrient levels provide high enough levels of nutrients to balance out deficiencies that may be present in the indigenous diet. Mineral levels found by atomic absorption analysis are listed in Table VII. Magnesium, zinc, iron and copper are all present in more than adequate amounts. It may well be, however, that the AID vitamin pre-mix should specify a higher level of pyridoxine than is presently the case.

Table VI. Fortification Levels in Thriposha Compared to FAO Nutrient Requirements for 4 to 6 year-old Children (1974)

Nutrient	Thriposha[1] (nutrients/lb)	FAO Standard (nutrients/day)	Thriposha[1] (nutrients/1000 Kcal)	FAO Standard (nutrients/1000 Kcal)
Thiamin (mg)	1.3	0.7	0.8	0.4
Riboflavin (mg)	1.5	1.1	0.9	0.6
Ascorbic acid (mg)	145.0	20.0	85.0	11.0
Pyridoxine HCl (mg)	0.6	0.9[2]	0.4	0.5[2]
Niacin (mg)	21.5	12.1	12.7	6.6
Calcium pantothenate (mg)	10.0	--	5.9	--
Folic acid (μg)	720	100	424	55
Vitamin B_{12} (μg)	14.4	1.5	8.5	0.8
Vitamin A (I.U.)	6000	1000	3530	550
Vitamin D (I.U.)	720	400	424	218
Vitamin E (I.U.)	27.2	9[2]	16	5[2]
Calcium (mg)	2200	450	1294	246
Zinc (mg)	6.6	10.0	3.9	5.5
Iron (mg)	55.4	7.5	32.6	4.1
Kcalories	1700	1830	1000	1000

[1]Includes following nutrients per pound from the sorghum: thiamin 0.3 mg, riboflavin 0.1 mg, niacin 3.5 mg.

[2]RDA established by NAS/NRC, 1974.

Table VII. Mineral Analysis of Thriposha[1] Compared to FAO Requirements for 4 to 6 year-old Children (1974)

Mineral	Concentration ppm	mg/1000 Kcal	FAO Standard mg/1000 Kcal
Magnesium	1990	532	110[2]
Zinc	37.4	10.0	5.5[2]
Iron	90.8	24.3	4.1
Copper	7.0	1.9	0.9[3]
Cadmium	< 0.3	--	--
Chromium	< 0.3	--	--
Mercury	< 0.3	--	--

[1]Determined on a Perkin Elmer Model 303 Atomic Absorption Spectrophotometer

[2]RDA established by NAS/NRC, 1974

[3]Daily allowance estimated by FAO at 80 mg/kg

The proximate analysis and rat growth evaluations of Thriposha, WSB and sorghum are shown in Table VIII. The protein content of 19.0% for the Thriposha is the theoretical amount based on its formulation. The corrected PER for Thriposha of 2.23 (casein = 2.50) was not significantly less than the 2.27 for WSB.

Based on the theoretical chemical scores for wheat-soy mixtures shown in Table III, one would not expect that the addition of 20 parts sorghum to 80 parts WSB would reduce the PER much, since WSB should be limiting in methionine, not lysine.

The PER of 2.23 for Thriposha suggests that it should be adequate in quality for feeding young children. Preliminary results from Dr. George Graham's laboratory indicate that the Thriposha is comparable to WSB in nitrogen retention when fed to previously malnourished children.

Table VIII. Laboratory Results on Thriposha and its Components

Proximate Analysis	Thriposha	Wheat/soy Blend	Sorghum
Protein (%)[1]	19.0	21.0	10.2
Moisture (%)	8.0	8.1	8.2
Ash (%)	3.9	4.6	1.0
Fat (%)	6.2	6.0	2.5
Fiber (%)	1.7	1.8	0.8
Carbohydrates (%)	61.2	58.5	77.3
Calories/100 g	377	372	372

Rat Growth Evaluation	Thriposha	Wheat/soy Blend	Sorghum	AMRC Casein
Weight gain (g)	98.2 ± 3.4[3]	101.5 ± 4.1	21.3 ± 1.0	92.0 ± 2.7
Food consumption (g)	396 ± 9	402 ± 12	231 ± 5	331 ± 7
PER	2.61 ± 0.04	2.66 ± 0.06	0.97 ± 0.03	2.92 ± 2.5
Corrected PER[2]	2.23	2.27	0.83	2.50

[1]N x 6.25

[2]Corrected relative to an assigned value for AMRC casein equal to 2.50. Sample evaluated at 9.5% protein in diet.

[3]Mean ± SEM

Corn-Soy Blend (CSB)

A series of corn-soy blends was made using the Brady Crop Cooker. Dehulled soy or whole soybeans were used in combination with whole or degerminated corn. The ingredients were mixed either before or after extrusion. When the corn and soy were mixed before extrusion, the extrusion temperature was 310°F or 340°F. When the soy and corn were blended following extrusion, the soy was extruded at 280°F and the corn at either 310°F or 340°F.

The various blends, a standard sample of CSB, and ANRC casein were evaluated in a standard rat growth assay, with weight gain, protein efficiency ratio (PER) and protein retention efficiency (PRE) measured after a growth period of 14 days. The standard AOAC method was used, except for the duration of feeding, and all PER's were corrected relative to an assigned value of 2.5 for ANRC casein.

On discussing the results, several points should be held in mind. Weight gain can vary with palatability and small differences in protein level in the final diets. PER has the disadvantage that the numerical values obtained have no physiological relevance, and also, uncorrected PER's can vary substantially with rat strain and environmental factors. Correcting PER's to an assigned standard value for ANRC reference casein has the advantage of yielding numerical values that can more easily be compared from lab to lab. PRE's take utilization of protein for maintenance as well as for growth into account, and also have the advantage of being on a scale essentially the same as net protein utilization (NPU), i.e., the percentage of dietary protein utilized for growth and maintenance. All four of these measures of protein quality are listed in Table IX for all experimental groups. However, only the corrected PER's and the PRE values will be discussed in the text.

When the ingredients used were dehulled soy and whole corn, protein quality was not significantly different when the corn and soy were mixed prior to extrusion from results obtained by extruding the corn and soy separately and dry blending them. In contrast, when degerminated corn and dehulled soy were the ingredients, the PRE's were significantly less when extruded together than when extruded separately. When whole soy and degerminated corn were the ingredients, extruding the soy and corn together also yielded lower PRE's but in this case the difference did not reach statistical significance. In no case did cooking the corn or corn-soy at 310° give a significantly different PER than cooking the same material at 340°F. The lowered PER when degerminated corn

Table IX. Effect of Brady Crop Cooker Processing Variables on Protein Quality

Conditions	Temperature[1]	Weight gain (g)	PER[2]	Corrected[3] PER	PRE[4]
		Dehulled soy/Whole corn			
Cooked together	310°F	65.7 ± 1.7[5]	3.62 ± 0.07	2.50 ± 0.05	68.6 ± 1.1
Cooked together	340°F	71.5 ± 2.2	3.65 ± 0.06	2.52 ± 0.04	68.3 ± 1.1
Cooked separately	280/310°F	66.7 ± 2.6	3.81 ± 0.10	2.63 ± 0.07	71.5 ± 1.8
Cooked separately	280/340°F	60.4 ± 3.0	3.73 ± 0.07	2.57 ± 0.05	71.8 ± 1.3
		Dehulled soy/Degerminated corn			
Cooked together	310°F	55.1 ± 3.3	3.25 ± 0.13	2.24 ± 0.09	63.5 ± 2.1
Cooked together	340°F	62.8 ± 1.7	3.24 ± 0.05	2.24 ± 0.03	61.8 ± 0.8
Cooked separately	280/340°F	53.7 ± 3.6	3.73 ± 0.13	2.57 ± 0.09	73.3 ± 1.8
		Whole soy/Degerminated corn			
Cooked together	310°F	60.2 ± 2.4	3.46 ± 0.05	2.39 ± 0.03	66.6 ± 1.0
Cooked together	340°F	64.2 ± 3.6	3.33 ± 0.12	2.30 ± 0.08	63.4 ± 1.9
Cooked separately	280/340°F	55.4 ± 2.3	3.61 ± 0.09	2.49 ± 0.06	70.4 ± 1.3
CSB-Krause Milling		57.6 ± 2.9	3.65 ± 0.08	2.52 ± 0.06	70.9 ± 1.3
ANRC casein		48.6 ± 2.6	3.61 ± 0.12	2.50 ± 0.08	72.3 ± 1.9

[1]When cooked separately, first temperature listed is for soy

[2]PER = weight gain (g)/protein consumed (g)

[3]Corrected PER = PER x 2.5/PER for casein

[4]PRE = 16 weight gain (g) + weight loss - protein free (g)/protein consumed (g)

[5]Mean ± standard error (n = 10)

was extruded together with soy could be interpreted in terms of a reaction of lysine from soy with carbohydrate from the corn. It may be that reactive sites in the degerminated corn were more accessible than was the case for whole corn. The mechanism is certainly not understood at this time. However, even in the case of dehulled soy and degerminated corn extruded together, the resulting PER of 2.25 was only slightly less than that of casein and more than adequate in quality to meet the needs of young children, provided digestibility is acceptable.

SUMMARY

Nutritional issues involved in establishing specifications for blended foods were considered in the light of the rationale of the LEC program and current understanding of protein-energy relationships. Suggestions were made for establishing standards for the energy, fat, protein and fiber content of blended food, and vitamin and mineral fortification levels. It was proposed that, for countries where cereals are the dietary staples, blended food could well be higher in energy and lower in protein than is now the case for most Title II foods. Results of a rat growth evaluation of Thriposha, made from 80 parts WSB and 20 parts extruded sorghum, and a series of corn-soy blends made on a Brady Crop Cooker were presented. From the standpoint of protein quality and quantity, all products evaluated should be satisfactory for use in preschool feeding programs.

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Discussion - Wednesday Afternoon

Moderator:

Stephen Bogyo
Consultant
Tarrytown, New York

Dr. Bogyo:

Are there any questions on the afternoon papers?

Mr. Fox:

I want to add something to Dr. Hansen's remarks. In evaluating the extruders we have continually referred to the Insta-Pro Model 500 extruder, and I want to point out that the Insta-Pro extruder is actually made in three sizes. The other two are the Model 2000 and the new Model 2500, which is twice as big as the Model 500.

Dr. Bressani:

I would like to ask Dr. Hansen two questions. One has to do with the addition of urea as a lubricant. What I would like to know is how much did you add, and what happens to the urea when it goes through? Also, would you please expand a bit on the production of leaf-protein concentrate.

Dr. Hanson:

The first question was about the amount of urea that we used in the product. We have a mixture of 20% urea, 5% sodium bentonite and 75% starch source from either corn, milo, sorghum or wheat. The process is one of heating the machine first with an oil seed and then introducing that mixture, making sure the product does not separate. When the machine is hot, the urea will melt and serve as the lubricant, the idea being that the product will form a matrix and will in effect slow down the release of ammonia from the product when ingested by ruminants. That is a process that produces what we call the "Golden Pro" product.

Mr. Zeller:

In making "Golden Pro." the product comes out a small hole in the form of a big rubbery rope. A slinger-type cutter clips it off at a rate of 7,000 cuts a minute and throws it into a conditioning drum. This particle sizing is done so that we can get it into a condition we can handle. That would be difficult on the Brady, owing to the lack of cutting equipment.

Dr. Bressani:

What is the recovery of the urea?

Dr. Hanson:

Ninety-nine percent. We have no ammonia smell whatsoever around the machine when it is running.

The second question was related to the leaf-protein concentrate. The University of Wisconsin has perfected a unit to extract the liquid from alfalfa plants. Then the product is run through a coagulator where live steam is injected. It coagulates the protein which is skimmed off a settling tank. It can also be centrifuged. Then they mix the concentrate with grain and extrude it to put it into a more palatable form and to dry it. They are running a preliminary experiment with swine that shows that the product is highly acceptable. Previously they had considerable difficulty getting them to eat it.

Dr. Bressani:

It is two operations. One is extracting the protein, and the other is mixing it with the grain and extruding it.

Dr. Hanson:

Yes. The only purpose of the extruder in this case is to put the product in a form that the animals will accept.

Mr. Zeller:

You understand that, in the case of "Golden Pro," what we are doing is using moisture-starved corn. The urea melts at the same temperature that the corn will either parch or gelatinize. At that point the liquid urea then furnishes the liquid agent and gelatinizes the starch cell, thereby encapsulating it.

Mr. Sterner:

I have a question for Dr. Jansen with regard to Table II in his paper. Do you have data on the relationship between nutritional intake during pregnancy and lactation and growth of progeny?

Dr. Jansen:

What we wanted to do was to see what happens to the offspring of mothers who ate less food but of better protein quality. To do that, the 16 groups of rats in the experiment were fed different levels of bread, bread and lysine, bread, lysine and threonine or casein. I have a paper in the process of publication with all of the data, but the results showed that the development of offspring of mothers who were fed protein-improved bread was better, even though they consumed only 87% as much protein and energy. The effects on progeny are directly proportionate to total food output of the mother. In other words, offspring of mothers that did not lactate well didn't grow well. There is no evidence that protein quality or nutrient levels of the milk are different under either of these conditions.

Dr. Graham:

The calorie recommendations made by the FAO/WHO Expert Committee are for healthy well nourished children growing along the 50th percentile. A lot of people don't realize that and try to apply them to children of the same ages in developing countries, who are inevitably much smaller.

The most reliable data base for the protein recommendations is the intake of breast milk for the first five months of life, and for older age groups, the data of Young et al. These data have since been questioned by Young, by the way. As a matter of fact, he has shown that those estimated requirements do not maintain body composition for a long period of time. Regardless of that, let us accept tha basic protein recommendations for the purpose of discussion. The corrections that are suggested for vegetable protein are lacking. They mistakenly assume that the only correction that has to be made is for amino acid composition. Most major vegetable proteins in the world are only 60-70% as digestible as high quality animal protein. Another mistaken assumption is that you can eat enough more rice, corn, potatoes or sweet potatoes to satisfy your protein requirements, and that the only reason people don't is because they can't afford to.

Dr. Bogyo:

The question was asked whether or not low-cost extruders really have relevance and industrial importance. I believe this type of machinery is one of many that can be applied to process relatively palatable and acceptable food staples. It seems to have considerable versatility and flexibility. We know it can be applied to incorporate protein into other staple commodities. We also know it can produce a flour, gruel, snack, etc., so in terms of alternative equipment--say, a macaroni press--it is one of several that has applications.

Dr. Harper:

There was one other comment relative to fat addition to products and its effects on rancidity. Fat is not absolutely required in either one of these machines to extrude products. They are easier to operate if they do have some fat in the system. Typically, our data show that the addition of soybeans at about the 30% level in any of these products provides enough of its natural antioxidant systems--α-tocopherols, vitamin E, etc.--to produce a situation wherein the rancidity is substantially less than in products where the extruded material is 100% cereal. There is a potential rancidity problem, but we believe this can be solved by the addition of appropriate anti-oxidants and we are working right now to identify those.

Dr. Bogyo:

Would it not also be true from what Dr.Jansen reported that one of the shortcomings of this whole family of foods for young children is its relatively low caloric density?

Dr. Jansen:

Yes. Caloric densities can be improved through the addition of a fat or oil and at the same time ease the extrusion process.

Dr. Bogyo:

I was also surprised that the final moisture came out to be only 4-5%. If it really comes down to economics, and fat is not available, I think that a few percent of additional water would do what the fat does. Is that a correct guess?

Dr. Harper:

One to five percent water can be added directly to the extruder to aid extrusion and increase the moisture content of the finished products. You have to remember that we are in Colorado where our average relative humidity is 10%. This means that the grains we are extruding are low-moisture grains. If you talk about the tropics, where often the moisture level of the grains being extruded is right at the maximum level allowable for storage or maybe even slightly above (which is 15% or somewhat higher), the resulting moisture in the finished products is going to be somewhat higher.

Dr. Bogyo:

It would be an interesting study to examine the energy requirements of extruding wet and redrying. What would be the economics of drying extruded products?

Dr. Harper:

Dryers are very expensive to purchase and operate, particularly in countries where fossil fuels are at a premium. Although these LEC's use electricity or diesel the fact that no additional product drying is required, we believe offers some economic advantage.

Mr. Samaan:

Our main objective for these extruders is to use them at low cost in less developed countries. From the description of the two machine being tested, many of the parts seem to be wearing rapidly. Knowing that in these countries foreign exchange is always in short supply, I wonder whether these parts could be manufactured locally. Has there been enough research done

on the main parts of these machines, specifically their longevity?

Dr. Bogyo:

I have worked with many machines at General Foods, and as far as extruders are concerned, they are maintenance-free and parts are relatively easy to replace.

Mr. Fox:

There has been quite a bit of research done. As a matter of fact, in our machine--and I am only speaking for our machine at this point--we have designed it so that wearing parts can be replaced relatively low cost. As Dr. Hansen said, there are four steam locks. There is a hardened ring against which the products run--between the steam locak and ring--which wears. When you get a worn spot and you start to lose heat because of the wear, you can move the ring and start wearing a new spot on the same ring. We are talking about a piece that costs only $10 that can be worn in four spots on each side--a total of eight spots before it has to be replaced. It can be rebuilt if you have a machine shop, or if there is a local hardware or blacksmith. That very piece could be welded and brought back to original specifications and turned down on a lathe. I have mentioned that the first machine we put in Uganda ran over 2,000 tons over a 2 to 3-year period and never had a part replaced. Wear is relative to the product you are running, and you will find that this low-cost extruder, by using friction and pressure as the source of heat, reduces wear cost to less than the cost of other sources of energy needed to heat and dry.

Mr. Zeller:

We are talking as if this were something completely new. We have been working in this field for quite a few years, and thousands of tons have been processed. We have had a tremendous amount of feedback and information on energy and replacement parts. Our franchised manufacturers all have machines, and we operate a plant at Westside, Iowa with 2,000 extruders in it. We process thousands and thousands of tons, so we have these figures. The general figure on energy cost is about $1.50 per ton. Replacement parts and maintenance are also in the area of between $1.50 and $1.75 per ton. The third factor is that you have to shrink most products. Here we are talking about moisture, and in the case of soybeans, we shrink them almost 8%. These are the three basic figures you have to add to labor and other localized costs.

Discussion of LEC Demonstrations at Agricultural Engineering Research Center

Moderator:

Alvin I. Nelson
Department of Food Science
University of Illinois
Urbana, Illinois

Dr. Harper:

I would like to comment on some questions that were asked during the demonstration of the two low-cost extrusion cookers before we open the discussion to individual questions or comments.

One question concerned the cost of the LEC's and what was meant by low cost. Yesterday, Mr. Stone reviewed the costs of these extrusion systems and showed the total capital requirements, depending on the exact system, ranging from approximately $70,000 up to $200,000. Since this may appear high, let me comment. First, the cost figures that Mr. Stone showed were complete cost figures or the costs of starting a plant from scratch and doing everything that is required to put that plant in production. In most cases, many of those inputs are already going to exist at a specific site. For instance, in the installation in Sri Lanka, there was a building, and the dehulling and cleaning equipment in the existing plant were incorporated into the final design. The total dollar input of equipment, shipment and installation for Sri Lanka was less than $40,000. The reason the total cost figures were presented was to allow someone looking at a new situation to consider all possible costs and obtain the total perspective. For each specific site, inputs which are existing can be removed from the total list to obtain the actual costs.

Another comment relative to costs was "How do these costs compare against alternate systems?" We have not obtained specific costs for all alternate extrusion systems so that a direct answer cannot be given. Most other extrusion systems which could be used as alternates to LEC's make wet products. A boiler and a dryer are required which increases the total system's capital and operating costs significantly. For such a total plant the costs on a comparable basis to those presented for the LEC's could range between $300,000 and $1,000,000 for a system producing 1,000 pounds per hour. Our definition of a low-cost extrusion system would be one which costs between $70,000 and $100,000 for a capacity of 2,000 pounds per hour.

Other participants have asked about roller dryers or spray dryers to make nutritious beverage bases. When looking at a typical roller dryer that has a capacity of 1/2 ton per hour, the capital costs of equipment alone are about $70,000 to which must be added the costs of boilers, etc., which means these systems aren't low-cost systems by our definition.

In the near future we hope to get a better grasp on some of the costs of alternate process systems so that interested parties can have more guidance.

Mr. Fox:

We are in the process of doing this very thing that you are talking about. We have an individual comparing an Anderson IBEC and a Wenger extruder with capacities from 6 to 10 tons per hour. Within a month we will have the entire cost of the system including the building, the boiler, the equipment--everything necessary to build the plant. In comparison with these figures, the alternate of using Triple "F" equipment will be given. If there is anyone interested, please give me your name, address and a note saying that you would like a copy, and I will be glad to send you one.

Dr. Harper:

Another question was how people or groups could get started in LEC processing and evaluation. Yesterday, comments were made by Dr. Lachmann concerning pilot or test installations that exist in Guatemala, Kenya, Indonesia, and The Philippines. At these sites, an extruder and power source--a very limited system--are provided so people can do some experimentation to determine with their own local ingredients how this particular equipment may fit into plans to produce low-cost nutritious foods. Once a product is developed and some experience is gained, the required capital investment, the location, operational plans, clearances, etc., will be much easier to project and obtain. People interested in this program should contact their USAID mission in their home country.

Dr. Mukhopadhyay:

Can you comment on the extent of gelatinization and exact measurement of gelatinization, because if the product is very puffed, it won't go into solution and make a gel which can be tested for viscosity. In other words, how do we really know when a product has been properly cooked and that uncooked material is not present?

Dr. Harper:

One of the best ways to tell whether a product is cooked properly or not is simply to taste it. That is not a very quantitative test, but typically if a product is pleasing to the taste and there are no raw flavor notes, it is well cooked. Certainly with an increased temperature in an extruder you can bring out more of a toasted note. Cooking is related to starch gelatinization and other physical properties of the product. Viscosity measurement does not adequately describe whether a product is undercooked or overcooked, because viscosity increases as the temperature increases then falls off sharply at high temperatures. It should be considered as one of several tests that describe an acceptable product.

Viscosity measurements are made in a variety of ways. Normally the product is ground and made into a gruel and then the viscosity of the gruel is measured. Some viscosimeters used are: a consistometer, where the spread of the resulting gruel is measured; a consistometer where the product flowing down a channel is measured; and a Brookfield viscosimeter which will measure actual viscosity. Viscosity is only an indication of the degree of gelatinization of the starch. There are other techniques, such as iodine binding techniques and color metric techniques that can also be correlated with gelatinization. There are published references in the literature dealing with light bifringents of starch granules which is a measure of damage and gelatinization. The reason viscosity is often used is because it is fast.

Dr. Lorenz:

We do not really have a precise definition for when something is properly cooked. If it is the degree of gelatinization, it is something which is never compeltely accomplished because of the limited amount of water present. Therefore, we probably do have to go to measurements such as viscosity to get an indication of the degree of cooking.

Dr. Bogyo:

If you want to make a very simple test and you do not have a laboratory, I suggest you first make a preliminary cooking test and find just what concentration gives you a gruel--visualize making cream of wheat. Once this is done, mix the gruel again to break it up with a mortar and pestle. Now add the same amount to cold water and bring it slowly to a boil to see how it continues to thicken. The original product is not fully gelatinized because not enough water was present in the cooking. The extruder will "cook" in terms of sanitation and enzymes inactivation, but it will not "cook" the food and classically gelatinize starch. The above test will give a pretty good incication of how well the starch is gelatinized in an extruded product.

Dr. Mosha:

Is the purpose of the research to find results or to give practical guidelines on how to make improved foods for babies?

Dr. Harper:

The important objectives of the studies are to determine exactly how extrusion operations, ingredients, processing conditions, etc., affect the physical properties of human foods made on these machines. For instance, if you want a very thick gruel, how would you go about making one and assure that the product is digestible, the enzymes deactivated, and how these produce change. Our experience over a wide set of processing conditions would indicate that LEC's are versatile in that sense and that you can use a wide range of ingredients and change their physical properties through processing conditions. We don't know all of the answers, but we certainly know and can suggest many things directionally to change the properties of the products.

Dr. Trier:

It seems that we have not heard anything about the uniformity of the products, their stability and the quality of the product from batch to batch. It is important and desirable to go to more quantitative analysis. Can you discuss these points?

Dr. Harper:

Uniformity of the product, meaning the microscopic uniformity of the materials, varies with the feed of the extruder. If whole grains are fed, the uniformity of the material being extruded is fairly low. Discrete pieces of corn or soybean can be seen in the finished product which leads to some interesting textural and perceptual characteristics that may have some value in snack items, but if you are trying to make a gruel, this lack of uniformity would be a detriment. By pregrinding the feed material in advance of extrusion, the uniformity of the resulting extrudate is much better. The uniformity is better the finer the pregrind, although if the material gets too fine, severe problems in feeding the extruder occur and plugging problems can result. We have found, through experience, that grinding to approximately 40 mesh is a very desirable pretreatment to increase uniformity.

In terms of operating the LEC's, the operating uniformity has been found to be satisfactory. None of these LEC's is the type of machine that can be set up and not monitored during operation. The plant should be designed with an operator assigned to each extruder. His job would not require minute-by-minute adjustments. During start-up, adjustments are more frequent until the LEC is lined out at equilibrium conditions, since the heating of the machine is by temperature in the barrel. Once this is done, only minor adjustments should have to be made--principally a trimming action to made sure the machine is not drifting to a new operating condition.

The uniformity from day-to-day will be most generally affected by changes in the raw ingredients that are available. As the corn or soybeans may fluctuate from batch to batch, these variations may be seen as differences in the resulting product. Compensating operating conditions can be made to assure product uniformity such as the addition of water or oil, changing the cooking temperature, etc. These fluctuations can be damped out through the changed operation of the equipment. The natural variability

of cereals, legumes and natural products is a problem that millers and food processors live with daily, and the extruder can help minimize its effect on the final product.

Mr. Fox:

For years we have used a very simple test to determine whether the soybeans are adequately extrusion-cooked to remove the urease and the trypsin inhibitor. Our laboratory tests have shown that an operator running only soybeans can tell if they are cooked by the appearance of the product coming from the machine. To further check this point, take a pint jar, put several inches of the processed soybean meal in the bottom followed by a tablespoon of pure urea on the top of the meal. Finally, add some warm water to make a gruel, then cap it. A poorly cooked product will give a very strong ammonia smell within 15 minutes, and if it is well cooked, no ammonia odor will result for several hours. Overcooking, in our estimation, is where no ammonia odor will result after several days of setting.

Dr. Harper:

In terms of uniformity of products and operations, the demonstration last night was under absolutely the hardest operating conditions, for the many formulations required quick changes on the LEC's. In such a case, the operator needs to stay alert to avoid plugging.

Mr. Zeller:

To make it even more difficult for the operators, they were using only one general configuration in the Triple "F" machine. It wasn't quite proper for cooking soybeans or the cereal products--it had to be averaged for all products. This makes it very difficult to go from product to product, and they did a very good job.

Dr. Lee:

Have you considered the possibility of making the production unit into a mobile unit?

Dr. Harper:

That is an idea that has been discussed. The mobile unit would have most of the equipment on a truck bed, and set-up for operation would be very simple and quick. It would have advantages for testing and demonstration--maybe even disaster relief.

Mr. Fox:

Triple "F" has such a unit with a Perkins 135 hp diesel on a trailer to run a generator and the extruder. The whole package is no bigger than a quarter of this room. It does not have a grinder-mixer, but portable grinding-mixing equipment can be provided.

Exploration of the Potential for Low-cost Extrusion Cookers in Latin America

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INTRODUCTION

The recognition of malnutrition, its socio-economic causes, its high prevalence, its contribution to infant and child mortality, and the implications it has on the future of developing countries, has motivated research on the development of protein foods of high quality and low cost to help provide improved nutrition to vulnerable groups.

Much research has been carried out resulting in a great variety of formulations, many of which have never appeared in the market, much less had an impact in decreasing the incidence of malnutrition. The reasons are not well-defined, but among them is the fact that their cost is above the purchasing capacity of the people who can best benefit from their use. Although part of the cost is due to the increasing cost of the food sources used, the capital investment to be made to produce them is too high to be attractive, particularly in view of the fact that in order for them to be increasingly consumed, these high-protein foods should be of a low cost.

INCAP has been very active in this particular field, and various formulations using a variety of components have been developed. These mixtures have been subjected to nutritional evaluation, the results of which indicated their relatively high quality.

During the last three years, requests for high-protein foods have been received from at least nine countries in Latin America. Because the availability of components for such mixtures differs from one country to the next, the information obtained previously at INCAP has been useful, at least in providing the formula. However, it represents the beginning of a program in which the processing is probably a very important component. The need for such locally produced high-protein foods is increasing, in view of the fact that food aid programs might be discontinued in the near future.

There are various ways by which such foods can be prepared industrially. They range from simple mixing of already processed cereal and oil seed flours to processing with drum dryers, sophisticated extruders and equipment of that nature. However, the availability of simple inexpensive extrusion cooking equipment can facilitate greatly the production of foods for populations who need more and better quality protein as well as increased intakes of energy.

INCAP'S PROGRAM

INCAP has been active since 1954 in the development of high-protein foods for human consumption, and relatively large numbers of formulations, using a wide variety of ingredients, have been tested. One such formulation, INCAP Vegetable Mixture 9 known as INCAPARINA, has been in the Guatemalan market since 1959, with sales reaching about 5 million pounds per year in 1975. Because of this, and because of INCAP's close relationship with the Pan American Health Organization, many requests for such formulations have been received from various countries in Latin America. In view of this, interest developed at INCAP to provide these requesting organizations with more than formulations, research was initiated in processing techniques, including extrusion cooking.

When a Brady extruder (Fig. 1) became available to INCAP, on loan from USDA through CARE, two objectives were established. One consisted of testing the potential of the extruder to process a variety of ingredients, and the other of teaching the handling of the machine to those interested in the process. Both objectives have been met since the equipment became available. Because of the potential of the machine, its use has been recommended; however, it has become necessary to study the processing of the mixtures with more detail--an activity which has been undertaken on at least four different formulations.

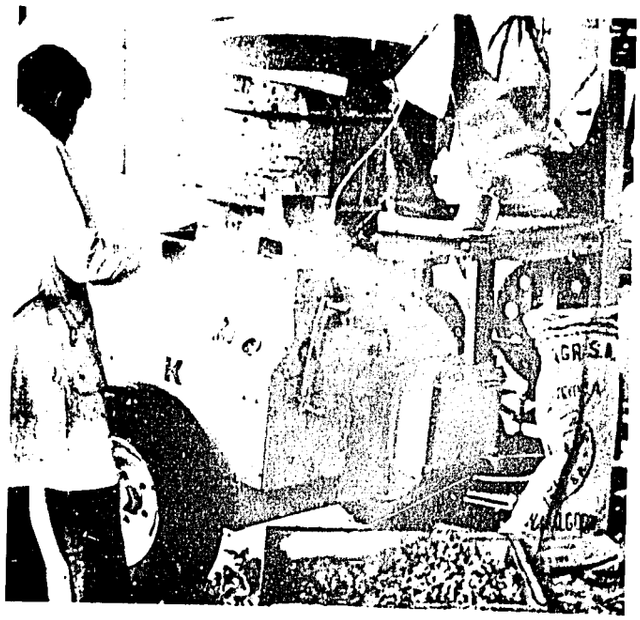


Figure 1. Personnel working with the Brady Crop Cooker at INCAP.

EXPERIENCE GAINED WITH THE BRADY EXTRUDER

Whole Soybeans

Since soybeans are beginning to be produced in Central America, interest has been shown in processing them for a variety of uses. Representative results of one of our studies in this area are shown in Table I. It can be seen that with a 10% moisture content in the beans, there is need to pass the extruded product through the machine up to as many as three times in order to decrease trypsin inhibitor activity in the material to levels which do not interfere with animal performance. The thrice-extruded product assayed through biological tests with young rats resulted in weight gains and feed and protein efficiency values similar to those obtained with solvent-extracted soy bean meal.

Table I. Processing of Soybeans by the Brady Extruder[1]

Treatment	TUI/ml	Average weight gain, (g)[2]	Feed efficiency[2]	PER[2]
Raw	46.9	19	11.68	0.78
Extruded once	24.8	25	9.24	1.01
Extruded twice	9.6	29	8.03	1.19
Extruded 3 times	1.6	44	5.57	1.63
Autoclaved	9.8	41	5 76	1.71
Soybean meal	10.2	47	5.28	1.99
Casein	--	67	3.06	3.15

[1]Variety: Improved Pelikan. Processing conditions: moisture content of beans = 10.2%; feed rate = 2 rpm; temperature = 325°F; production per hour = 364 kg.

[2]At 14 days

These results are really not surprising, since it has been very well established that in order to maximize the nutritional value of soybeans, it is necessary to cook them with a moisture level higher than normally found in grain.

Cottonseed and Cereal Grains

One of the most abundant oil seeds in Central America is cottonseed. Its main limiting factor is the pigment gossypol, which is toxic by itself and which has a high affinity to react with protein through binding to the ε-amino group of lysine, making it biologically unavailable to the animal.

Some representative results of the effect of extrusion cooking on mixtures of cottonseed kernels with either corn or sorghum are shown in Table II. The ingredients composition and the processing conditions are shown in the upper two sections of the table, while the lower part shows some analytical and biological values of the product before and after extrusion. Blends with cottonseed can be extruded as well as those containing soybeans; however, the cottonseed kernels must be free of lint and hulls. Total gossypol remains pratically the same after extrusion in comparison with the raw product; however, free gossypol decreases to levels which are not physiologically active. The protein quality is not so high as was expected, suggesting some binding of lysine. However, this is an area which requires additional research.

Table II. Processing of Mixtures Containing Cottonseed Kernels and Grains

Corn (degerminated), %	70	0
Sorghum, %	0	80
Cottonseed kernels, %	30	20
Particle size of mixture	20 mesh	20 mesh
Input feeding rate, cut/hr	2	2
Temperature, °F	310	310
Water added, gal/hr	7.5	0
Output rate, kg/hr	297	300
Raw:		
Total gossypol, %	0.360	0.240
Extruded:		
Total gossypol, %	0.370	0.288
Free gossypol, %	0.027	0.011
Weight gain, g	27	36
PER	1.26	1.46

Another example is shown in Table III. In this case, the blends contained four ingredients, one of which was cottonseed kernels at a level of 20%. This level would provide around 5-6% oil in the blend. The biological results show an improvement in protein quality from 1.30 to 1.66 for the formula on the first column, as well as an improvement for the second mixture from 1.52 to 2.22. These results suggest again that extrusion reduces gossypol (although analytical values are not shown), and that it also improves the quality of legume grains such as cowpeas. It should be indicated, however, that cowpeas are legume grains with relatively low levels of trypsin inhibitor, as compared to common beans or soybeans.

Table III. Processing by the Brady Extruder of Mixtures Containing Cottonseed Kernels

Cottonseed kernels, %	20	20
Cottonseed flour, %	20	6
Corn, %	50	38
Cassava flour, %	10	--
Cowpea (*V. sinensis*), %	--	36
Input feeding rate, cut/hr	2	2
Temperature, °F	310	310
Water added, g/hr	0	0
Output rate, kg/hr	600	600
Raw, weight gain, g	38	48
PER	1.30	1.52
Extruded, weight gain, g	52	89
PER	1.66	2.22

Cottonseed and Legume Foods

It was indicated that cottonseed is one of the most abundant sources of energy and protein in Latin America. Therefore, it is important to study this source in more detail. One limitation is gossypol: however, from the point of view of protein quality, its limiting factor is lysine. On the other hand, there is much interest to increase utilization of legume foods in ways different than those now in use. Furthermore, they are good sources of lysine. Table IV summarizes some experiences of processing mixtures of cottonseed and legume foods with the Brady extruder. Two have been tested so far: the common bean and the cowpea. Below the formulas some biological information is presented which suggests that the process is capable of inactivating the antiphysiological factors present in legume foods. The raw samples, in which common beans were present, caused 100% mortality of the experimental animals. However the processed samples were capable of inducing relatively good performance from the experimental animals.

Table IV. Processing of Mixtures of Cottonseed Flour and Legume Grains with the Brady Extruder

	Formula %	Formula %	Formula %
Cottonseed flour	17	17	--
Beans (*P. vulgaris*)	36	--	50
Cowpea (*V. sinensis*)	--	36	50
Corn	47	47	--
Raw:			
Weight gain, g	--[1]	48	--[1]
PER	--	1.46	--
Extruded			
Weight gain, g	74	86	50
PER	1.56	2.04	1.41

[1] All animals died.

Foods Containing High Amounts of Starch

It is well known that in tropical Latin America starch roots and tubers are consumed by the population. These foods are very low in protein content; therefore, it was of interest to learn whether such foods combined with legume foods--such as cowpeas--could be processed with the Brady extruder. Results of one study are shown in Table V. Two blends were processed--one, a corn/cowpea mixture, and the second, a cassava/cowpea blend. Both blends were easily extruded, and both showed an improvement in protein quality. The cowpea/cassava blend was also tested with young swine, with results similar to those obtained with rats. Roots and tubers are difficult to store after harvest. Present drying procedures are costly, particularly, at the later stages. The Brady extruder offers a good possibility of handling this material at relatively high moisture content (20-30%), thus helping the preservation and commercialization.

Table V. Processing of Mixtures of Corn/Cowpea and Cowpea/Cassava

Mixture	Extrusion[1]	Weight gain, g	PER
Cowpea/corn, 28/72	no	30	1.1
Cowpea/corn, 28/72	yes	61	1.9
Cowpea/cassava, 19/81	no	25	1.0
Cowpea/cassava, 19/81	yes	31	1.6

[1] Conditions: particle size = 20 mesh; temperature = 290 °F. Output rate: 390 kg/hr; no water added; feeding rate = 2 rpm.

From the samples shown, as well as from others not presented, it is concluded that the equipment is capable of processing a large variety of materials. Our interest and efforts after this initial phase are to study the different possibilities in more detail.

PROBLEM AREAS

From the work described, various problems have been identified with the extruder and are shown in Table VI. The problems have been divided into three groups: those related to the equipment; those related to nutritional considerations; and those related to the product. The last two groups are closely related to the mechanical problems of the machine. Among these, the addition of moisture and the adjustment of the mechanical control seem to be important: (1) to be able to destroy antiphsiological factors, (2) to affect more structural characteristics, (3) to improve on functional properties, and (4) to achieve consistency of nutritional values and all other characteristics.

Table VI. Problem Areas Related to Processing with the Brady Extruder

1. Equipment

   Feeding of blend
   Adjustment of mechanical controls
   Temperature control
   Forms of extruded product
   Addition of moisture and oil conditioning of blend

2. Nutritional

   Lack of complete destruction of antiphysiological factors (trypsin inhibitors, gossypol, others)
   Lack of uniform nutritional values (PER)
   Stability of nutritional supplements (vitamins)
   Stability of extruded product under storage

3. Physical and Organoleptic Characteristics of Product

   Texture
   Palatability
   Standardization of physical properties of extruded product

Table VII. Physical and Nutritional Characteristics of Mixtures of Corn/Soybeans of Different Particle Size Made by the Brady Extruder

Description of sample	TUI/ml	Water Retention, % Raw	Water Retention, % Extruded	Water Absorption, % Raw	Water Absorption, % Extruded	g/liter	PER[1]
Raw	14.1	--	--	2.71	--	638.6	0.94
Small particle size	11.4	4.00	510	2.55	4.64	183.9	2.60
Intermediate size	8.[illegible]	4.50	827	2.77	4.57	191.2	2.41
Coarse size	7.[illegible]	7.20	1,013	2.82	5.12	206.5	2.49
Casein	--	--	--	--	--	--	3.15

[1] 14 days

PRESENT RESEARCH

As indicated above, attempts are being made to optimize the conditions for processing of specific blends formulated at the request of various countries. One product is a blend of soybeans and corn mixed in a 30/70 weight ratio. Physical characteristics of the mixture before extrusion cooking and the addition of moisture were factors considered. Table VII shows the effect of processing [illegible] of three particle sizes with a standard particle size of soybeans. All three mixtures could be processed; however, feeding rate problems were found with the material with the lower particle size. Furthermore, the equipment became jammed. Much better products were obtained from the intermediate and coarse particle sizes--with preference for the intermediate--when the physical appearance of the products was evaluated.

Figure 2 summarizes other results in which the intermediate particle size corn was processed with three levels of added moisture. It can be seen that trypsin inhibitor activity decreased as moisture increased. Likewise, higher moisture resulted in a product with a higher specific volume. Some improvement in protein quality was also observed with increased moisture content. In view of these results, attempts are being made to set up a device which will permit addition of water, application of heat, and mixing before the mixture is extruded.

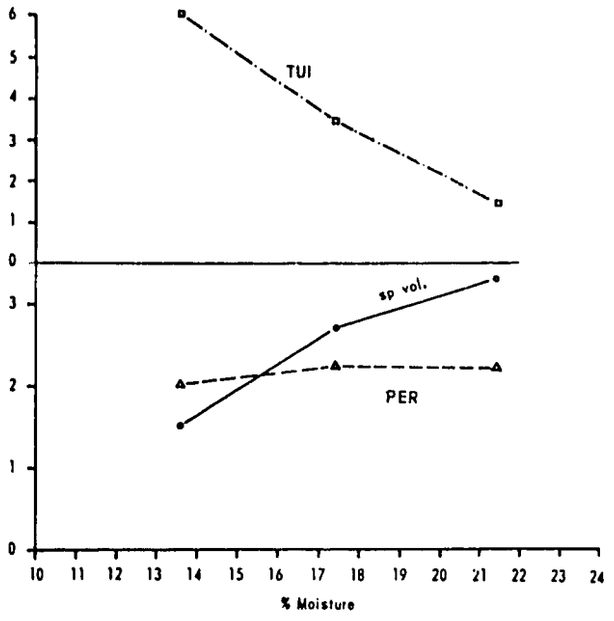


Figure 2. Effect of moisture on the physical and nutritional characteristics of the extruded product.

POTENTIAL APPLICATIONS

The studies underway to find optimum processing conditions for various mixtures, as requested by government agencies of some Latin American countries, will be described briefly.

El Salvador

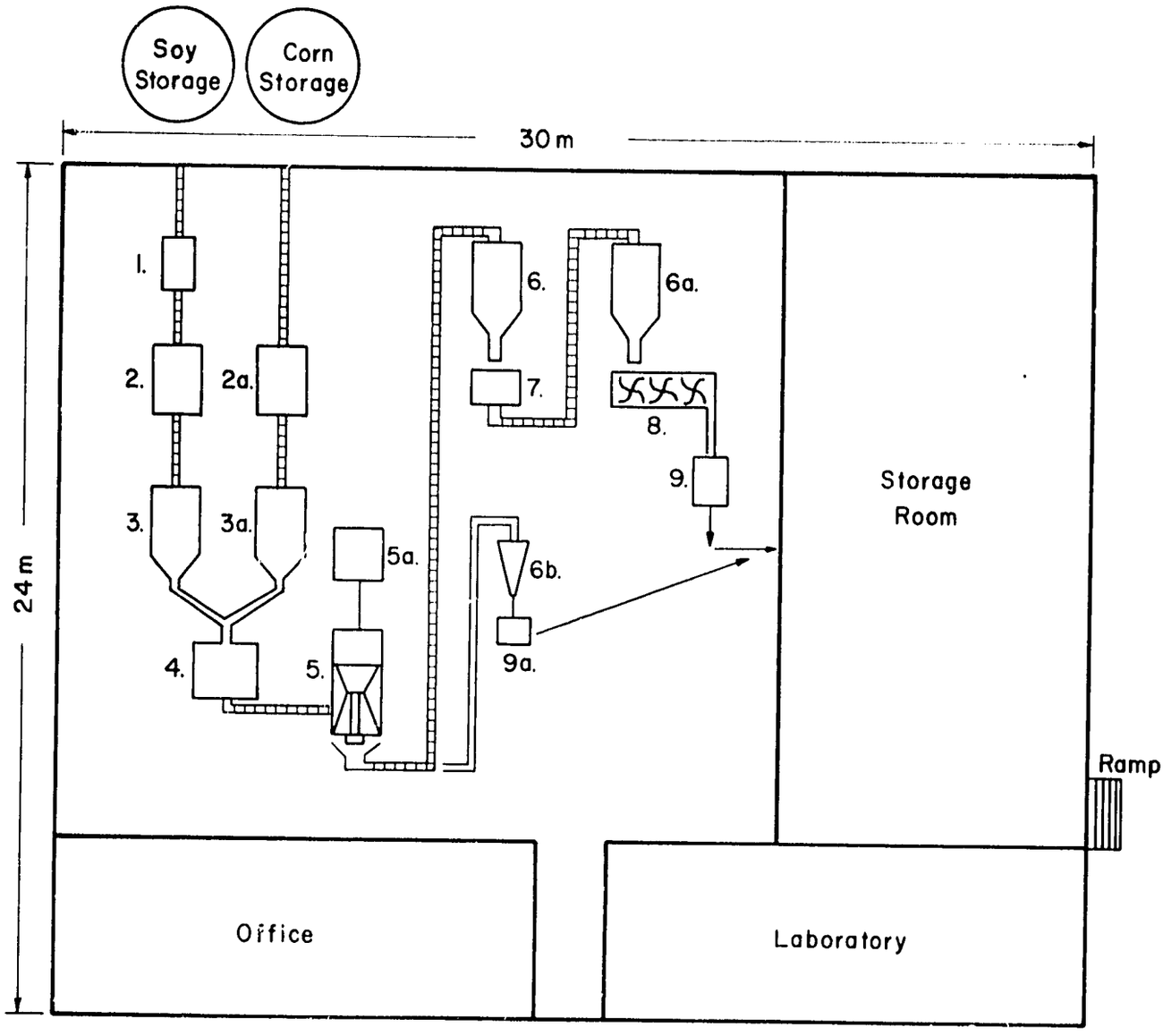
The ingredients composition of two mixtures to be processed with the Brady extruder is shown in Table VIII. Preliminary test runs showed that the mixtures could be processed without mechanical problems if components were not ground too fine. Studies also included water addition and preheating before extrusion in order to rupture gossypol glands--a necessary treatment.

Samples of the mixtures before and after processing will be analyzed for free and total gossypol, available lysine, free fatty acid and trypsin inhibitor activity and will be assayed for protein quality. Physical characteristics of the ground, processed product will also be determined. Once optimum conditions are known, large batches will be processed for acceptability trials.

Table VIII. Ingredient Composition of a High-Protein Food for El Salvador

Ingredient	%	%
Corn or other cereal	25	37[1]
Cowpea	45	36[1]
Cottonseed flour	27	6
Cottonseed kernel	--	20[1]
Vitamin and mineral supplement	3	1

[1] Processed in a blend with the Brady extruder.



1. Soybean Dehuller
2. Soybean Cleaner
2a. Corn Cleaner
3. Soybean Storage
3a. Corn Storage
4. Mix-All Mill
5. Brady Crop Cooker
5a. Motor for Crop Cooker
6. Surge Tank
6a. Surge Tank
6b. Surge Tank
7. Mill
8. Mixer
9. Packaging
9a. Packaging

Figure 3. Floor plan of proposed processing plant in Honduras.

Honduras

The mixture suggested for Honduras is made from 70 parts corn and 30 parts whole soybeans. Conditions for processing this mixture have been developed, and the quality of the product to be obtained is already known. By the end of 1975, a prototype processing plant was proposed to the Honduran Government as shown in Figure 3. The plant includes silos for the grains, dehulling equipment for soybeans, grinder, extruder, grinder and mixer, culminating with packaging equipment. The blending equipment is for mixing antioxidant, flavoring compounds and a standard vitamin mixture of the 70/30 corn/soybean blend. Samples have been sent for acceptability trials, and results were highly encouraging. A final decision has not been made by the government agency which requested the mixture.

Panama

A high-protein, quality food called "Nutrebien" was formulated for Panama in 1973. The composition is shown in Table IX. It is made of 60 parts rice flour, 16 parts whole milk powder and 24 parts sugar. Because of its high cost, requests have been made by the Nutrition Section of the Ministry of Health to study the possibility of reducing the cost by modifications of the ingredients without changing nutritive value and acceptability. Preliminary tests were carried out in December 1975, in which rice was processed with the Brady extruder, alone or mixed with corn or with soybeans. These were added to the formulas shown in the table. Acceptability was good, and the fact that it did not require cooking before consumption was a very attractive characteristic to the mothers. At the present time studies are starting on optimum processing conditions to be followed by chemical and biological analyses. Consideration will have to be given to stability of the product, since various vitamin and mineral supplements (iron) will be added. The program also includes storage tests and large-scale acceptability tests.

NOTE: Material presented was taken from the following paper.

Bressani, R., M. R. Molina, L. G. Elias, H. Gudiel and R. Cuevas. 1976. Exploration of the Potential for Low-cost Extrusion Cookers in Latin America. Institute of Nutrition of Central America and Panama (INCAP), Guatemala, Central America.

Table IX. Ingredient Composition of "Nutrebien" Supplemental Food for Panama

Ingredient	%	%	%
Rice	60	60[1]	60[1]
Whole milk	16	8	--
Sugar	24	24	24
Soybean (full-fat)	--	8[1]	16[1]

[1]Processed individually or in a blend with the Brady extruder.

Ecuador

A formula very much like the one for Panama has been proposed for Ecuador. It may use oats rather than rice, or both will be made, one for the highlands and one for the lowlands. A chemical engineer is now at INCAP working on the laboratory production of such a mixture and receiving training for quality control.

CONCLUSION

Even though the Brady extruder has been at INCAP for a relatively short period of time, the work carried out has suggested that the equipment has much potential to process mixtures of a variety of ingredients. At least 15 students attending the graduate program in Food Science and Technology of INCAP have been trained in the use of the machine for the production of foods for human consumption, as well as for animal feeding. It is felt that it is just a matter of time before one or all of the potential applications become a reality.

Exploration of the Potential for Low-cost Extrusion Cookers in East Africa

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PART I

Objectives

In mid-1974, EAIRO and USAID signed a Memorandum of Understanding to define in general terms the work to be performed by each party. The broad objective of EAIRO's work is to evaluate a Brady extruder, thereby assessing the usefulness of this type of extrusion cooker for the manufacture of low-cost nutritious foods and food ingredients in East Africa. In April 1976, we drew up a research program for test runs on the extruder.

The purpose of the testing program was to produce: (1) weaning foods, (2) bread fortifiers and enriched flours, and (3) nutritious snacks with flavoring.

Experience Gained with LEC

Tests conducted to date on the Brady (Fig. 1) involved using various combinations of degermed maize meal and soybeans (dehulled) to produce a weaning food. Nearly 1.5 tons of well-cooked product (70% maize/30% soy) were shipped to Tanzania for market testing. This is the most promising application of the Brady Project. Product evaluation results will be reported later.

Figure 1. The Brady Crop Cooker with personnel at EAIRO facilities in Nairobi, Kenya.

Suggestions for Additional Research

A. Weaning Foods--Duration: approximately 3 months

1. Goals

   a. be 15-20% protein
   b. be well-cooked
   c. be of low fiber
   d. use dehulled seeds
   e. emphasize mixture of approximately 70% cereal (maize) and 30% oil seeds (soybeans)

2. Possible Ingredients

   a. maize
   b. sorghum
   c. sim sim

3. Formulations (300 lb batches)

   a. 90%-10% maize-soy (completed)
   b. 80%-20% maize-soy (completed)
   c. 70%-30% maize-soy (completed)
   d. 90%-10% sorghum-soy (270 lb-30 lb)
   e. 80%-20% sorghum-soy (240 lb-60 lb)
   f. 70%-30% sorghum-soy (210 lb-90 lb)
   g. 90%-10% sorghum-sim sim (270 lb-30 lb)
   h. 80%-20% sorghum-sim sim (240 lb-60 lb)
   i. 70%-30% sorghum-sim sim (210 lb-90 lb)
   j. 90%-10% maize-sim sim (270 lb-30 lb)
   k. 80%-20% maize-sim sim (240 lb-60 lb)
   l. 70%-30% maize-sim sim (210 lb-90 lb)

4. Temperatures

   a. very low (280-310°F)
   b. very high (310-340°F)

B. Bread Fortifiers and Enriched Flours--Duration: approximately 2 months

1. Possible Ingredients

   a. soybeans (100 lb)
   b. sim sim
   c. peanuts (probably)
   d. defatted meal

2. Temperatures: 280°F or higher, if possible

C. Snacks (600-lb batches), Duration: approximately 1 month

1. Goals

   a. a crisp product
   b. 10% protein
   c. good and presentable color
   d. less than 10% oil

2. Possible Ingredients

   a. rice
   b. maize
   c. sorghum
   d. soybeans
   e. peanuts
   f. sim sim

3. Proportions

   a. 100% cereal-0% oil seeds
   b. 90% cereal-10% oil seeds
   c. 80% cereal-20% oil seeds

4. Temperature: 320°F or higher

5. Flavorings

   a. bananas
   b. chili sauce
   c. cheese
   d. other

6. Formulations (600 lb batches)

   a. 90%-10% rice-soy (540 lb-60 lb)
   b. 80%-20% rice-soy (480 lb-120 lb)
   c. 70%-30% rice-soy (420 lb-180 lb)
   d. 90%-10% rice-sim sim (540 lb-60 lb)
   e. 80%-20% rice-sim sim (480 lb-120 lb)
   f. 70%-30% rice-sim sim (420 lb-180 lb)
   g. 90%-10% rice-peanut (540 lb-60 lb)
   h. 80%-20% rice-peanut (480 lb-120 lb)
   i. 70%-30% rice-peanut (420 lb-180 lb)
   j. 90%-10% maize-peanut (540 lb-60 lb)
   k. 80%-20% maize-peanut (480 lb-120 lb)
   l. 70%-30% maize-peanut (420 lb-180 lb)

Specific Evaluation Sites

Bakery research was conducted at the Wheat Quality Control labs of the Ministry of Agriculture at Njoro, Kenya.

PART II

Introduction

Fortifying wheat flour with full-fat soy flour in making bread can raise protein content, balance essential amino acids, and increase bread's caloric value. Such fortification can adversely affect baking quality of wheat flour. Sodium stearyl-2-lactylate (SSL) could increase the stability of dough containing 8% soy flour. The effect was enhanced with increased additions of SSL (0.25 to 3.0%). All breads with 4 to 24% soy flour exhibited a small loaf volume. When 1.0% SSL was added, acceptable bread resulted from wheat fortified with soy flour up to 16%.

Protein malnutrition, a serious problem of people whose diets consist mainly of cereal or starch foods, has aroused keen interest in fortifying breads or other products with protein-rich foods. Of all the protein-rich additives now available, soy flour is most attractive in price and nutritional quality. Soy flour has been extensively studied and generally recommended as a bread fortifier. However, in many poverty areas where diets are deficient in both protein and calories, full-fat soy flour can become an ideal supplement because of its high protein and fat content (Fig. 2). Furthermore, to produce full-fat soy flour, simple and low-cost equipment, like the Brady Crop Cooker, can be set up and run in Africa.

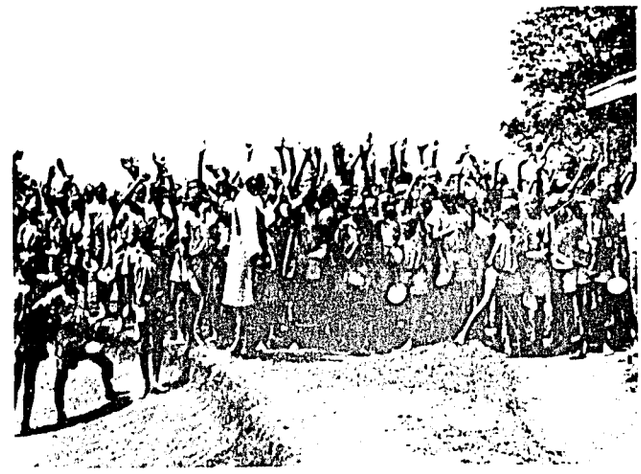

Figure 2. "The 'ayes' have it!" East African children respond in the affirmative during acceptability test of extruded food.

Many workers, notably Finney et al. (1963), Pomeranz et al. (1969), and Tsen and Hoover (1971) have shown that adding glycolipids and dough conditioners improve baking performance of flours fortified with soy products, particularly defatted soy flour.

Bookwalter and Mustakas (1971) used extrusion-cooked, full-fat soy flour in high-protein bread. They found that loaf volume decreased less with extruded products than with non-extruded, full-fat soy flour.

Our study--part of a research program on extrusion cooking for production of low-cost nutritious foods--was undertaken to examine dough and baking properties of wheat flour fortified with full-fat soy flour and changes which occurred when sodium stearyl-2-lactylate was added.

Materials and Methods

Wheat flour was milled by a commercial mill for home baking. Although this is a weak wheat flour, it is the most available in East Africa. The full-fat soy flour was cooked in the Brady at 260°F. Their proximate analyses were:

Flour	Moisture, %	Protein,[1] %	Fat, %
Wheat flour	11.0	10.8	--
Full-fat soy flour	4.0	35.0	21.0

[1]Protein content is %N x 6.25 for soy; and %N x 5.7 for wheat flour.

Farinograms

Farinograms were obtained by the constant dough weight methods, using 50 grams of sample (AACC, 1962).

Baking Test

The "Remix" Baking Test (Irving and McMullan, 1960) was used. The method requires no skilled punching, detects extreme strength more readily and discriminates more widely between strong and weak flours.

Formula

Flour (14% m.b)	100.0 g
Water (distilled)	variable
Yeast	1.2 ADY (25 ml)
Sugar	2.5 g
Salt	1.0 g
Potassium bromate	1.5 mg%
Phosphate	0.1 g
Malt	0.3 g

Procedure

1. Mix ingredients for 2.0 minutes in a mixer (National Manufacturing Co., Lincoln, NE)
2. Ferment for 140 minutes at 30°C
3. Ferment for 25 minutes (recovery time)
4. Sheet and mold
5. Proof for 55 minutes at 30°C (86°F)
6. Bake 25 minutes at 430°F

Results and Discussion

Rheological Properties of Doughs Fortified with Various Percentages of Full-fat Soy Flour and Treated with and without 1.0% SSL

Table I shows changes in absorption, developing time, and stability of doughs of wheat flour fortified with 0 to 24% soy flour with and without SSL added.

Absorption of the fortified flour dough increased slightly as full-fat soy flour was increased. Dough peak time was 5.0 minutes for wheat flour dough and 6.5 minutes for dough fortified with 24% soy flour. Despite the different percentages of fortified soy flour, changes in peak time among fortified doughs were extremely small. Surprisingly, dough stability increased with higher levels of soy.

Adding 1.0% SSL did not affect absorption but could delay dough development and increase dough stability of wheat flour fortified with soy flour (Table I).

To substantiate that SSL could increase mixing stability of dough containing soy flour, additional tests were made to examine effects of SSL added at 0.25, 0.50, 1.00, 1.50, 2.00, 2.50 and 3.00% SSL on doughs containing 8% full-fat soy flour. That both dough-developing time and stability increased as SSL increased confirmed the dough-strengthening effect of SSL for soy fortified dough (Table II).

Effect of Different Percentages of Full-fat Soy Flour on Baking Quality

To explore how much full-fat soy flour could be used, we fortified wheat flour with 4, 8, 12, 16, 20 and 24% soy flour and evaluated their baking performances. The "Remix" Baking Test (Irving and McMullan, 1960) was employed.

Table III shows the adverse effects of full-fat soy flour on loaf volume of finished bread; loaf volume produced progressively with the soy flour increments.

The improving effect of SSL was obvious. Without 1% SSL, all finished breads supplemented with 8 to 24% soy flour had small loaf volumes. However, with 1% SSL breads made from wheat flour fortified with soy flour, up to 16% had acceptable specific volumes (Table III).

Table I. Farinographic Characteristics of Wheat Flour Fortified with Indicated Percentages of Full-fat Soy Flour and SSL

Full-fat Soy Flour	Absorption, %	Peak Time, minutes	Stability, minutes	Absorption, %	Peak Time, minutes	Stability, minutes
0	58.0	5.00	7.5	56.8	2.0	14.0
4	57.4	6.00	8.0	56.8	9.25	15.5
8	57.2	5.50	8.5	--	8.0	17.0
12	58.0	4.50	9.0	55.6	10.0	17.5
16	59.0	5.50	9.5	57.0	10.0	17.0
20	59.2	6.00	11.5	57.4	10.0	17.0
24	60.2	6.50	13.0	59.2	9.25	17.0

Table II. Farinographic Characteristics of Wheat Flour Fortified with 8% Full-fat Soy Flour and Treated with Indicated Percentages of SSL

Full-fat Soy Flour %	SSL, %	Absorption, %	Peak Time, minutes	Stability, minutes
0	0.0	58.0	5.0	7.5
8	0.0	57.2	5.5	8.5
8	0.25	--	6.5	10.0
8	0.5	56.2	5.25	12.0
8	1.0	--	8.0	17.0
8	1.5	55.8	7.75	18.75
8	2.0	55.0	13.25	19.00
8	2.5	55.0	17.75	18.75
8	3.0	53.4	16.25	18.75

Table III. Effects on Baking Quality of Fortifying Wheat Flour with Indicated Percentages of Full-fat Soy Flour and SSL

Full-fat Soy Flour %	SSL, %	Absorption, %	Average Loaf Volume, cc	Average Specific Volume, cc/g
0	0.0	58.0	560	4.3
4	0.0	57.4	490	3.4
8	0.0	57.2	500	3.8
12	0.0	58.0	450	3.5
16	0.0	59.0	420	3.2
20	0.0	59.2	430	2.9
24	0.0	60.0	370	2.9
0	1.0	56.8	640	5.1
4	1.0	56.8	625	4.9
8	1.0	--	--	--
12	1.0	55.6	570	4.5
16	1.0	57.0	560	4.3
20	1.0	57.4	510	4.0
24	1.0	59.2	480	3.8
8	0.0	57.4	500	3.8
8	0.25	--	--	--
8	0.50	56.2	560	4.4
8	1.00	56.0	575	4.5
8	1.50	55.8	530	4.2
8	2.00	55.0	530	3.4
8	2.50	55.0	530	3.4
8	3.00	53.4	430	2.9

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Low-cost Extrusion Cooker Use in India

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India is the second most populous and the seventh largest country in the world. The existing large number of people and the present population growth are thought to be the major causes of proverty and malnutrition in the country. The nutrition survey among preschool children showed that in 90% of them the heights and weights were below the 10th percentile values of American children of corresponding ages. Eighteen percent of the children were suffering from grade III malnutrition (weight deficit of 40% or more), and 65% of the children were suffering from grade I and II malnutrition (weight deficits of 10-25% and 25-40%, respectively). In view of the importance of proper nutrition in the early part of life, the Government of India has been sponsoring large-scale supplementary feeding programs for preschool and school children. Mere feeding programs cannot bring a permanent solution to this problem. Only well-administered and consistent integrated programs produce positive results.

The Special Nutrition Feeding Program for preschool children began in 1971-72 by the Union Social Welfare Department. The benefits were extended to pregnant and nursing women as well. The supplement consists of 300 calories and 10-15 grams of protein for children and 500 calories and 25 grams of protein for pregnant and nursing women. The scheme includes immunization and medical checkup. Bread and milk or other processed foods are the main items of food in urban areas. In tribal areas, locally produced foods, gift foods or Bal Ahar are used. CARE gift commodities are used in many areas, hence the cost of food on an average comes to within 22 paise[1] per beneficiary per day. To correct the ill effects of malnutrition, a new Central Government Scheme for Integrated Child Development Services was started in 1975 as a pilot project in 30 centers.

The Applied Nutrition Program is basically educational in character. It aims at stimulating self-help activities for optimum use of available food resources. One of the main components of the program is demonstration feeding. The number of beneficiaries varies from 20 to 30 at each center. Rs.10 crore[2] was allocated in the Fourth Five-Year Plan for setting additional blocks. Under this scheme feeding is carried out at balwadis, health centers or similar centers. At the state level the Department of Community Development is usually responsible for implementing the program.

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[1] 1 rupee (Rs.) = 11.75 U.S. cents
100 paise = 1 rupee

[2] Crore is a mathematical term meaning 10,000,000 or 10^7 units.

Feeding programs for children through balwadis include immunization, health checkup and socialization through games and recreation. A provision of 15 paise per child per day was made. Allowing for fuel and other items to be supplied through local contribution, the total cost per child per day amounted to approximately 25 paise.

The school feeding program has been initiated by the government on a large scale. The main school feeding program is the Mid-day Meal Program, largely assisted by CARE. Nearly 10% of the beneficiaries are preschool children. Bal Ahar is one of the food supplements in this program. Each child receives 75 grams of Bal Ahar, which provides about 300 calories and 15 grams of protein. Fifteen thousand tons of Bal Ahar were produced in 1971-72 (present production has gone up to 40,000 tons).

The programs are implemented by various departments of the government--like Education, Social, Welfare, Panchayati Raj, Health and Family Planning, Industry and Labor, State Social Welfare Board and several voluntary agencies like mahila mandals, youth clubs, Indian Red Cross, Ramakrishna Mission, etc. Several voluntary agencies like CASA, CRS, CINI, etc., are also organizing integrated nutrition programs, partly with gift foods.

Table I summarizes the overall nutrition programs in the country.

In most of the programs raw foods are supplied which require cooking at the feeding centers. A few typical foods are: soy-fortified bulgur, whole wheat, soy-fortified flour, CSM, CSB, soy-fortified sorghum grits, milk powder, Bal Ahar, etc. Only bread and biscuits are ready-to-eat foods, but their shelf life is relatively poor. So there is need for bulk production of ready-to-eat foods for institutional feeding in order to insure safety, convenience and economy.

There has been some public awareness of nutrition in recent times in the country. In the "Study of Food Habits in Calcutta" made in 1969 and sponsored by the USAID, it was revealed that 32% of the housewives were aware of protein, and 64% of them were aware of vitamins. But the existing high-nutrition foods commercially marketed in India are generally beyond the reach of poorer segments of the population. Table II shows the types of high-protein foods made in the country and their total production, which is rather insignificant compared to the total need of the country.

Table 1. Physical Targets Achieved in 1973-74 Under the Special Nutrition Program in India.

	Urban Slums	Tribal Areas	Total
Beneficiaries	1,813,957	1,884,447	3,698,404
Centers	8,253	19,864	28,117

Source: Handbook on Social Welfare Statistics, Department of Social Welfare, Government of India, 1974

Allotment of Applied Nutrition Program Blocks Since Inception

Third Plan	Block Allotted During 1966-67 to 1968-69	Block Allotted During 4th Plan	Allotted during 1974-75	Proposed during 1975-76	Total ANP Block
219	520	442	94	100	1,281

Source: Report 1974-75, Ministry of Agriculture & Irrigation, Department of Rural Development, Government of India

Number of Balwadis Functioning in 1973-74 Under the Program of Nutrition

Number of Balwadis Functioning	Number of Beneficiaries	Expenditure (Rs. in lakhs[1])	Coverage of Mid-day Meals Program in Schools During the years 1971-72 and 1972-73 Number of Beneficiaries (lakhs[1]) 1971-72	1972-73
5,950	224,644	325.95	119.48	110.19

Source: Handbook on Social Welfare Statistics, Department of Social Welfare, Government of India, 1974

[1] 1 lakh = 100,000 or 10^5

There are many ways through which ready-to-eat foods could be manufactured. Roller drying and extrusion cooking are the most common methods in preparation of such foods. Roller drying normally is expensive, because the water evaporation required per ton of finished product can be as much as 20 times that in an extrusion cooker. During the past 20 years, considerable development has taken place in extrusion cooking technology.

But the interest in the use of extrusion cookers is relatively new in India. During the past five or six years a few extrusion cookers have been installed in different parts of the country. In January 1976, a workshop on "Extruder-based Foods in India" was organized by the Protein Foods and Nutrition Development Association of India in order to examine the relevance of extruder cookers in India, their present status and potential applications.

Textured vegetable protein is being produced and marketed by Soya Products and Research Association, Bareilly, Uttar Pradesh with the trade name "Nutri Nugget." Mysore Snack Foods, Bangalore, Karnataka is producing "Crunchies," a snack food. Also at "Amul's" factory, a Wenger X-25 extruder-cooker-dryer was installed with UNICEF assistance. With the participation of the Government of Gujarat, Union Social Welfare Department, Food and Nutrition Board (Government of India) and CARE, the extrusion-cooked foods are being introduced in the Special Nutrition and Mid-day Meal Programs for supplementary feeding. A Manley extruder is operating at Delhi for production of snack foods. Also, one extruder is known to have been installed at Poona. Another extruder is already under installation, with the assistance of UNICEF, at the extruded food plant in Hyderabad, where the Government of India, the Government of Andhra Pradesh and CARE are also participating. The plant is capable of providing a ready-to-eat snack to 200,000 beneficiaries. An Anderson extruder cooker is being installed at Gaziabad with the UNICHEM group.

Yet the necessity for a low-cost extruder particularly for developing countries is being felt because most of the extruder plants require large capital investment, sophisticated controls and skills, and large overheads and indirect costs. In 1973, one low-cost extruder, the Brady #206 Crop Cooker, was brought to Calcutta by CARE-India with the consent of the Department of Food, Ministry of Agriculture, Government of India, to test its suitability in preparing ready-to-eat nutritious foods for distribution in feeding programs. The machine was developed by the manufacturer mainly to produce heat-processed soybeans for use as livestock ration. Previously, it had not been tried in manufacturing snack or ready-to-eat foods. The machine was installed at the factory premises of the United Flour Mills Co. Ltd. and the United Cereal Products Ltd. in 1973. The UFM-UCPL provided

Table II. Types, Approximate Quantities and Value of Protein-based or Protein-enriched Processed Foods Produced Annually in India[1]

	Quantity tons/year	Price Rs./kg	Rough Value Rs. crores
Milk powders	20,000	15	30.0
Infant and baby foods	18,000	20	36.0
Weaning foods	1,000	20	2.0
Beverage powders (malted milk, cocoa, etc.)	12,000	20	24.0
Protein-rich powders[2]	2,000	8	1.6
Bal Ahar[2]	15,000	3	4.5
Biscuits (enriched with protein and vitamins)	700	15	1.0
Bread (enriched with protein and vitamins)	45,000	3	13.5
Extruded foods	2,000	12	2.4
"Pharmaceutical" foods	300	40	1.2
			116.2

[1]Source: "Protein Foods and Nutrition Development Association of India," Newsletter No. 23, 1975.

[2]Largely for use in feeding programs.

space, a motor, a mixer, skilled and unskilled workers, whereas the Department of Food, Ministry of Agriculture provided part of the raw materials, and CARE provided part of the raw materials and general supervision. Trials were conducted mostly under the technical guidance of the author, who is the Technical Advisor to the UCPL under contract between UCPL and Jadavpur University.

The main objective of the study was to utilize locally available food resources for manufacture of acceptable products and many varieties of low-cost raw materials available in different parts of the country were used. Trials were started in October 1973 with the technical assistance of representatives from the Koehring Farm Division. Tables III and IV indicate the findings on some important types of food combinations. From these trials, the following conclusions were made:

1. The machine can use any dry food material (moisture 10-15%) with at least 5-10% oil in it and produce a semi-powder or irregular chips, which can be screened to different sizes and can be used as ready-to-eat snacks or as a porridge base.

2. The machine cannot use a very finely ground raw material or a coarse material with a large amount of added oil. Coarse materials often come out uncooked and high amounts of added oil adversely affect the free-flowing character of the raw ingredients. Ground raw materials, nearly 20-mesh size, were found to produce desirable results.

3. Many of the products were poorly puffed and expanded, and appeared to be gritty and uncooked.

4. The machine can stabilize parboiled rice bran (Table V).

5. The main limitation of the machine was that it cannot produce a shaped product.

6. Because of the presence of oil, the finished product turned rancid within a short time in storage.

Trials were continued to subsequent years in order to develop a more acceptable, uniform and well-puffed and cooked product. It was found that cooking with added water was more desirable than cooking with added oil.

The experimental data for these trials are given in Table VI. It was observed that a highly puffed product was obtainable by this process. The density of the product was comparable with samples obtained from other commercial extrusion cookers. From the above studies, the following conclusions were drawn:

1. A uniformly cooked product can be obtained by adding water and using less added oil.

2. A highly puffed product can be obtained by using a suitable percentage of added water, which varies from product to product.

3. An optimum percentage of added water, which differs for each product combination is required. Below this level, the machine jams or the product comes out as a continuous stream which cannot be separated by the rotating knife above this level.

4. The granularity of the ingredients must also be adjusted to an optimum value, below which the feed auger becomes ineffective, and above which the materials come out uncooked.

5. The dried, finished product has long shelf life if it contains lesser amounts of oil.

6. A manufacturing unit based on the Brady #206 Crop Cooker can well fit into the infrastructure of small-scale industries in India. Table VII indicates the estimated capital investment and processing cost for such a unit.

7. The product can be sized into small chips for consumption as snack food. After grinding into a fine powder, it also can be used as a porridge with cold water.

Table III. Trials on Brady #206 Crop Cooker (hp - 100, rpm - 580)

Item Number	Raw Materials Composition, % by weight	Granularity	Steady State Temperature °F	Processing Conditions: Feed Auger Setting	Processing Conditions: Average Output Rate, kg/hr	Steady Current amps
1	Corn 80 Soybean 20	degermed corn grit dehulled soy grit	280	1.5	250	60
2	Corn 70 Soybean 30	degermed corn grit dehulled soy grit	310	1.5	--	60
3	Corn 95 Salad oil 5	degermed corn grits	250	1.5	--	--
4	Corn 85 Salad oil 15	ground degermed corn pass through 20 mesh	240	--	--	65
5	Soybean 100	dehull soy grits	200	--	--	--
6	Corn 70 Bengalgram 15 Groundnut 15	all ground pass through 20 mesh	280	1.5	--	39
7	Corn 75 Groundnut 25	all ground pass through 20 mesh	290	1.5	180	37
8	Wheat 75 Soybean 25	all ground pass through 20 mesh	285	--	290	76
9	Wheat 80 Groundnut 15 Salad oil 5	all ground pass through 20 mesh	315	--	216	52
10	Wheat 80 Soybean 15 Salad oil 5	all ground pass through 20 mesh	310	--	270	54
11	Bajra 85 (*Pennisetum typhoideum*) Groundnut 15	all ground pass through 20 mesh	290	--	285	60
12	Tapioca chips 50 Soybean 50	all ground Pass through 20 mesh	--	--	--	--
13	Rice 50 Soybean 50	all ground pass through 20 mesh	--	--	--	--
14	Ragi 80 (*Eleusine coracana*) Soybean 20	whole ragi and ground soybean pass through 20 mesh	--	--	--	--
15	Soy fortified Bulgur 95 Salad oil 5	not ground	--	2.0	--	--

Table IV. Trials on Brady #206 Crop Cooker

Item Number	Machine Performance	Product Quality: Final Moisture, %	Product Quality: Texture	Additional Remarks
1	Smooth	6.5	slightly puffed	Few uncooked grits came out
2	Smooth	5.8	well puffed	None
3	Tends to jam	--	very hard	A solid tube came out--uncooked grits visible
4	Fluctuating load	--	well puffed	Raw material flow poor in feed auger
5	Smooth	--	small flakes	No urease activity
6	Not smooth	6.9	slightly puffed	Groundnut flavor detectable
7	Smooth	--	well puffed	None
8	Smooth	--	slightly puffed	None
9	Smooth	--	as above	None
10	Smooth	6.6	as above	None
11	Tends to jam	8.9	not puffed	Hard texture
12	Tends to jam	--	not puffed	Hard and gritty
13	Fluctuating load	--	not puffed	Gritty
14	Smooth	--	not puffed	Gritty
15	Smooth	6.8	slightly puffed	None

Table V. FFA Development During Storage in Extrusion Cooked Parboiled Rice Bran

Cooking Temp., °F	Months: 0	1	3	6	10
Control	1.64 (9.76)[1]	1.98 (8.80)	6.79 (7.95)	33.56 (6.49)	35.73 (7.02)
220	1.67 (5.26)	1.69 (5.48)		3.65 (6.12)	6.89 (6.85)
250	2.52 (4.74)	2.10 (5.00)	4.50 (--)	4.42 (5.56)	8.08 (5.82)
280	1.51 (4.56)	1.23 (4.52)			
300	1.83 (3.46)	1.50 (4.10)			

[1] Figure within parentheses indicates corresponding moisture.

In 1975 nearly one ton of ready-to-eat food in the form of highly puffed snacks was produced from wheat and Bengalgram dal of the same specifications as stated in item 21 of Table VI. The product was sweetened (10% added sugar) and salted (2% added salt plus 5% salad oil and then flavored with ground spices) separately in two batches. The products were then put to acceptability trials with preschool children in five MCH centers controlled by local voluntary agencies. The acceptability trial was conducted by CARE-West Bengal in collaboration with the Indian Dietetic Association. Three hundred children were given an 80-gram ration per day for four weeks. The ready-to-eat food was highly acceptable, and children preferred it to the porridge made from wheat suji normally served in the centers.

Throughout the world the consumption of ready-to-eat and convenience foods is increasing rapidly. The consumption of bread and biscuits has increased severalfold in India during the past two decades as indicated in Table VIII. There has been a 250% increase in bread production during the 1960's. Biscuits have an added advantage in shelf life and so penetrate deeply into the rural areas. But the traditional snack foods prepared from rice are often overlooked. The three principal ready-to-eat foods from rice are the puffed rice (murmura), beaten rice (chura) and parched paddy (kheel). These are mostly prepared in home-scale or cottage-scale industries.

Table VI. Trials on Brady #206 Crop Cooker (hp - 100, rpm - 580)

Number	Raw Materials,[1] Composition in Parts by Weight	Processing Conditions Steady State Temperature, °F	Final Product Average Moisture	Average Bulk Density, g/ml	Density, g/ml (mean ± S.E.)
16	degermed corn 100 water 10	300	6.1	0.123	0.201 ± 0.023
17	parboiled rice 100 water 8	285	6.0	0.131	0.228 ± 0.0213
18	milo (*Sorghum vulgare*) 100 water 10	280	5.5	0.140	0.232 ± 0.014
19	wheat 100 water 12	320	6.3	0.26	0.553 ± 0.0186
20	dried tapioca chips 100 water 10	290	5.1	0.1643	0.269 ± 0.0132
21	wheat 75 dehusked Bengalgram 25 water 10	320	4.85	0.276	0.616 ± 0.0098
22	wheat 75 dehusked Bengalgram 15 salad oil 10	310	4.5	0.437	0.912 ± 0.0256

[1]All ingredients ground to pass through 20 mesh.

Table VII. Estimate of Processing Cost in Brady #206 Crop Cooker

Capital	
Land	Rs.100,000[1]
Shed and building	Rs.250,000
Machinery	
Extruder	Rs. 80,000
Motor	Rs. 60,000
Ancillary equipment	Rs.200,000
	Rs.690,000
Running Expenditure (annual)	
Salary and wages	Rs. 60,000
Electricity and other utilities	Rs. 80,000
Maintenance	Rs. 20,000
Fixed charges	Rs.120,000
	Rs.280,000
Total Material Processed Annually (2 shift basis)	1,200 tons
Processing Cost per Ton	Rs. 233

[1]1 rupee = 11.75 (U.S.) cents

As much as 10% of the rice grown in the country is utilized in production of these commodities, so nearly 4 million tons of snack foods are made from rice. These products are also given to children in different forms. The puffed rice is often consumed in villages after soaking in cold water for convenience in eating. A mixed, fried snack (prepared from sev, beaten rice, groundnut, Bengalgram, etc.), known as chamachu, is also consumed to a large extent today. By and large, puffed rice is eaten as supplementary snacks in the morning and afternoons. For many children it is a breakfast food and is also eaten at tiffin time. Puffed rice is a widely accepted product in West Bengal. In the "Calcutta Food Habits Study" it was revealed that 45% of all households consume puffed rice regularly. Seventeen percent of Calcutta's pre-school children eat puffed rice every day and poorer children eat relatively more of it.

Table VIII. Bread and Biscuit Production in India

Year	Biscuit Production, tons	Bread Production, tons
1950	--	--
1951	15,864	--
1959	19,668	~60,000
1967	56,424	--
1970	62,196	165,000
1971-72	--	198,000
1973	70,175	--

Extruded low-cost, ready-to-eat snacks may have wide acceptability in India and may be marketed through regular commercial channels, but the potential for using the ready-to-eat foods in institutional feeding is greater. Nineteen percent of the population is below six years of age or about 100 million children are in the preschool age group. Another 100 million children are in the age group between 6 and and 15. At present only about 9 million preschool children and about 11 million school children are covered by the nutrition program. Hence there is great scope of expanding the institutional feeding programs, and low-cost, ready-to-eat foods can fit into such programs in a meaningful way.

The Brady #206 Crop Cooker is a simple machine and seems to have great utility in the manufacture of ready-to-eat snacks for institutional feeding programs. But additional research and investigational work may be continued in the following lines before installing the machine in large numbers in various parts of the country for utilization of many kinds of locally available food resources:

1. To establish the optimum granularity and optimum moisture content of the various combinations of raw ingredients in order to obtain an acceptable product.

2. To explore the possibility of making TVP from soybean in the form of minced meat.

3. To study the losses of major nutrients in the process of extrusion cooking for a major variety of products.

4. To innovate gadgets for automatic control of the cone clearance in relation to the change in the process temperature.

5. To design a suitable device for making a shaped product.

Exploration of Potential for Low-cost Extrusion Cooker in India

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INTRODUCTION

Ready-to-Eat (RTE) Food is a relatively new concept in the history of Child Nutrition Program in India. Since the inception of the CARE-assisted Child Nutrition Program in 1960, food has generally been distributed in a raw form to the rural schools where it was then cooked each day and served to the children. Although many millions of children were fed daily with food prepared at the schools, there were numerous problems involved in daily preparation at the feeding centers. Fuel was expensive and scarce in the rural area; cooks, who were either volunteers or received only a small honorarium, were often unreliable; cooking facilities were primitive at best; and the headmasters had to take time away from their teaching duties to supervise the program.

To overcome these problems, experiments have been conducted with various methods of centrally preparing food. The advantages of a centrally prepared food are numerous:

1. Central cooking is more hygienic, there are fewer losses and accounting is easy.
2. Central preparation helps insure more regular feeding.
3. The time needed by teachers to supervise the program is greatly reduced.
4. Because of the quality control, centrally prepared food is often more acceptable to children.

However, in order for a centrally prepared food to be practical, it must come close to meeting these varied and difficult criteria:

1. High acceptability by the children.
2. Low cost of production.
3. High bulk density to facilitate transportation to the individual feeding centers.
4. Long shelf life.

Past experiments with centrally prepared food have included uppama (a boiled food similar to rice) in the Madras Central Kitchen Scheme and such RTE products as extruded deep-fried noodles (sev), a dry-roasted sweetened product (panjeeree) and various forms of biscuits. Unfortunately, however, each of these methods has its drawbacks. The Madras system requires daily distribution of a hot meal and it is very expensive; the fried noodles require a great deal of oil; and the dry-roasted products usually require the addition of expensive sugar.

It is against this background of experiments in centrally prepared food that CARE imported a Brady Crop Cooker in 1973. The main objective of this experimental program was to try to develop a product that would meet the criteria of long shelf life, high bulk density, low cost of production and acceptability by the children.

PAST AND PRESENT EXPERIENCES

During 1973 and 1974 different experiments were conducted with the Brady Crop Cooker with a variety of grains and mixes. Corn and oil; corn, bengalgram and ground peanut; corn, soy and oil; whole wheat, gram and oil; whole bajra (millet) and peanuts; and tapioca (semi-powder form) and dehulled crushed soy were all tried. (See Table I for formulation.)

Table I. Formulations

1.	Degermed corn	85%	90%
	Salad oil	15%	10%
2.	Degermed corn	70%	
	Bengalgram	15%	
	Ground peanuts	15%	
3.	Corn	80%	
	Soy	15%	
	Salad oil	5%	
4.	Whole wheat	75%	
	Gram	15%	
	Salad oil	10%	
5.	Whole Bazra (millet)	85%	
	Peanut	15%	
6.	Tapioca (semi-powder)	50%	
	Dehulled crushed soy	50%	

With almost all of these combinations there was the same problem of puffing. Each of these formulations, when suddenly heated, expanded or puffed. When this puffing took place while the raw material was still in the barrel of the extruder, the machine jammed. If the puffing took place as the product was extruded, there was a very low bulk density to the final product, and this increased delivery costs and storage problems.

The puffing of the product also caused the feed auger to jam. Puffed material would back up in the machine and quickly choked the hole at the top of the extruder through which the feed auger supplied the extruder screw. This blockage would also cause the steam to escape through the supply holes rather than through the end of the extruder. If either of the two screws jams, then the cooker must be stopped immediately, and the screw must be disassembled and cleaned thoroughly. This is a time-consuming process and can be very difficult if the molten foodstuffs in the extruder barrel congeals and hardens before the screw is removed.

The annular die also allows little control over the product shape or density, and this is a limiting factor when trying to control the problem of puffing.

It was also found that when attempts were made to produce a more homogeneous product by using a finely ground raw material there were problems with the food auger clogging. This limited the types of material that could be used, as both moist and dry types of flour mixes caused clogging.

Eventually, a fairly satisfactory product was developed using whole wheat (*Triticum aestivum*) and channa dal (*Dolichos biflorus*), a dried pulse similar to dried lentils. These were mixed in the ratio of 3 to 1. An 80-gram ration of this mix provided 300 calories and approximately 12 grams of protein. This is slightly below the optimum recommended as a supplement for school children, but it is still within permissible limits. (See Table II for varieties.)

Sweet and spicy variations of this mix were developed, and various experiments were conducted to determine both the shelf life and acceptability of the products. In general, it was found that extruded food (chips) would remain crisp for three months if properly protected in polyethylene laminated woven bags or containers.

Acceptability trials were conducted in five MCH (Mother-Child Health) centers, and from each center 60 children were chosen randomly over a period of four weeks. The basic objective of these trials was to determine the acceptability of the sweet and spicy formulations. The term "acceptability" was taken to denote an overall acceptance of the product by the children. To facilitate quantifying the degree of acceptability, the following attributes were taken into account:

1. general acceptance
2. taste
3. texture
4. quantity sufficiency
5. comparative analysis with the most-preferred normal food (porridge)

Table II. Variations and Analysis of Wheat-Dal Product[1]

Basic Formulation		
Wheat (*Triticum aestivum*)	75 %	
Channa dal (*Dolichos biflorus*)	25 %	
Spicy Variety (sprayed with):		
Salt	1.0%	
Mineral salt	1.0%	
Red chili powder	0.5%	
Black pepper	0.4%	
Citric acid	0.2%	
Salad oil	5.0%	
Sweetened Variety (coated with 10% sucrose solution on final weight)		
Analysis		
Moisture	2.58	2.98
Fat	3.60	0.90
Protein (N x 6.25)	16.00	13.31
Crude fiber	1.76	2.80
Ash	2.68	3.22
Available carbohydrates	73.38	76.79
	100.00	100.00
Energy (calories)	400	378

[1]The product was made on the Brady in the form of blended, uneven, irregular chips. It was broken into a regular size and spray-spiced or sugar-coated.

In comparisons with the most preferred food, responses indicated that 73% of the children felt that the spicy variety was better or equal to their favorite food. In the case of the sweetened variety, 58% preferred the extruded product to porridge. In terms of texture, both formulations rated about equal, although the spicy variety was slightly preferred.

The initial ration used was 80 grams, but it was usually found that only about 60 to 65 grams could be eaten at one sitting without taking water. The rest (15-20 grams) was observed to be taken home and possibly shared with other family members. In view of the fact that the full ration was not usually consumed at one sitting, it was felt that a ration of 70 grams might be more realistic.

Finally, in a general comparison--taking into account the three critical attributes of general acceptability, comparison with the most preferred food (porridge) and the variety preferred--it was found that the spicy variety of extruded product was the more acceptable of the two. This preference for the spicy variety was significant, as its cost of production was considerably less than that of the sweetened variety.

During the course of CARE-India's experiments with the Brady Crop Cooker, a number of problem areas in the preprocessing stage, processing stage and post-processing stage came to light.

Prior to the raw materials being fed into the auger, it was premixed by hand in order to provide a free-flowing mixture into the machine. This type of hand mixing was time consuming and unsanitary, and there was a problem of achieving uniformity in the mixture. A uniform mix was particularly important when there were so few ways to control the temperature, and it was essential if the cooker was to produce a standard product. A premixing unit that would automatically add the proper amount of moisture and thoroughly mix the ingredients would do much to achieve a standard product. Also, if this premixing could be combined with a gravity feed system, then the output of the cooker would be increased and production costs would be lower.

Processing problems mainly revolved around the puffing phenomenon and the factors that limited the kinds of materials that the machine could effectively handle. One of the main factors here was the limited control that the operator had over the cooking process. He can control the temperature only through changing the die opening or changing the rate of feed. If a heat-control system could be included in the machine, it would be much more versatile, and there would not be nearly so much time and material wasted at the beginning of the day in getting the machine adjusted.

Fine materials and floury products, either dry or moist, which facilitate the production of a homogeneous product tend to get stuck at the end of the feed auger and eventually cause jamming. This inability to effectively handle fine materials limits the selection of raw materials and recipes. If some method could be found to adjust the extruder so that it could utilize floury products more effectively, then the versatility of the Brady could be greatly increased.

Puffing created a product of low bulk density, and puffed products tend to lose their crispness quickly in hot, humid countries unless they are cooled adequately and protected by good packing. A cooling system may be necessary in some instances or during certain seasons. Another factor which contributed to the problem of low bulk density is the curling of the chips as they come from the extruder. These odd shapes make it difficult to pack the product tightly, thus increasing storage problems and increasing packaging costs. The provision of a rotating knife might solve part of this problem.

Although this paper has dealt mainly with the problems that developed during the experimental period, the general impression of the Brady was positive. The studies and tests conducted in Calcutta with the Brady have shown that the processing costs, when compared to other RTE production methods, are extremely low. The spicy chips have a high acceptability among children without the addition of costly sugar. With proper packing and storage the shelf life is adequate, and the potential of a 3,000-kg-a-day production capacity makes the Brady economical in terms of the capital investment. There are still problems to be solved, modifications to be made and additional equipment to be developed, but the trials in India have shown the Brady to be both feasible and economical.

QUESTION AND ANSWER SESSION

Mr. Sonaggere:

What was the cost per ton of the food?

Mr. Gupta:

Production costs came to about 233 rupees per ton; in terms of dollars, $25 per ton.

Exploration of Potential for Low-cost Extrusion Cooker—Worldwide

Mark Sterner
Meals for Millions Foundation, Inc.
Santa Monica, California

INTRODUCTION

Meetings such as this one are valuable, because reports from the field relative to problems encountered help us who are working with designs of machinery to address those problems in a form of engineering.

Extrusion technology has long held promise of being able to offer itself as a tool in developing countries for the production of highly nutritious, low-cost foods. It has for many years remained just this--a promise--and there are still relatively few success stories in less developed countries (LDC's). The question is "Why?" From the point of view of Meals for Millions, there are two major answers.

DETERRENTS TO THE COOKING-EXTRUDER IN LDC's

The first deterrent to widespread application is capital cost. Versatile cooking extruders used in the United States for commercial production of human food are expensive and generally unaffordable by a company or a food development laboratory in LDC's. Even the low-cost CSU unit becomes less so, as you add the cost of a diesel engine. Hard currency problems of LDC's generally add to the dilemma and, of course, with imported equipment there is always the problem of getting replacement parts on a timely basis and with reasonable ease.

The second answer is of a cultural nature. The industrial countries have long been accustomed to working with the machinery and have the necessary expertise to keep it in operation. LDC's have less experience in this area. A cooking extruder is traditionally unstable in operation, especially when texturizing vegetable proteins. They require a good deal of artistry to make products that consistently meet even minimal quality control standards.

HOW TO STABILIZE THE OPERATION

MFM took a serious look at these problems and went to work, first on solving the one of operation instability. The solution we found rests primarily in redesigning the screw so that free vapor could not interrupt the inlet feed or surge through the outlet. No scientific equations really hold up in extrusion cooker design work, so what we are doing is applying artistry to the design so that operation can be reduced to a science. Control was achieved by developing a screw with a double flight and interrupting each flight one-half revolution every one and one-half revolutions in an alternate fashion (Fig. 1).

TESTING THE NEW DESIGN

In our work directed toward texturization of protein, our first attempt at applying this principle was on a Wenger X-5, a machine with a one-inch diameter screw. Previously our experience, as well as that of others, would report short bursts of textured vegetable protein product coming from the die, but we would never experience enough stability to gather useful data. However, on our first attempt at texturing with the new screw design, once we had established the correct water and meal percentages, we had stability within one minute of startup and maintained texturing without further adjustments or manipulation of barrel temperature. Temperature gradient along the length of the barrel remained constant and ranged from ambient at the inlet, gradually increasing to about 300°F at the outlet. We noticed an additional benefit of less power consumption (25% less) for a given throughput.

Realizing this success, we made a screw with the same design characteristics for a Sprout Waldron 450 cooking extruder, a machine with a four and one half-inch diameter screw. Whereas we had never been able to texture protein on this machine before, we were able to do it with similar stability as experienced on the modified Wenger X-5.

MFM's NEW LOW-COST COOKING EXTRUDER

Convinced that our screw design had overcome the stability problem when texturing protein, we set about solving the other problem of high cost by designing a low-cost cooking extruder. The work is funded by a grant from AID through PACT. Our design standard is that:

1. using a 2 1/2-inch screw, the machine will texture protein at the rate of 100 pounds per hour with an energy consumption of less than 15 kW per hour;

2. the same machine with a different screw design will gelatinize starch, expand cereals and cook legumes at a rate of throughput on the order of 2 to 10 times that of textured vegetable protein;

3. it can be machined and fabricated in any LDC having a simple lathe and vertical milling machine.

When it comes to the cost factor, there is no way you can reproduce a single machine situation to compete with the cost economy you can achieve by mass

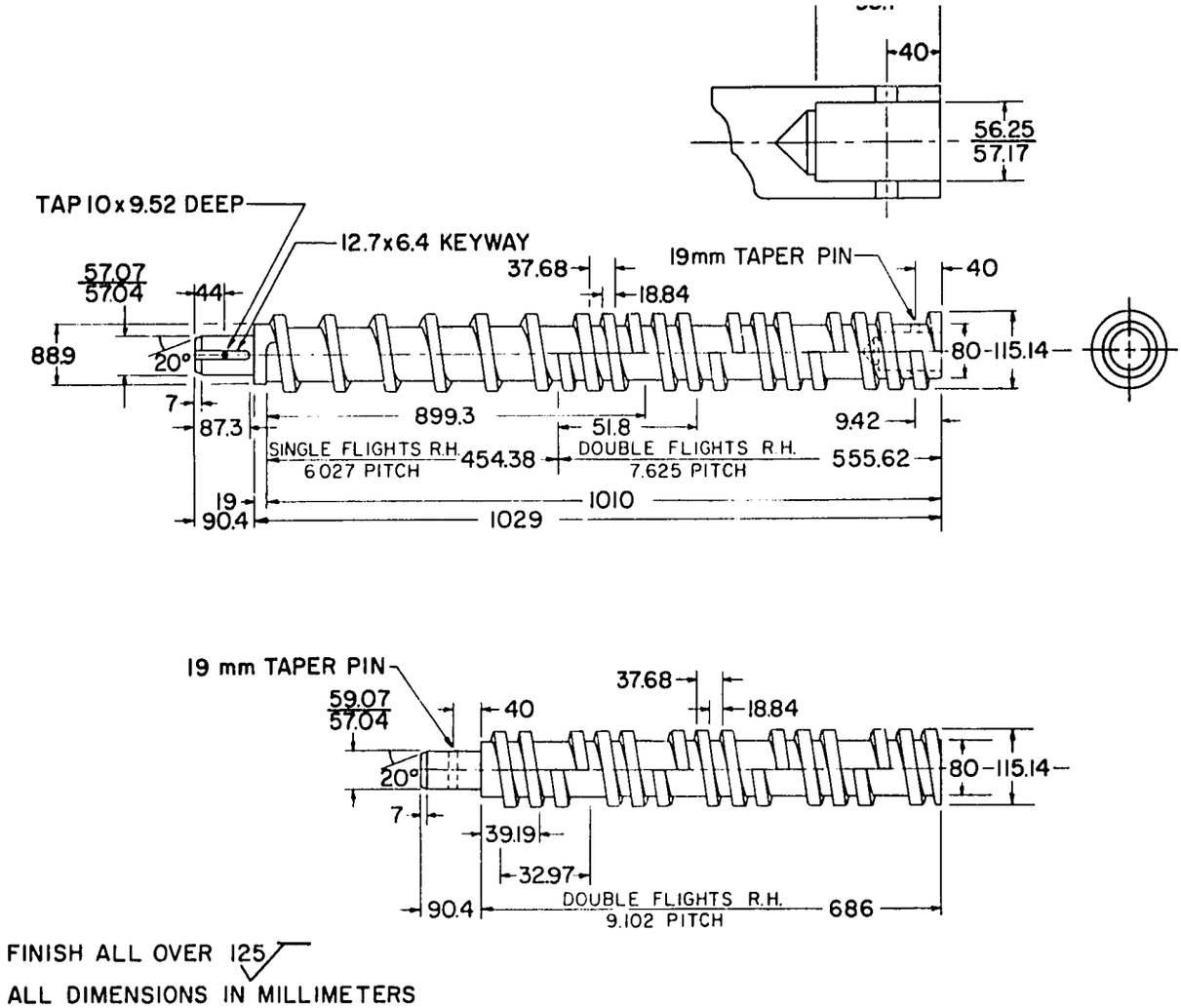


Figure 1. Diagram of internal screw for MFM extruder.

production. We, however, have set as a goal that this machine can be built with all of its versatility for $5,000 or less in the United States. It is now near completion, and we are under the $5,000 goal. We expect to top out at about $4,200 or $4,300. In a developing country, I believe it could be built for approximately the same, because our labor rate is much higher; however, their steel and so forth will be higher.

One of the things we are doing is to develop the power train and the bearing housing from the rear end and transmission of an automobile. We are using a compact automobile, because most developing countries have that size available. Use of such parts enables us to obtain replacements locally and to lower the cost of producing the extruder. The transmission of an automobile also can be reversed to unjam the machine, because the direction of jamming is toward the outward end. If you reverse it slightly and open up the die at the end, it will clean itself out completely, very rapidly.

A frequent problem of prototype work is the new and simpler ways of achieving the same end results which keep presenting themselves, tending to make the original design obsolete before the prototype is completed. Such is the experience in this case.

TRANSFERRING THE TECHNOLOGY

On the basis of current interest, MFM has set an objective of transferring the technologies of extruder design, manufacture and utilization to 20 LDC's. Field machining, fabrication and testing of two units will commence just as soon as testing of the prototype is completed in our pilot plant. Dr. Harper has kindly consented to further evaluate this unit at the CSU pilot plant. The first two countries, tentatively selected are Korea and Ecuador. In Korea the fabrication and testing will be carried out by the Korean Institute of Science and Technology. In Ecuador, Meals for Millions has a project to produce a nutritious instant colada (a thick, strawberry-flavored drink made of rice and soy) for the target population of children ages 0-6 in Guayaquil.

THE NEED FOR AN HISTORICAL PERSPECTIVE

Meals for Millions believes it is of crucial importance to view the subject of low-cost extrusion cookers in the broader context of providing realistic solutions to world hunger and malnutrition. It is for this reason, that at this meeting of interested parties from around the world, we feel it is the appropriate forum to sound a note of caution as we view the potential for low-cost extrusion cooking. While the technology exists for production of low-cost, highly nutritious foods, we must understand that each country has a unique set of circumstances that goes beyond the availability of raw material and technology.

To reinforce this point, I am going to review some past history. In its zeal to improve the world's nutrition, Meals for Millions made some mistakes in the past--mistakes from which we have learned ourselves and which, I believe, can serve as valuable lessons to others anxious to impart what they feel are "perfect" solutions to this hungry world. Let me give you a brief summary of our experience: Meals for Millions' product, Multi-Purpose Food (MPF), although less well-known, predated by 10 years or more other low-cost protein concentrate meals such as Incaparina, Fortifex, Arlac, and CSM and the like. In 1966, 20 years after Meals for Millions' charter and an equal number of years' experience in worldwide donor-supported distribution of the product, we began serious efforts to transfer appropriate technology to produce MPF from existing local resources. That was the same year that our pilot plant, laboratory and training school facilities were constructed in Santa Monica, California.

Since the problem of malnutrition was already a global one, we were operating under the then-popular American hypothesis that a model, mass-produced MPF plant, with some flexibility, could be installed in LDC's to make MPF from locally available oil seed residues. In the classic American tradition--blinded by wealth, optimism and altruistic motivation--we failed to take seriously the fact that none of the above-mentioned products was a commercial success on its own merits. Without massive government and private voluntary organizations' (PVO's) efforts, product distribution languished.

In those times, local governments were occupied with implementation of grants to build country infrastructure, so it was difficult to interest them in paying much attention to the nutritional problems of their people. Meals for Millions endeavored to bypass that problem by interesting people with a little capital to go into the production of MPF in their own LDC's. These shrewd business people consistently asked one nagging question: "How many plants are producing MPF in the United States, and how much is being sold there?" Our somewhat inadequate response was that since America is not deficient in protein resources, there was no need for the MPF product there. That sounded reasonable, but the truth was that nowhere had MPF ever had a commercial value. This is a most important point, for if a product has no money or exchange values placed on it by the consumer, it is because people don't want it for one reason or another.

"SECOND GENERATION" FOODS - A MUST IN LDC's

Eventually through trial and error, some of it costly and discouraging, we came to realize that the real answer to successfully penetrating local eating habits with a nutritious food is with what I call ready-to-eat "second generation" foods (the "first" generation being the so-called "poverty" foods mentioned before: MPF, CSM, etc.).

A cooking extruder is very useful in developing second generation foods. Low-cost, highly nutritious foods need not be synonymous with powdered foods. The real answer, we found, is to look at the marketplace (even donation programs are truly a market) with a completely open mind and as few parameters as possible.

THE KEY: MARKET TESTING

Conducting a thorough market study to determine what kind of food product ought to be developed for a given culture is not a luxury. We believe it to be a necessity. All too often a laboratory develops a near perfect nutritional food, and because it can be made inexpensively, and because raw materials exist locally, a decision is made to produce and market the product. Elizabeth Orr, of Tropical Products Institute, has been most diligent in following the results of these kind of efforts. She has come to the conclusion that the reason these products have failed to meet the target of wide acceptance is because there is no effort to find out the basic eating habits and preferences of the target population. A cooking extruder can produce low-cost nutritious foods that would in fact please the population suffering nutritional deficiencies, if only we would first determine from the potential consumers what they want to eat before we create it in the laboratory.

APPLICATIONS FOR THE FUTURE

Meals for Millions believe that the products developed by low-cost cooking extrusion technology should meet the type of criteria outlined above and should be subject to rigorous market testing before they are to be part of a distribution scheme or for the commercial market. If we apply the technology on the basis of need indicated by a market study, we will see more success which will spur an even greater demand for low-cost extrusion cookers worldwide. Failures discourage technology proliferation. Successes encourage wider acceptance.

Specifically with respect to the development of a low-cost extrusion cooker, MFM believes it can produce a second design even less costly to make, yet as effective and rugged as the prototype now nearing completion. Our ideas, we admit, are novel and need to be proven. They are as novel as using a short, square, spineless tube for the barrel and eliminating the power train. We plan to test these new concepts just as soon as the current prototype is out of the machine shop and undergoing tests in our pilot plant.

You have heard of the desire for solutions to field problems. MFM's energies are spent doing just that.

Food Production Applications in Sri Lanka

Justin R. Jackson
CARE: Sri Lanka
Colombo, Sri Lanka

When the Thriposha Program started in Sri Lanka we knew that the odds of success were against us. There have been few successes and many past failures in developing, producing and marketing high-protein, low-cost infant cereal products. Nevertheless, we decided to approach the problem on a pragmatic level.

The Sri Lanka Ministry of Health and CARE with the concurrence of USAID (the monitors of the overseas distribution of P.L. 480 Title II commodities) decided to begin with a medically selected recipient program where a two week (750 gram) take-home ration would be distributed without cost to the recipient through Health Clinics and Estates. But unlike many take-home free distribution programs in other countries, the recipients would be given a product in an attractive plastic bag which would be packaged at a central packaging operation and distributed island-wide through the Ministry of Health's Mother-Child clinics. This contrasts with free distribution programs in some other countries where the recipients are asked to bring their own containers, and the commodity is literally dished out at the center.

The packaging of Thriposha is central to its success to date. It provides value and dignity to the recipient and also relieves the already overworked medical and clerical staff at the clinics of the burden of having to measure and handle an unpacked commodity.

It was also decided to provide a name for the product which would give it local identification. First the name "Babec" was used. But when it was realized that "Babbec," which means baby in Singhala and Tamil, also has the connotation of "being with child" the name was dropped, and a search began for another more suitable name. Finally, the name "Thriposha" was found acceptable to the national languages and also conveyed the triple nutrient value of the product.

We feel that because we gave the product a local identification--a name and a package printed in three languages of the country--we increased its acceptance. In fact, in less than two and one-half years we are distributing a product which is known in 96% of the households and has been used in 82% of the low-income homes on the Island.[1] Last month we produced and distributed the 10 millionth packet.

[1]Determined by the pre-market survey conducted by Sevum Seva Market Research Service for the Thriposha Program during November 1975 through February 1976.

The production aspects of the program were also initiated on a pragmatic basis. We did not begin by designing a pilot plant or importing machinery. Rather, the Ministry of Health selected three well-known firms with reputations for their quality products to repack an imported product. Initially, Thriposha consisted of 100% wheat-soy blend (WSB). It was therefore necessary to repack it from its standard 50-lb, P.L. 480 bag into new, smaller plastic bags. This process relied entirely on local packaging facilities. Even the plastic bags were manufactured and printed locally as were the master 4-ply Kraft bags into which the smaller plastic bags were packed.

At this stage in the development of the program, a great deal of time and effort was devoted to working out the many supply and production problems associated with a large-scale program of this nature. One of the initial production problems encountered was infestation. We knew that if Thriposha was distributed with weevils we would lose the program overnight. At the time of our first infestation attack we closed down all production operations and undertook a thorough cleaning of the facilities. In addition, we instituted a regular preventive program of fumigating the imported commodities as soon as they arrived in Sri Lanka. For this we used a product of proven reliability and safety, Phostoxin. We are presently planning to install an entoliter at the end of the blending line to insure that neither weevils nor their eggs creep into the product before packaging.

At this point, however, we had only a repacked imported product. The next phase of our program was to blend local cereals. It was decided that the local cereals had to be precooked to insure that the end-product would be digestible for infants. It would also facilitate home preparation. Unfortunately, no extrusion facilities were available. First we tried parboiling the cereals--with limited success. The process did not completely gelatinize the starches, and the end-product had unacceptable bacterial counts. We then hit upon a process of baking the cereals. But unlike toasting and roasting--a process sometimes used--we made a wet dough and baked the cereals like a cookie or biscuit. This process was possible because one of the selected packers was a biscuit manufacturer (Ceylon Biscuit Ltd.). In addition to a modern continuous production line, they also had a smaller batch line which could accept the local cereal dough, which did not behave like regular flour dough. A local metal casting shop manufactured a grinder to grind the baked biscuit back into a powder.

The next problem was finding a suitable blender. Again a pragmatic solution was found by using two mixers originally designed for cement. At this stage we were incorporating cooked local cereals with WSB.

However, we soon reached our baking capacity for this process and were 50% short of our target of blending 20% local cereals with 80% WSB to produce Thriposha.

We needed to find a solution for increasing our capacity to process local cereals. We tried to bake them on a more automatic baking line, but the dough was the wrong consistency and did not hold together. Fortunately we learned that Mr. P. R. Crowley, Director of the Nutrition and Agribusiness Group, USDA, was scheduled to visit Indonesia, and we asked that he be routed through Sri Lanka on his way. With Mr. Crowley's encouragement, we requested CARE-New York to purchase a Brady 206 cooker-extruder--for obvious reasons we do not refer to it as a crop cooker! Colorado State University, with funds provided by USAID through USDA, agreed to design the extrusion facility and to purchase the necessary support equipment. Dr. Judson Harper and Mr. Ronald Tribelhorn spent 10 days in Sri Lanka during July 1975 to consult with us and to design the system. The equipment was ordered on their return to the United States. CARE-New York acted as the central receiving point and crated the equipment for export to Colombo. While awaiting the arrival of the equipment, we undertook the preparations for the installation. The shipment arrived just before Christmas, and it was cleared through customs and inventoried on New Year's Eve.

Colorado State University had provided detailed instruction and installation plans which greatly facilitated the assembly. Upon the approval of the GOSL, the system was installed at the Cereal Products Factory in Kundasale, 80 miles from Colombo, where the local cereals are cleaned, dehulled and lightly polished to remove some of the fiber from the grain (a process called pearling). The CSU-designed system consists of a cable conveyor (Cablevey) to carry the pearled grain to bulk storage tanks (Fig. 1). These tanks act as surge tanks so that there are sufficient materials for production at all times. Connected to the storage tanks are augers (screw conveyors) which transport the grain to a Modern Mill (Fig. 2). The Modern Mill acts as a proportioner and grinder and can blend up to four cereals and legumes to be extruded. The pregrinding of the grain makes it easier to extrude and also allows for more homogeneous cooking. From the Modern Mill the grain, which is now of grit-size particles, is conveyed by augers to the Brady cooker/extruder (Fig. 3). The Brady obtains its power from a 125 hp Cummins diesel engine which has a special transmission for the operation (Fig. 4). Water is added to the grain as it flows to act as a lubricant to keep it from plugging. As the cooked cereals come out of the extruder, they expand. Steam is given off as the moisture content of the product drops from 14 to 16% at the input to 7 to 9% at the output. The cooked product, which comes in a continuous ribbon, is cut into small chunks and conveyed to a cooler/dryer (Fig. 5) to further reduce the moisture content and the temperature. From there the product enters a Prater hammer mill (Fig. 6) where it is pulverized. Finally, it is conveyed by augers to a surge tank from which it is packed into 100-pound bags for transport to Colombo, where it is blended with WSB and packed for distribution.

When the equipment was nearly installed, Mr. Tribelhorn returned to Sri Lanka to assist with the installation of the augers and the check-out of the complete system (Fig. 7). He also trained the operations personnel in proper operation and maintenance (Fig. 8). The system was in working order by the middle of March--only 10 months after Mr. Crowley's visit.

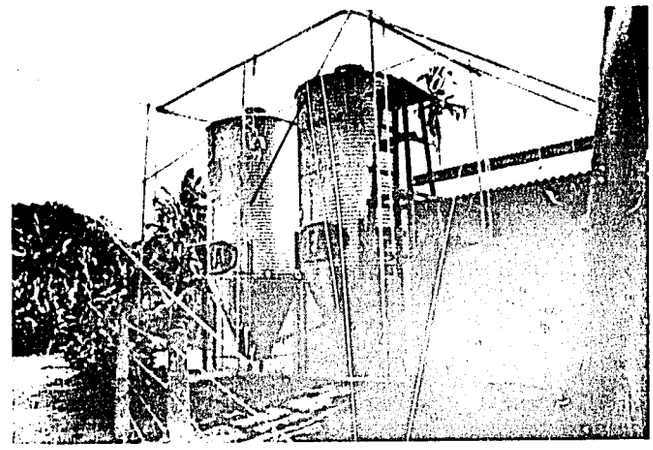


Figure 1. Cablevey conveying system and Read bulk storage tanks.

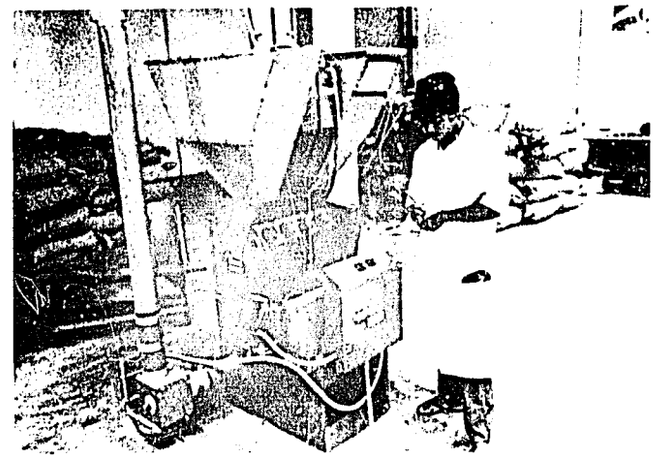


Figure 2. Operator taking readings from Modern Mill Model 400.

Figure 3. Personnel making adjustments on the Brady cooker/extruder.

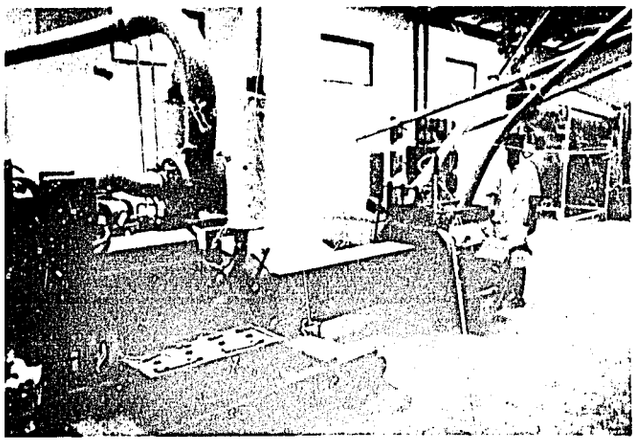


Figure 4. Cummins diesel engine used as a power source for the Brady cooker/extruder.

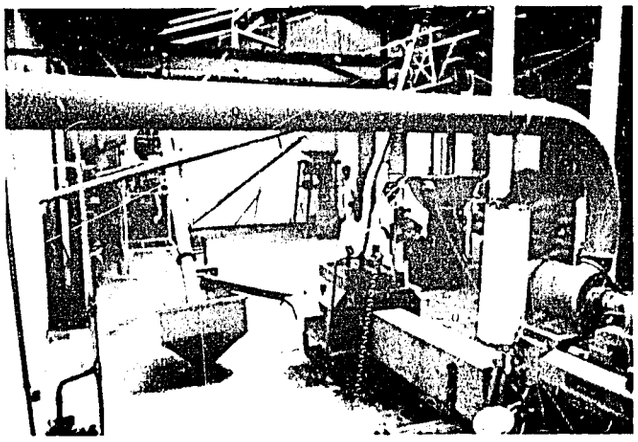


Figure 7. Thriposha plant in operation at Kundesale.

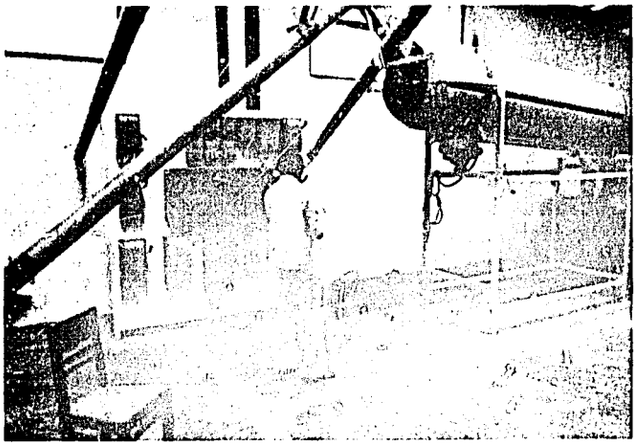


Figure 5. Dorsey-McComb cooler/dryer and the electrical distribution system.

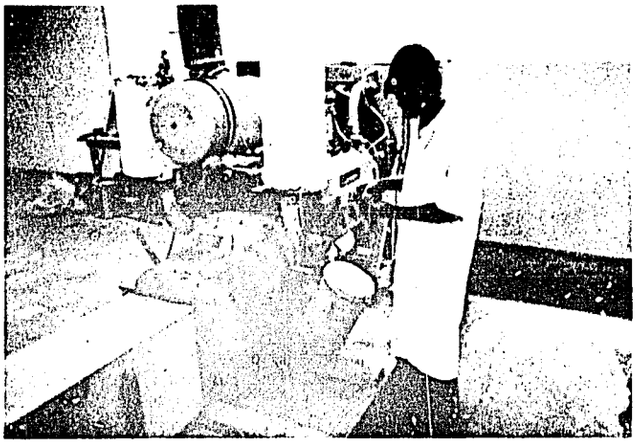


Figure 8. Thriposha plant operator performs daily maintenance check.

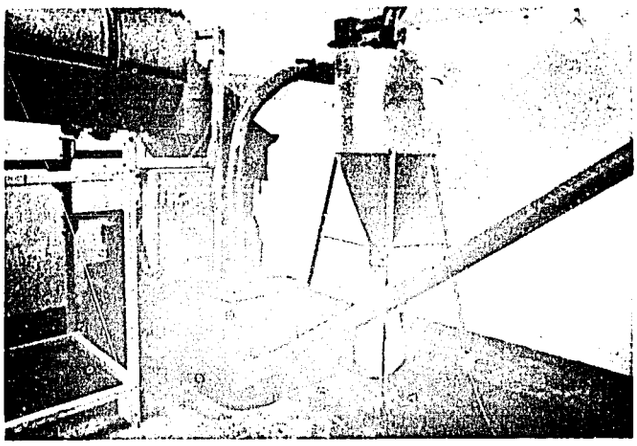


Figure 6. Prater hammer mill and air relief system.

Sri Lanka is now one of the first--if not the first--countries to use a low-cost cooker/extruder for the production of high-protein infant cereal on a large-scale basis. It has not been done without encountering a multitude of problems. While many of them have been overcome--and we are optimistic that the others will be, too--it might be beneficial to outline some of the more critical ones encountered with the cooker/extruder operation:

1. Replacement parts are problems. As Sri Lanka is one of the most seriously affected countries as a result of the oil crisis, foreign exchange is at a premium. Spare parts that we take for granted in the United States, such as oil filters, V-belts and basic tools needed for maintenance and repairs, are difficult--if not impossible to find.

2. Frequent replacement for custom-made parts--especially for the Brady is another problem. We have found that the rotor weldment (the screw which causes the friction to create the heat for the cooking process) is wearing out after 200 hours of use. At this rate we will require 15 to 25 of these per year. At nearly $500 each, the low-cost cooker/extruder becomes a capital liability. But fortunately, thanks to the ingenuity of Dr. Harper, we are renewing the worn area by welding it back to it original size and then machine grinding it to insure even height and a smooth finish. With this process we are hoping to extend the life of this part from 200 hours to 1,000 hours, thereby having to import only 3 or 4 per year.

3. Electric power failures are another problem. Despite the fact that Sri Lanka has inexpensive and relatively reliable hydroelectric power, we have experienced a sufficient number of power failures to be concerned. It is not a frequent problem, but it is an irritant and does cause loss of production time. The problem is not with voltage fluctuation, but rather with actual stoppage. The diesel-powered Brady continues to operate when electric power failures occur, but the other equipment conveying the input of cereals and carrying away the cooked product do not operate. Power failures therefore mean a loss of production time.

   To overcome this difficulty we are recommending that a second Brady be installed--possibly an electric model--so that we can have two units producing at the same time. At least this way we can achieve twice the output while we have power. We believe that the additional installation can be done for half of the initial installation cost, as the other equipment (Modern Mill, cooler/dryer and Prater Mill) has sufficient capacity to handle twice its present output.

We feel Thriposha has had a tremendous impact on nutrition and health service in Sri Lanka. We presently have 390,000 recipients participating. Because the program has a local identification, rather than one relying solely on imports and external assistance, and because the product has become widely accepted, decision-makers in the government have been able to allocate expenses for the program. These include the purchase of local cereals and legumes (which will be increased from 20 to 25% beginning next month), milling and processing costs, blending and packaging costs (including packaging materials), and the many other costs associated with the production and distribution of a high-protein infant cereal. This past year the Ministry of Health spent more than the local currency equivalent of one million dollars for the Thriposha program and has budgeted over two million dollars for the Fiscal Year 1977. Its support has been crucial to the success of the program. It has been made possible because a quality product has been produced.

So far, I have spoken only about the free distribution of Thriposha to medically selected recipients. The next phase of the program involves the commercial sale of Thriposha. The plant calls for implementation of this phase during 1978. The Ministry of Health is interested in the commercial sale of Thriposha because it wants to make it available to a larger number of recipients than can participate in the medically selected free distribution program limited in size by financial constraints. In other words, the target sales population for the commercial Thriposha program will be low-income families who are neither nutritionally eligible for the medical program nor able to afford the high-priced imported protein products.

The commercial Thriposha program must therefore be low cost in order for it to succeed. We know that the Brady system meets this objective, because it is costing $0.07 (US) per pound (or less than 3/4 of one United States' cent, including depreciation of the donated equipment). However, we are constrained by the relatively high cost of materials, especially legumes and packing materials.

While we have received special permission to test market Thriposha using P.L. 480 Title II inputs, the regular commercial sale of it cannot use Title II commodities because of U. S. legislation specifically prohibiting their sale. We must either produce sufficient indigenous cereals, which is a long-term objective, or rely for at least an interim period on imported commodities from other channels--possibly Title I sales. A great deal of work must precede even the commercial test market, now scheduled to begin in October 1977. We must have a fully formulated product for the market test, and we must undertake this process during fiscal year 1977. Finally, we must work out the marketing strategy, including pricing and distribution (which is expected to be through the state-controlled Cooperative Marketing Retail outlets throughout the island), and we must design and test the commercial package. The commercial Thriposha program will be government-controlled but will be produced by the private sector. We have already begun this process with a just completed pre-test market survey of 674 randomly selected, low-income families, of whom 550 were found to be Thriposha users. This survey gives us encouragement while pointing out many problems which must be overcome or avoided. We are confident that we will succeed by continuing to approach the problem in a systematic and pragmatic manner.

THRIPOSHA PROGRAM INPUTS[1]

Source	Fiscal Year 1976	Fiscal Year 1977
Ministry of Health Government of Sri Lanka	$1,215,690	$2,054,500
CARE and P.L. 480 Inputs	1,632,961	2,111,425
Total Value--Thriposha Program	$2,848,651	$4,165,925

[1]Calculated at constant values for P.L. 480 commodities and a constant exchange rate of US $1.00 - Rs. 7.00

In conclusion, it might be appropriate to mention that while the extrusion facilities of the Thriposha program in Sri Lanka are production oriented, it is hoped that the system also will act as a demonstration model. We invite you to visit the plant if you are ever in that part of the world.

Sri Lanka Nutrition Intervention Projects Using Extruded Products

Beatrice V. De Mel
Medical Research Institute
Ministry of Health
Colombo, Sri Lanka

The food and nutrition situation confronting Sri Lanka today is in many respects similar in nature, though not in magnitude, to those confronting many developing countries of the world. The three major factors that generally determine the nutritional profile of any country are population growth, food production and the distribution of food. The population of Sri Lanka, which stood at 5.5 million in 1935, rose to 14.1 million in 1975, and according to current projections, Sri Lanka's population, even allowing for the most optimistic estimates of the impact of family planning programs, will reach 21.9 million in the year 2000 (Fig. 1).

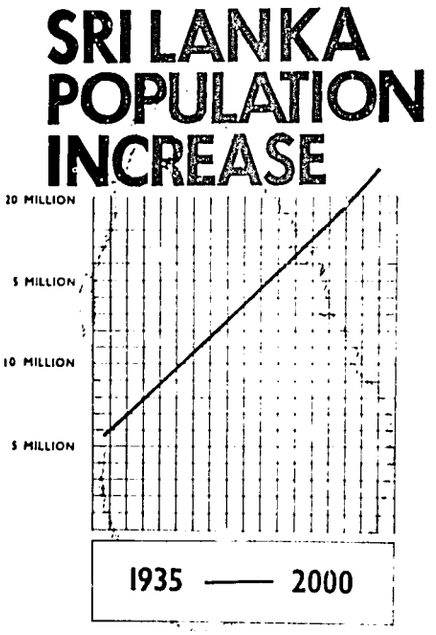


Figure 1. Estimated Sri Lanka population increase.

The age structure of Sri Lanka's population is also unfavorable from the nutritional and economical standpoints due to a high dependency ratio. Children below 14 years constitute 39% of the total population, of which 15% are under 5 years and 3% under 1 year. It would seem unlikely that the situation will be materially different by the turn of this century (Fig. 2).

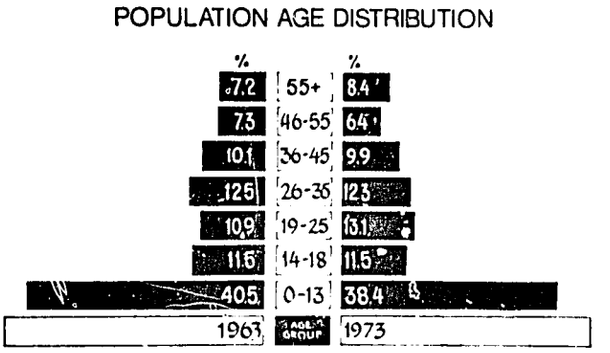


Figure 2. Population age distribution.

The increase of world food production over the last 15 years, especially of rice and wheat, has brought about an increase in Sri Lanka's intake of about 75 grams of cereals per head per day--equivalent to 256 calories and 6 grams of protein (Fig. 3).

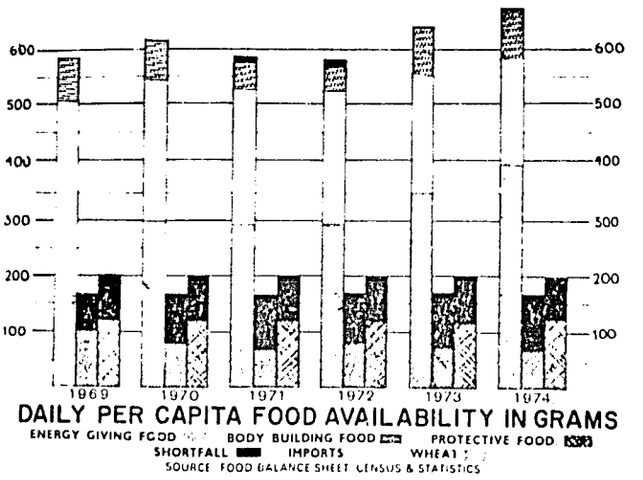


Figure 3. Daily per capita food availability.

Our highest recorded available per capita supply for the last 15 years was in 1970, when 2,359 calories and 50 grams of protein were available per head per day. The FAO/WHO 1973 recommendations, modified to suit the physiological needs of our population, indicate that 2,200 calories and 48 grams of protein on a per capita basis would constitute an adequate diet. Food balance sheets for the last 15 years indicate that on this basis sufficient energy foods were available (Table I). Three successive years of poor harvest due to droughts, floods and other unfavorable weather conditions have resulted in a substantial drop in food production since 1972. This amounted to about 40 grams of rice per head per day. During this period there was also a decrease in wheat production in the developed countries, and imports of wheat were reduced due to high prices creating difficulties with balance of payments. This is of significance because wheat does not grow in Sri Lanka. It was introduced during World War II and has now become part of the people's diet. With a trade deficit of $200 million last year there was a shortfall of 20 grams of wheat per head per day. The highest deficit on record is expected this year, and 60% of the deficit will be for imports of rice, wheat and sugar. Sri Lanka has become dangerously dependent on current production and hence on fluctuating weather conditions. Food prices have risen, bringing additional hardships to the poorer consumers who spent almost 80% of their income on food. In the face of a constantly growing population (2.2% a year), these events are extremely disquieting, as the increase in food production is between 1-2% below the rise in population. In 1974 the food situation was extremely precarious, and the energy crisis makes the future uncertain in terms of food production even if the climatic conditions improve. It seems doubtful whether Sri Lanka--without foreign assistance--can afford the vast input in fertilizers. Also, as food production depends mostly on chena cultivation (shifting cultivation) by small farmers, it is not only difficult to increase production but also impossible to project food crop production and targets.

Table 1. Daily Per Capita Availability of Food Supply in Grams--Food Balance Sheet (Census and Statistics)

	1969	1970	1971	1972	1973	1974
Cereals						
Rice	274.7	298.8	281.0	275.0	262.8	271.8
Wheat	88.8	80.9	64.0	58.4	90.8	89.3
Total (including others)	372.1	385.5	349.7	338.0	360.8	369.0
Coconut kernel	61.4	84.7	84.7	102.5	84.6	85.6
Fats and oils	10.0	11.5	11.0	11.0	8.0	7.0
Yams	81.6	70.4	76.3	59.8	105.6	127.6
Sugars	62.9	61.7	58.9	57.1	45.7	18.0
Total	588.0	613.8	580.5	569.2	604.9	607.2
Pulses	18.5	16.2	8.0	7.3	4.0	2.0
Meats	5.3	4.7	4.9	4.8	4.7	3.3
Fish	28.1	22.6	19.7	23.7	18.9	17.7
Milk and milk products	33.2	33.0	35.4	43.8	41.9	30.6
Eggs	5.5	5.3	5.7	6.4	6.5	4.0
Total	90.6	81.8	73.7	86.0	76.0	57.6
Vegetables	118.8	130.1	92.9	92.9	92.9	97.2
Fruits	25.7	29.5	29.2	29.3	27.6	28.4
Total	137.5	159.6	121.1	122.2	120.5	125.6
TOTAL	816.1	855.2	775.3	777.4	801.4	790.4
Calories	2,223	2,359	2,209	2,250	2,213	2,135
Protein	50.0	50.8	44.9	45.4	45.1	44.9
Animal	10.6	9.8	9.6	10.5	8.7	7.4
Fat	45.3	55.9	52.9	60.6	50.2	48.3

The findings of the comprehensive Socio-Economic Survey of the Census and Statistics of 1969-70 revealed that there is an unequal distribution of food within Sri Lanka where the marginally adequate average is not reached among the poorer sections of the population. Thus in 43% of the sample (households that earn less than $29 per month) the diet was inadequate (Fig. 4). The urban poor were the worst affected (Table II). A more detailed analysis, assessing the adequacy of intakes of each household according to its individual age/sex composition and on a basis of "moderate activity," confirmed the presence of a diet deficit. This is especially noteworthy since it occurred at a time when food supplies were the most abundant for many years, locally and internationally.

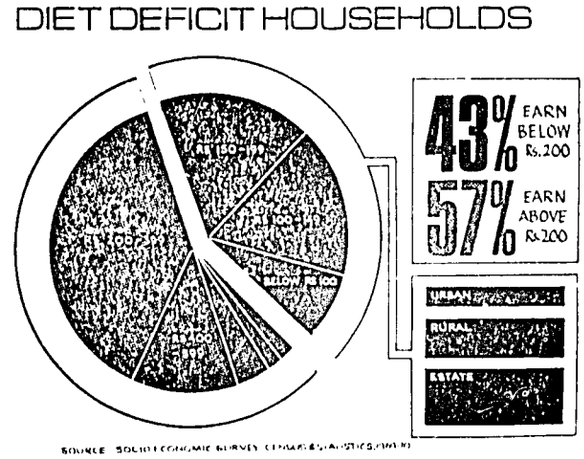


Figure 4. Diet deficient households.

Fifty-six percent of the 2,094,815 households in the island were adequate in energy and protein; 13% were adequate in energy but not in protein; 2% were inadequate in energy but adequate in protein; and 29% were inadequate in both. The total number of households considered to be inadequate in energy was 649,605, and protein-deficient households with or without energy inadequacy numbered 873,500. However, as the utilization of dietary protein is influenced by such factors as energy intake, level of mineral and vitamin intake and the quality of the protein itself, it is demonstrable that about 912,113 do suffer from some degree of protein-energy inadequacy.

Awareness of the need for integrated nutritional intervention measures to combat malnutrition is gaining ground in developing countries. In Sri Lanka, a Food and Nutrition Technical Unit is being formed in the Planning Ministry. This unit will direct the policy-making body at ministerial level.

Presently the nutrition situation is being relieved by a wide variety of intervention programs. The largest intervention and the longest in existence is the government subsidy on rice, wheat flour and sugar. The cost was around $129 million in 1974, when over 12 million beneficiaries received 10% of their calories and 12% of their protein requirements daily. The free rice ration alone supplies 18% of all calories for the lowest income group and was not without significance during the food shortage.

Table II. Percentage of Adequacy of Energy and Protein by Sectors and Zones According to Income Classes--All Island Socio-economic Survey, 1969-1970.

Sectors	Nutrients	Income Classes: Below Rs 100	Rs 100-140	Rs 150-199	Below Rs 200	Rs 200-399	Rs 400-599	Rs 600-799	Rs 800-999	Rs over 1,000	All Classes
Urban	Energy (cals)	78	87	92	86	94	109	106	111	113	98
	Protein "	77	87	94	99	99	109	114	123	130	109
	Percentage	2.9	6.6	11.5	21	37.5	17.9	8.4	5.1	8.1	100
Rural	Energy (cals)	89	97	100	95	106	118	118	117	131	101
	Protein "	85	97	101	97	106	117	123	126	140	107
	Percentage	9.2	17.5	17.7	44.4	37.9	12.0	3.7	1.1	0.9	100
Estate	Energy (cals)	103	107	107	106	110	113	140	140	173	110
	Protein "	111	117	119	118	123	125	160	164	239	128
	Percentage	8.8	26.8	25.8	61.4	33.5	4.0	0.8	0.1	0.2	100
All classes	Energy (cals)	88	96	98	94	103	111	114	115	120	103
	Protein "	84	94	98	99	113	122	127	130	136	112
	Percentage	8.1	16.8	17.7	42.6	37.7	12.0	4.1	1.6	2.0	100
Zone I	Energy (cals)				90	102	108	112	113	119	102
	Protein "				101	110	119	125	128	138	112
Zone II	Energy (cals)				94	102	121	123	106	140	109
	Protein "				99	115	126	125	115	153	110
Zone III	Energy (cals)				106	104	108	110	116	129	107
	Protein "				100	104	109	111	116	133	105
Zone IV	Energy (cals)				92	100	110	116	121	116	98
	Protein "				111	120	134	122	155	164	116

Since 1956, the largest intervention program is that of the Ministry of Health. In 1973 the Thriposha Project within the Family Health Program came into being (Fig. 5). It is now a medically approved and carefully monitored program for pregnant and lactating women, infants, preschool and primary school children. Monthly, 194,462 moderately-to-severely malnourished women and children are being rehabilitated through 640 health centers, 1,993 clinics and 180 estate health centers.

Table III shows that the coverage of malnourished women and children is most effective in the disadvantaged areas of the hill regions. The low coverage in Colombo is due to the withdrawal of Thriposa from the cooperatives in February of this year. The Plantation Estate Program, partly conducted through polyclinics run by the Family Health Program, reaches 40% of the malnourished participants through 161 estates. The School Feeding Program covers around 850,000 primary school children, of whom the estimated 100,000 severely malnourished receive in addition a supplement of Thriposha, as well, through 980 schools.

In addition, during the past few years a WFP "Food-for Work" intervention program reaching 165,000 families has been undertaken in drought-stricken areas. The control of nutritional anemias in 160,000 anemic, pregnant mothers is now underway through the Family Health Program at an annual cost of $54,000 worth of haematinics funded by UNFPA. Further, the current UNFPA population control program, though not directly concerned with providing food, is important in raising nutritional status.

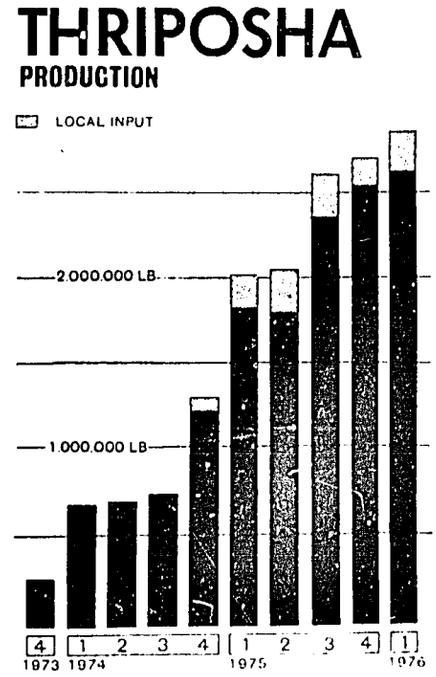


Figure 5. Thriposha production.

Table III. Thriposha Coverage of Malnourished Vulnerable Groups in Sri Lanka (March 1976)

Health Districts	Total Population	Diet Deficient Households	Thriposha Beneficiaries	Percent of Coverage
	1976	1969-70[1]	1976[2]	
1. Colombo	2,975,000	184,675	54,007	29[3]
2. Kalutara	796,000	36,056	10,935	30
3. Galle	798,000	64,321	17,363	27
4. Matara	1,026,000	74,531	13,742	18
5. Anuradhapura	699,000	35,130	24,003	68
6. Kurunegala	1,145,000	63,075	33,664	53
7. Puttalam	433,000	23,589	9,254	39
8. Jaffna	763,000	55,725	35,186	63
9. Vavuniya	205,000	12,864	11,172	86
10. Batticaloa	616,000	54,458	22,443	41
11. Kegalle	696,000	64,345	22,871	36
12. Kandy	1,768,000	109,160	75,600	69
13. Matale	565,000	27,069	11,771	43
14. Ratnapura	737,000	53,713	18,740	34
15. Badulla	942,000	44,720	31,923	71
	14,164,000	903,431	392,674[4,5]	

[1]Socio-economic Survey--Census and Statistics 1969-70

[2]Vulnerable groups

[3]12% higher figure due to irregular hospitalized beneficiaries.

[4]The percentage coverage was 48% up to February 1976, when 35,000 preschool children were receiving Thriposha.

[5]Beneficiaries comprise: pregnant women - 28,359; lactating mothers - 12,651; infants -14,248 and preschool children - 108,697.

The trend in the delivery of health services in Sri Lanka is an attempt to use our limited resources of money, personnel and facilities to reach the largest number as effectively and economically as possible within the context of rapidly rising costs. The major aspects of this trend are to train auxiliaries (midwives); the employment of screening procedures, as in the Thriposha Program of the Family Health Program; and to increase emphasis on self-help to improve health. The "at-risk concept" is now the most positive approach of the program.

THE THRIPOSHA PROGRAM

Thriposha is a precooked fortified weaning food mainly composed of WSB supplied by CARE from U.S. "Food for Peace" sources. Twenty-five percent of the weaning food is now being produced from locally grown pulses (soy) and cereals (sorghum/maize) and processed in Sri Lanka. The development of this product is expected to eventually evolve into a 100% indigenous weaning food. The first processing extruder unit is already operating, and plans call for a full-scale blending food plant by 1979. The use of extrusion cooking in processing human food is well established. Thriposha is now a blend of 80% WSB and 20% extruded mixture of sorghum and soy. It is projected that weaning food will be sold commercially through government cooperatives by 1978.

Objectives:

The promotion of adequate growth is a more positive objective than the mere prevention of malnutrition. It also reflects a more effective approach to the control of malnutrition in the community.

At all levels of its use, Thriposha--whether ultimately purchased by the middle class (37%), or distributed free to the working class households (43% of the population)--will help the country to meet this objective.

It helps pregnant women to bear a child of normal weight and thereafter plays a vital role in maintaining lactation.

For the infant and preschool child it fills the vital gap between the available and the adequate.

Though at the moment the program is operating on the specific objective of reducing the incidence of malnourishment by supplementing inadequate diets, the feedback from this, together with the findings of the C.D.C. Survey, will establish a pattern of geographical areas and socio-economic groups at risk. This would in turn provide the basis for any future adjustments in the system of intervention.

Accessibility:

The accessibility of the vulnerable groups to Thriposha is very high usually within a 5-to-10-mile radius of the 2,000 health points (Fig. 6). The socio-economic survey of 1969-70 has delineated 903,431 diet-deficient families with incomes less than Rs. 400 per month in the urban, rural and estate sectors, especially in the regions where the prevalence of malnutrition has been found to be high as indicated by a higher infant mortality rate (Fig. 7). The only constraint to full accessibility is transport. Once the Family Health Program is fully integrated with the Thriposha Program, this problem will be greatly minimized.

Acceptability:

Thriposha is widely accepted throughout the country. This was confirmed by the CARE-commissioned market survey just completed of 674 random interviews in seven districts where 92% of low-income interviewers had heard of Thriposha, while 82% were using it.

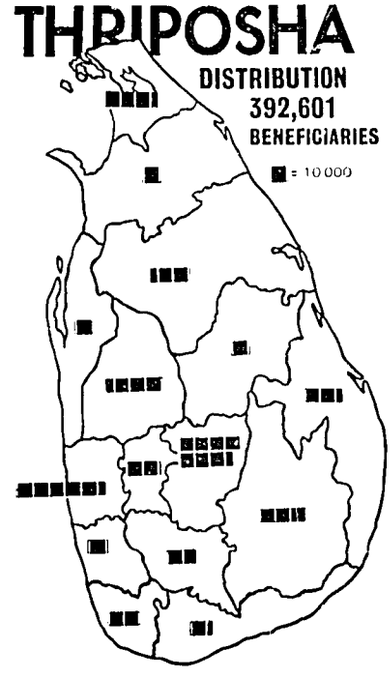


Figure 6. Thriposha distribution.

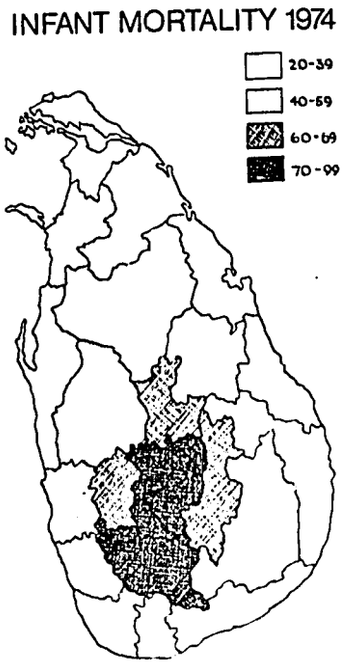


Figure 7. Infant mortality in Sri Lanka.

Ninety-one percent reported liking the taste. There is no traditional method of weaning a child in Sri Lanka. Breast feeding is prolonged to two years, and solids are not usually introduced until around the 10th month of age in small amounts as a biscuit, baby rusk, plantain or rice conjee. A desire to be modern--usually among the poor urban mothers, who are without adequate knowledge or money--has led to the cessation of breast feeding without the provision of adequate amounts of artificial milk under hygienic conditions. They are lured into buying expensive cereal-based foods, which they then use sparingly due to cost. Most infants are on their home diets by 15 months of age. Thriposha has become highly acceptable as a supplementary food from 6 months of age onward, as it can be easily incorporated into preparations such as rotti (52%), pittu (46%), drink (29%) and conjee/kali (21%). The last two represent the form in which it is given to infants. The market survey revealed that most had the notion that Thriposha is a flour--unfortified and not precooked.

Cost:

Of all the branded cereal-based foods on the market, Thriposha has the best nutritive value for money paid when priced at Rs. 3/- per pound. It is anticipated that 57% of our population which earns above $29 per month will buy their supplies at this price from one of the 607 cooperative stores in the country. The balance of 43% earning less than $29 will continue to be beneficiaries under the Ministry of Health Program. This beneficiary level is not likely to rise (Tables IV and V).

Table IV. Cost of Imported Brand Cereal Infant Foods

	1975		1976	
	Imports Tins	Cost Rs	Imports Tins	Cost Rs
Nestum	93,200	220,590	132,000	716,000
Farex	8,400	59,756	85,000	510,000
Farlene	24,000	133,190	30,500	215,000
	125,600	413,536	247,500	1,441,000

Table V. Comparative Cost of Nutrients of Infant, Invalid and Weaning Foods

Commodity	Maximum retail, Rs	Selling weight	Rice per 1-lb pkg, Rs	Calories per ounce	Cost per 100 calories, Rs	Cost per gram, Rs
Sustagen (chocolate)	26.95	1 lb	26.95	390	0.43	0.25
Sustagen (vanilla)	26.45	1 lb	26.45	390	0.42	0.25
Casilan	23.80	8 ozs	47.00	108	2.72	0.12
Sanatogen	23.75	180 gms	59.00	NA	NA	0.15
Meritene	25.65	1 lb	25.65	NA	NA	0.32
Complan	22.95	1 lb	22.95	450	0.32	0.16
Nestum	19.00	1 lb	19.00	108	1.10	0.38
Farlene	15.65	250 gms	28.00	NA	NA	0.24
Protinex	16.00	125 gms	57.00	NA	NA	0.21
Farex (cereal)	14.25	10 ozs	22.80	110	1.29	0.35
Marmite	10.75	8 ozs	21.50	35	3.83	47.00
Enfamil	5.50	1 lb	5.50	20 fl	1.70	0.10
S.M.A.	4.95	1 lb	4.95	20 fl	1.54	0.09
Thriposha	3.00	1 lb	3.00	108	0.19	0.04

Selection of Beneficiaries:

1. Infants and preschool children (Figs. 8 and 9):

   (a) Those having 2nd and 3rd degree protein-calories malnutrition (PCM) are indicated in the chart supplied by those undertaking the program. The local standard used corresponds to the 50th percentile of the Harvard standard, and the degree of PCM was based on the Gomez classification.

   (b) Those with kwashiorkor and marasmus are hospitalized and treated with Thriposha. If weighing scales are not available, the arm circumference index is used. Twenty-seven percent of the centers have weighing scales and 15 percent use the arm tape.

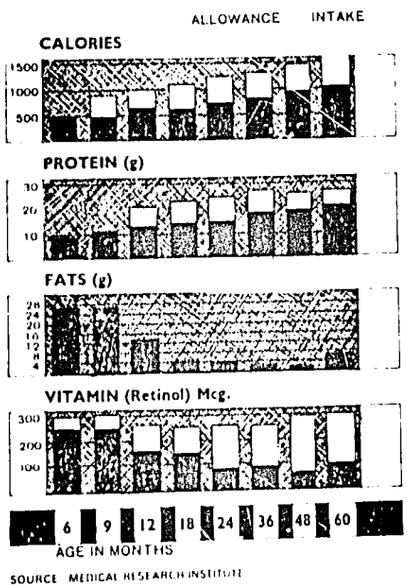


Figure 8. Average daily intake of nutrients of low income, rural preschool children, 1962-1972.

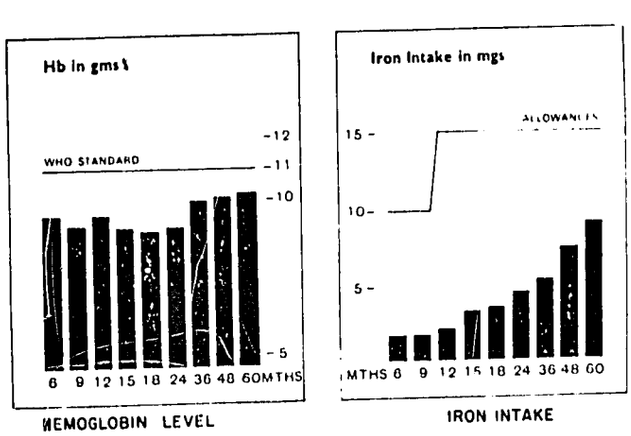


Figure 9. Hemoglobin levels and iron intake of low income, preschool children 1962-1972.

2. Pregnant women:

   Those having Hb percentage of less than 50 are shown by the Talquist method of Hb estimation.

3. Lactating mothers:

   Those having difficulty in maintaining their breast milk supply and if undernourished and anemic. The quantum of the Thriposha supplement was based on the dietary survey where the shortfall was between 200-400 calories, 8-10 g protein, 5-10 mg iron, and 100-200 mg vitamin A.

Nutritive Value:

The results of the analysis of proximate nutrients, minerals and vitamins by the WARF Institute in Wisconsin indicate that Thriposha is safe to use in child feeding, and the values compare very favorably with those recommended by the Protein Advisory Group (Tables VI and VII).

Educational Complement to the Program:

The Thriposha Program has spotlighted the lack of understanding that mothers have about the quantity and quality of food an infant and young child require for their growing needs. As a result, the Thriposha program is now backed by an intensive nutrition awareness and education program. This scheme has trained approximately 50% of all health staff and is funded by the UNFPA through the Family Health Program. All nutrition education material is being provided by CARE. Presently, CARE has four health educators in the field.

Table VI. Fortification Levels in Thriposha Compared to FAO Nutrient Requirements for 4-6 year-old Children (1974)

	Thriposha (Nutrients/ 1,000 kcals)	FAO Standard (Nutrients/ 1,000 kcals)
Thiamin (mg)	0.8	0.4
Riboflavin (mg)	0.9	0.6
Ascorbic acid (mg)	85	11
Pyridoxine HCl (mg)	0.4	0.5
Niacin (mg)	12.7	6.6
Ca pantothenate (mg)	5.9	--
Folic acid (mg)	424	55
Vitamin B_{12} (mg)	8.5	0.8
Vitamin A (I.U.)	3,530	550
Vitamin D (I.U.)	424	218
Vitamin E (I.U.)	16.0	5
Calcium	1,294	246
Zinc	3.9	5.5
Iron	32.6	4.1
Kcalories	1,000	1,000

Table VII. Laboratory Results on Thriposha and its Components

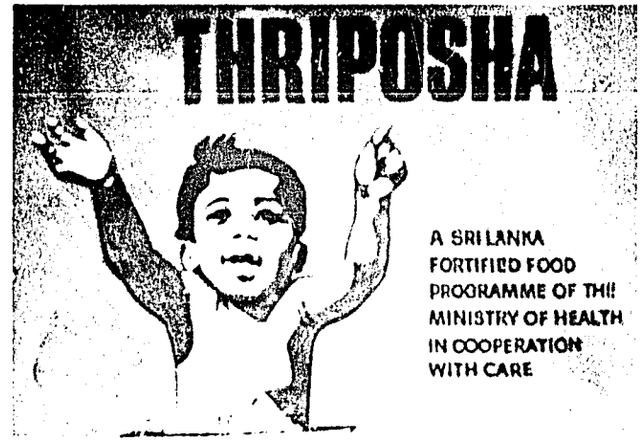
Proximate Analysis	Thriposha	Wheat-Soy Blend
Protein (%)	19.0	21.0
Moisture (%)	8.0	8.1
Ash (%)	3.9	4.6
Fat (%)	6.2	6.0
Fiber (%)	1.7	1.8
Carbohydrates (%)	61.2	58.5
Calories/100 g	377	372
PER corrected	2.23	2.27

There is a need for extruded products other than Thriposha to utilize the projected surplus of sorghum and maize in place of imported wheat flour (Tables VIII and IX).

Sorghum is earmarked by the government for reducing the import of wheat flour for bread by substitution at a 10% level. Extruded maize, ready-cooked foods can provide alternative balanced foods for hundreds in place of imported wheat. Since sorghum and maize are not traditionally eaten cereals and as they require much processing, they have not found favor with the people of Sri Lanka. Therfore, extruded foods have a place, provided they can be economically produced.

Table VIII. Estimated Per Capita Consumption and Total Quantities Required of Rice Substitutes for the year 2000 as Compared with 1970 Estimates

Cereals	Per Capita Consumption (kg) 1970	2000	Total Quantity Required (million metric tons) 1970	2000
Rice	100	120	1.21	2.62
Wheat	30	10	0.36	0.22
Other grains (including sorghum and maize)	3	6	0.04	0.13



Thriposa trademark stamped on distribution bags.

Table IX. Agricultural Production and Growth Rates

Cereals	Agricultural Production Annual Average (bushels) 1949-51	1959-61	1969-71	Annual Growth Rates 1949-51 to 1959-61	1959-61 to 1969-71	1949-51 to 1969-71	1969-71 to 2000
Paddy	22,365,000	40,865,000	70,070,000	6.2	5.5	5.9	3.8
Maize	316,000	338,000	573,000	0.8	5.4	3.1	4.0

Food Production Applications in Indonesia, Part A

Earl J. Goodyear
CARE: West Java
Bandung, Indonesia

INTRODUCTION

The Problem

The question of whether there exists a malnutrition problem of any great magnitude in Indonesia is one that I need not elaborate on in great detail. The answer to this question is emphatically yes. Reliable nutritional data have been documented by the Government of Indonesia and many international organizations through surveys and field studies which refute a previous popular notion that the countryside is lush and fecund and the populace nutritionally satisfied.

As in other developing countries, Indonesia shows a deficit per capita calorie/protein availability set against the government daily standard of 2,100 calories. In 1972, the Department of Health estimated a shortfall of 15% for calories and 27% for protein for the Indonesian population as a whole. Such deficits are felt even more strongly at the lower ends of the economic scale and particularly among the most vulnerable sections of the population comprising infants, pregnant and lactating women, and preschool and primary school-aged children.

To reach the standard of 2,100 calories, an additional 250-450 calories per day, depending on which food availability table you select, would have to be achieved. Taking 300 calories per day per person, in terms of rice, would require the production of 4,462 million metric tons of milled rice. This represents an increase of about one-third of the existing total rice production in Indonesia. Recent increases in rice production over the past several years have averaged 5-6% along with a population increase of nearly 3%. The foregoing production problem is a good example of the need to diversify the Indonesian diet even if quality were omitted entirely.

Obviously, feeding a rapidly growing population is not just a matter of increasing food supplies. Raising food production alone does not yet automatically guarantee improved food intake nor the nutritional status of those who do not have the purchasing power to participate in the benefits of any production increase. Conversely, there is ample evidence that increasing purchasing power alone does not necessarily improve nutritional status either.

Malnutrition and the Integrated Program Concept

Malnutrition cannot be regarded as a phenomenon isolated from other manifestations of low-living standards, nor as the single and inevitable result of any one cause. In Indonesia, malnutrition has a complex etiology arising from a basic imbalance of the man per land ratio and the resultant deficiencies of both calories and protein. The problem is further complicated by a set of interlocking relationships between malnutrition and the socio-economic factors of low purchasing power, low productivity, lack of education, lack of health facilities and services, and a high birth rate.

Accepting that malnutrition is part of the complex problem of poverty, the basis for an effective approach in improving the food and nutritional problems facing Indonesia then should lie within a framework for improving the overall social and economic conditions of the poor. The need to attack malnutrition on a broad front calls for a systematic plan aimed at generating effective consumer demand for nutritionally desirable food in agricultural production planning in order to match supplies to the new demand.

The concept of planning nutrition in an integrated approach is in itself a *novus ordo seclorum*, which in Latin translates to a new order of the ages. Around the world, programs aimed at increased food production not only have had no explicit nutritional objectives in most cases, but have sometimes even worsened the existing nutritional situation. On the other hand, projects with specific nutritional objectives, such as intervention feeding or nutrition education programs, have lacked long-term impact because of an isolation from other aspects of development. This lack of integration within the scope of the total process of development has placed nutrition programs in the position of being solely concerned with health and welfare.

The adoption of a long-term approach, however, does not mean a neglect of the need for immediate action to alleviate the most severe hardships. Intervention programs, such as MCH or school feeding, nutrition education and other measures must continue. These short-term actions, included in an integrated nutrition program, should be regarded as a holding action--providing a vital breathing space--until the results of the integrated approach become visible.

CARE Integrated Nutrition Program in Indonesia

In 1973, CARE began to investigate the possibility of any integrated or comprehensive approach to some of the key nutritional problems in Indonesia. President Soeharto in his budget address in 1973 made a clear statement of intent to step-up the attack on inadequate nutrition as a serious obstacle to both development and the improvement of people's productivity and welfare. Presidential Instruction (INPRES)

Number 14 issued on September 13, 1974 on the "Improvement of Peoples' Menus" was meant to diversify and improve the nutritional value of peoples' food in terms of quality and quantity as part of an effort to improve general welfare and the quality of life.

In an attempt to respond positively to INPRES 14, the establishment of an Inter-Ministerial Committee for the Improvement of Nutrition and several complementary projects, such as the Improved Family Nutrition Program, the Nutrition Intervention Pilot Project and CARE's Integrated Nutrition Project, were undertaken. Among some of the common aspects of each project is one that includes the development, testing and implementation of locally developed multi-mixes (LDMM's) from existing or newly introduced secondary crop food grains.

The initial thrust of the CARE Integrated Nutrition Project is along four lines of activities: (1) nutrition supplementation through the distribution of P. L. 480 commodities with a shift to a locally produced blended food; (2) development, testing, and production of an indigenous product of high nutritional quality, particularly in protein, that can be replicated for home use as well as intervention feeding programs; (3) nutrition education information focusing on the preparation of more nutritional food combinations; and (4) agricultural extension production assistance to small farmers in the development of alternative cash crops of high nutritional value on marginal lands. Our strategy is based on the fact that food production marketing, consumption and the factors which condition them, can be represented in one single system approach.

Low-cost Extrusion Cookers and Their Potential in Indonesia

A key element in our project strategy involves the development of a locally developed multi-mix and of food combinations for use in the home or in nutritional supplementation programs. For this reason we requested the loan of a Brady Crop Cooker, Model #206, and a 100 hp Caterpillar diesel engine through the U. S. Department of Agriculture. Unfortunately, the Brady arrived in Indonesia in August, 1974 and the diesel engine cleared port of good order one year later. Since then several programming obstacles have delayed the planned testing of the Brady. Corresponding delays in receiving and clearing P. L. 480 corn and sorghum commodities for initial trials with indigenous food crops were unforeseen, as was a substantial cut in our counterpart's budget for research and testing.

We have, to date, completed a testing facility at the Agricultural University in Bogor for the Brady and associated equipment. Preliminary trials with small quantities of soybeans, corn and rice have been undertaken for the purpose of obtaining operational experience with the Brady. Eight combinations for a locally developed multi-mix (Table I) have been developed, and preliminary testing was carried out by the Government of Indonesia/CARE nutritionist. Testing procedures consisted of grinding and combining mixtures, simple cooking tests, and simple shelf-life tests. The full range of tests are envisaged, i.e., processing, acceptability trials, storage and shelf-life tests, nutritional assay, etc., of extruded products still need to be undertaken before we can fully evaluate the potential of the low-cost cooker under Indonesian conditions.

Table I. Locally Developed Multi-mixes (LDMM's)

Mixtures on which preliminary testing has been undertaken:

1. 66% sorghum + 34% red kidney beans
2. 40% sorghum + 30% cassava chips + 30% cowpeas
3. 66% rice + 34% green gram
4. 55% corn + 20% cassava chips + 25% legumes
5. 70% sorghum + 30% soybeans
6. 70% corn + 30% soybeans
7. 70% sorghum + 30% lima beans or long beans *(Koros - Phaseolus lunatus)*
8. 70% corn + 30% lima beans or long beans

CARE-Indonesia and our counterparts at the Agricultural University still have a long way to go. The first step to reaching our objectives will be to call on the Colorado State University team to visit Indonesia to supervise a training/testing program[1] on some of the food combinations already pretested in small trials. Once the "bugs" clogging our Brady Crop Cooker are removed, I feel confident that our testing program will move more fluidly in the future and that some of the assumptions I have stated about LEC technology will prove valid in Indonesia.

The potential of an intermediate technology like low-cost extrusion cookers for feeding programs can be quite promising. Their place within an overall attempt to improve people's diet would be to enable large-scale production of high-protein food combinations for use in institutional feeding programs now barred from receiving imported food assistance. This statement, however, is based on certain assumptions:

1. That LEC's are capable of successfully processing a range of locally produced food crops either singly or in combination for human consumption at a lower cost than other comparative forms of processing.
2. The extruder and associated equipment can be properly managed and maintained under local conditions of operation.
3. The Government of Indonesia is willing and able to accept a major portion of the cost for continuing feeding programs using indigenous mixtures rather than donated imported commodities.

[1]The training and testing program supervised by CSU personnel was held in August 1976.

Food Production Applications in Indonesia, Part B

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Indonesia is a large, diverse country consisting of seven main islands and more than 3,000 small islands scattered for about 5,000 kilometers east and west along the equator between China and Australia. This is the largest archipelago in the world encompassed by a single nation.

According to geographical size, Indonesia is the sixth largest country in the world and fifth in population after China, India, Russia and the United States of America. In 1975, its population of 132 million was more than half that of the United States.

Agriculture places a predominant role in Indonesia's economy. The annual production of the most important food crops in Indonesia from 1950 to 1970 is shown in Table I. It is clear, in volume terms, that rice is the most important food crop (Central Bureau of Statistics, 1972).

Table I. Production of Food Crops, Indonesia, by Years, 1950-1970 (from Central Bureau of Statistics)

Year	Wetland Stalk Paddy	Dryland Stalk Paddy	Total Dry Stalk Paddy[1]	Corn	Cassava	Sweet Potatoes	Peanuts	Beans
			(thousand tons)					
1950	10,425	1,145	11,570	1,571	5,783	1,422	150	205
1951	10,984	984	11,968	1,398	7,134	1,303	195	278
1952	11,566	1,207	12,772	1,638	7,535	2,292	167	286
1953	12,655	1,409	14,064	1,815	8,953	2,176	203	306
1954	13,342	1,719	15,061	2,720	9,569	2,111	248	401
1955	12,985	1,447	14,432	1,970	9,317	1,897	207	346
1956	13,308	1,310	14,619	1,965	9,131	2,638	218	357
1957	13,242	1,435	14,677	1,360	10,113	2,652	232	339
1958	13,331	1,463	15,344	2,634	11,273	3,103	231	418
1959	14,228	1,722	15,950	2,092	12,697	2,877	255	431
1960	14,876	1,984	16,860	2,460	11,376	2,669	256	442
1961	13,935	1,965	15,900	2,283	11,189	2,464	252	426
1962	14,855	2,256	17,111	3,243	11,386	3,680	261	293
1963	13,324	1,951	15,276	2,358	11,769	3,070	235	350
1964	13,990	2,202	16,192	3,769	12,262	3,958	261	392
1965	14,968	2,104	17,072	2,365	12,634	2,651	244	410
1966	15,517	2,443	17,960	3,717	11,232	2,476	263	417
1967	15,303	2,095	17,398	2,369	10,747	2,144	241	419
1968	17,195	2,354	19,550	3,166	11,356	2,364	287	420
1969[2]	18,726	2,040	20,766	2,284	10,845	1,904	257	416
1970[3]	19,367	2,221	21,588	2,433	10,401	1,931	310	378

[1]Dry stalk paddy can be converted to dry grain paddy by multiplying by 0.76.

[2]Preliminary figures.

[3]Forecast based on January-April production.

In the period of the first "Five-year Development Plan" (1969 to 1974) average increase in rice production was about 4.7% per year, and rice consumption during the same period was estimated at between 3.6 and 4.6% per year. In 1974, rice production was 15.4 million metric tons, and in the last year of the second "Five-year Development Plan," the GOI would like to increase production to 18.183 million metric tons (Dept. of Information, 1974).

Rice is the chief carbohydrate food in Indonesia. From 1954 to 1960, rice was more important than all of the other carbohydrate foods combined (Fig. 1). The available evidence indicates that it still is (Mears, 1962).

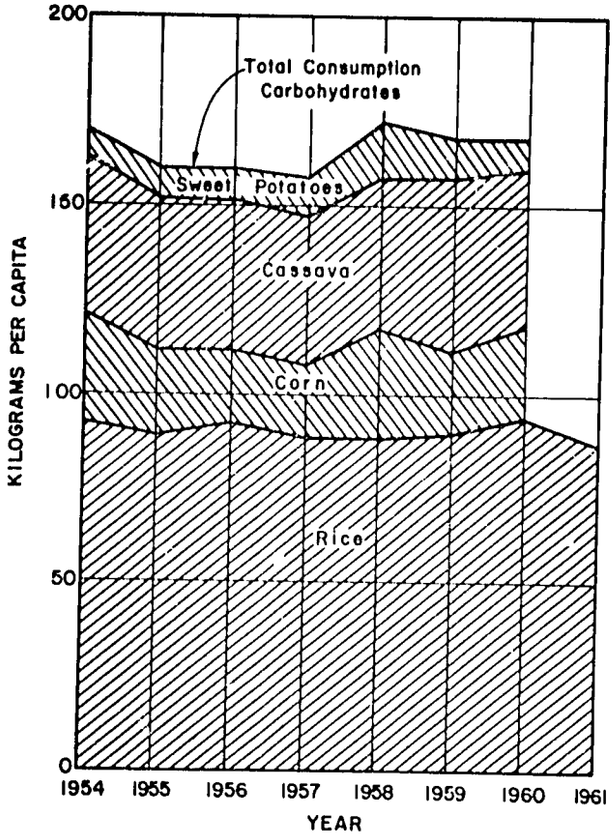

Figure 1. Average annual per capita consumption of carbohydrates, Indonesia, 1954-1960.

NUTRITIONAL PROBLEMS IN INDONESIA

The main nutritional problems in Indonesia are: (1) protein-calorie malnutrition (PCM), (2) vitamin A deficiency, (3) goiter, and (4) nutritional anemia. These problems afflict people of all ages, males and females. However, malnutrition is most rampant in vulnerable groups namely infants, preschool children, pregnant and lactating women, and low-income workers.

Nutritional problems in Indonesia seem to have a close relationship to the rice situation in the country. Rice is the most important item in the consumption pattern of the Indonesian people. This is indicated by the total amount of energy and protein consumed, which for the greatest part is attributed to rice. In order to prevent rice from playing a dominant role in the consumption pattern, efforts are being undertaken to diversify the menu of the people. A Presidential Instruction on this matter was issued on September 13, 1974 (INPRES No. 14/1974).

Many policies dealing with nutrition have been set out in the second "Five-year Development Plan." Three of them are: (1) supplementary feedings to alleviate nutrition problems among the vulnerable groups (infants, preschool children, pregnant and lactating women); (2) the extension of the Applied Nutrition Program to other provinces so that it will become a part of the rural development projects or community activities; and (3) the development of nutritious foods by food industries or other agencies. Low-cost nutritious food products should be given priority, so that people in need can afford to buy them.

APPLIED NUTRITION PROGRAM - EVALUATION STUDY, 1973

Starting with the Province of Central-Java in 1963, UNICEF/FAO/WHO-supported activities of the Indonesian Applied Nutrition Program in 1972 covered eight provinces: North- and South-Sumatra, West-, Central- and East-Java, Jogyakarta, Bali and West-NusaTenggara. At the request of BAPPENAS[1] in mid-1972, the National Committee for ANP agreed to have an evaluation made of the ANP (Sajogyo, 1974).

Some of the total sample of 1,053 households in 30 villages in eight provinces (8 villages in Sumatra, 18 in Java and 4 in Bali and West-NusaTenggara), the average food intake per day per person was found to be 1,528 calories (67% from rice); 42.8 grams protein (including 8.3 grams animal protein; 51% from rice); 20 grams fat; and a fairly high level of 5,832 I.U. vitamin A.

The evaluation study suggests that the priority target group be nursing mothers (with PCM-afflicted infants under two) and pregnant women. If projected on the 1973 population in Indonesia, the target group would involve about 3.5 million women, including 2.3 million nursing mothers with 3.1 million "below normal" PCM-afflicted children under two.

Households with such level of food intake may escape from calorie and protein shortages by consuming more rice and/or corn--to choose from the known staples--according to local preference. For these household high protein foods such as fish, meat, eggs or even pulses, are not relevant yet until more adequate levels of calories are attained.

In order to achieve a good method in nutrition education activities (the progress of ANP will be more measurable, especially on changing food habits and the improvement of diets of mothers and their infants or toddlers), new ways should be pioneered in nutrition education to insure that food-deficit households (generally they are low-income) may benefit.

According to this evaluation study, it was proposed that a pilot scheme be included to tests certain approaches to insure that low-income households benefit from the kind of nutrition education offered. It can be called the "nutrition-education-plus" approach, whereby food supplements are offered on a day-to-day

[1] BAPPENAS mean National Development Planning Board (Steering Committee), "Badan Perencanaan Pembangunan Nasional"

basis to the mothers (two-thirds are mothers with PCM-afflicted infants and toddlers under two; the rest, expectant mothers beyond five months pregnancy, to be more selective).

The pilot scheme, if covering 15 districts in eight ANP provinces for a period of three years, is to start in its first year in 60 subdistricts and 180 villages and is to cover in the third year 180 subdistricts and 1,080 villages. Two alternatives of "pilot size" are offered: a larger-sized pilot is to reach 150 mothers in one village in the third year of operation, offering a larger-sized food package to mothers and infants and toddlers, while a smaller-sized pilot is offering a smaller-sized food package and it is to reach only 100 mothers per village in its third year. The larger food package for mothers is a daily ration of 160 grams of cereals and 50 grams of pulses per person; for infants, 50 grams of cereals and 20 grams of pulses; and for toddlers (under two), 120 grams of cereals and 50 grams of pulses per day. The smaller food package for mothers is a daily ration of 100 grams of cereals and 30 grams of pulses; for infants, 40 grams of cereals and 20 grams of pulses; and for toddlers (under two), 100 grams of cereals and 30 grams of pulses. Cereals are rice or corn (and other cereals, if available), while pulses are soybeans, peanuts and other locally available beans.

The larger pilot scheme will reach in the three years of operation a target group of 135,000 mothers and 90,000 infants and toddlers in 1,080 villages, involving 82.1 million recipients per day, with food supplies of 11,500 metric tons of cereals and 4,000 metric tons of legumes (including 10% waste). The smaller pilot scheme will reach in three years a target group of 126,000 mothers and 84,000 infants and toddlers in 1,080 villages, involving 76.6 million recipients per day, with food supplies of 7,400 metric tons of cereals and 2,350 metric tons of pulses (including 10% waste), Tables II and III.

Table II. Needed Food Supplies--Cereals and Pulses--Used in a Pilot Project of Larger Food Packages[1] (from ANP - Survey 1973)

Food Supplies for	Target Groups: Mothers	Target Groups: Infants-Toddlers	Totals
First year	(9,000)	(6,000)	(15,000)
Cereals	576 tons	192 tons	770 tons
Pulses	180 tons	84 tons	270 tons
Recipient days[2]	(3,285,000)	(2,190,000)	(5,475,000)
Second year	(36,000)	(24,000)	(60,000)
Cereals	2,304 tons	768 tons	3,080 tons
Pulses	720 tons	336 tons	1,060 tons
Recipient days	(13,140,000)	(8,760,000)	(21,900,000)
Third year	(90,000)	(60,000)	(150,000)
Cereals	5,760 tons	1,920 tons	7,680 tons
Pulses	1,800 tons	840 tons	2,640 tons
Recipient days	(32,850,000)	(21,900,000)	(54,750,000)
Total - 3 years	(135,000)	(90,000)	(225,000)
Cereals	9,640 tons	2,880 tons	11,530 tons
Pulses	2,700 tons	1,260 tons	3,970 tons
Recipient days	(49,275,000)	(32,850,000)	(82,125,000)

[1]Nutrition-education plus food supplements aimed at mothers and their infants or toddlers to start in 18 villages during the first year and reach 1,080 villages (target group of 150 mothers in each village) in the third year.

[2]Recipient days based on 365 days in a year of food supplement.

Notes:

Cost of food supplement in rupiah (based on rice price of Rp 83,000 per metric ton): Rp 24.90 per mother; Rp 12.45 per infant or toddler; Rp 16.60 average per person per recipient day.

For larger food package:

a) expectant mothers (5 months or over): rice/corn 160 g, soybean 50 g (calories + protein = 740 cal + 28 g)

b) nursing mothers: rice/corn 160 g, soybean 50 g (calories + protein = 740 cal + 28 g)

c) infants (5 to 11 months): rice/corn 40 g, soybean 20 g (calories + protein = 210 cal + 10 g)

d) toddlers (12 to 23 months): rice/corn 120 g, soybean 50 g (calories + protein = 600 cal + 25 g)

LEC's IN INDONESIA

Extrusion cooking is important in the production of many food items and has several advantages: versatility, high productivity, low cost, ability to produce unique product shapes, and high product quality.

In order to determine the low-cost extrusion cooker's capability to produce nutritious foods with adequate storage life and to manufacture easily digested foods, especially for infants or toddlers, equipment testing and research were needed.

If the testing program soon to be conducted by CSU, in collaboration with Bogor Agricultural University (IPB) and CARE-Indonesia on low-cost extrusion cookers (i.e., the Brady Crop Cooker, Fig. 2), is successful, it may enable Presidential Instruction No. 14/1974 to be implemented on a national scale with a supplementary food program.

Figure 2. Indonesian personnel observing the Brady Crop Cooker demonstration during the training/testing program conducted by CSU at the Bogor Agricultural University in August 1976.

Table III. Needed Food Supplies--Cereals and Pulses--Used in a Pilot Project of Smaller Food Packages[1] (from ANP - Survey 1973)

Food Supplies for	Target Groups: Mothers	Target Groups: Infants-Toddlers	Totals
First year	(9,000)	(6,000)	(15,000)
Cereals	360 tons	168 tons	530 tons
Pulses	168 tons	50 tons	170 tons
Recipient days[2]	(3,285,000)	(2,190,000)	(5,475,000
Second year	(36,000)	(24,000)	(60,000)
Cereals	1,440 tons	672 tons	2,110 tons
Pulses	432	240 tons	670 tons
Recipient days	(13,140,000)	(8,760,000)	(21,900,000)
Third year	(81,000)	(54,000)	(135,000)
Cereals	3,240 tons	1,512 tons	4,750 tons
Pulses	972 tons	540 tons	1,510 tons
Recipient days	(29,560,000)	(19,715,000)	(49,275,000)
Total - 3 years	(126,000)	(84,000)	(210,000)
Cereals	5,040 tons	2,352 tons	7,390 tons
Pulses	1,512 tons	840 tons	2,350 tons
Recipient days	(45,935,000)	(30,665,000)	(76,650,000)

[1]Nutrition-education plus food supplements aimed at mothers and their infants or toddlers to start in 18 villages during the first year and reach 1,080 villages (target group of 150 mothers in each village) in the third year.

[2]Recipient days based on 365 days in a year of food supplement.

Notes:

Cost of food supplement in rupiah (based on rice price of Rp 83,000 per metric ton): Rp 12.45 per mother; Rp 8.30 per infant or toddler; Rp 12.45 average per person per recipient day.

For smaller food package:

a) expectant mothers (5 months or over: rice/corn 100 g, soybean 30 g (calories + protein = 460 cal + 17 g)

b) nursing mothers: rice/corn 100 g, soybean 30 g (calories + protein = 460 cal + 17 g)

c) infants (5 to 11 months): rice/corn 100 g, soybean 30 g (calories + protein = 210 cal + 10 g)

d) toddlers (12 to 23 months): rice/corn 100 g, soybean 30 g (calories + protein = 460 cal + 17 g)

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Feeding Programs: A Tool for Development in Costa Rica

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HISTORY OF CARE FEEDING PROGRAMS IN COSTA RICA

School Feeding

Since the mid-1950's, CARE/Costa Rica has been playing an important part in the development of school feeding programs utilizing P.L. 480 commodities. This resulted not only in building a solid base for ongoing, mostly self-supported programs, but also in helping to stimulate the local production of commodities like NFDM and processed cheddar cheese, which were previously unknown in Costa Rica.

Preschool Feeding and Nutrition Centers

Programs for feeding preschool children did not have the built-in facilities for large-scale feeding--like school feeding programs--and only reached a small number of children until 1966, when CARE, in collaboration with the Ministry of Public Health, the Ministry of Public Works, and local communities, entered into a Nutrition Center Construction program. As a result, the number of Nutrition Centers increased from 60 in 1966 to 320 in 1976; the number of recipients, from 3,500 to 21,000; the number of nutritionists, from 2 to 9; and supervisors, from 6 to 87 in the 10-year period.

Equally or even more important has been the catalytic effect of the program on community participation generating other communal efforts in the fields of health, nutrition and sanitation. Health care was added to the nutritional concerns, and each new nutrition center being constructed today serves also as a rural health clinic.

SOYBEAN PRODUCTION AND PROCESSING

The Beginning Stage - 1969

In line with its policy of developing local resources, CARE/Costa Rica in 1969 began its program of soybean planting and consumption. In spite of previous efforts, no concensus had been reached concerning the variety or varieties which were most suitable for Costa Rica, nor was there any established model for soybean processing and consumption. This program, with the help of other agencies, achieved the following results by 1976:

1. A broad interest in the soybean was generated.
2. New varieties were introduced.
3. Planting was done mostly by small- and medium-size farmers instead of by governmental agencies, as was previously the case.
4. Total acreage of planting had increased about tenfold by 1976.
5. Acceptable recipes were developed for home-cooked soybeans, facilitating consumption without the utilization of special processing equipment.
6. Suitable areas for soybean production were identified.
7. The basis for more advanced techniques in the production and processing of soybeans was established.

The Brady Crop Cooker - 1975

The next step was the installation of the Brady Crop Cooker for experimental and demonstration purposes prior to the production phase, which hopefully will be partially financed by an AID Operational Program Grant, with inputs by CARE and the local government. The machine has already aroused a great deal of interest, and an additional machine will be purchased by a private party for commercial production.

The AID Operational Program Grant

The major goals of the OPG are as follows:

1. To stimulate large-scale production, processing and consumption of the soybean
2. To demonstrate the effectiveness of the low-cost extrusion cooker in relation to more expensive extruder cooking processes and machinery
3. To provide inexpensive, high-protein soybean mixtures like CSB to governmental child feeding programs
4. To stimulate the processing and consumption of enriched local products, such as sorghum, yucca, bananas, rice and others

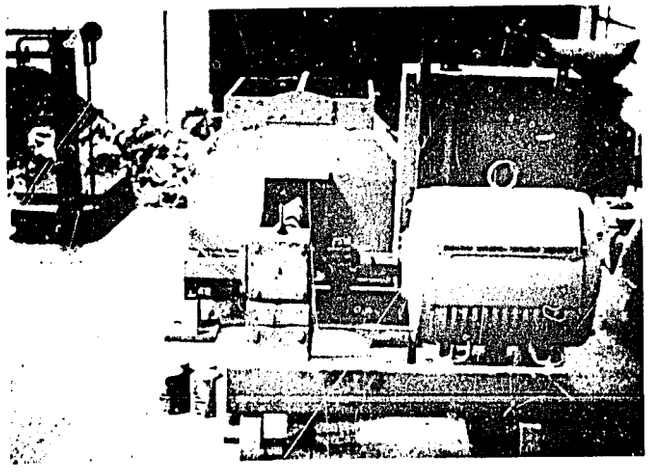
THE NUTRITION STRATEGY OF THE GOVERNMENT OF COSTA RICA

Asignaciones Familiares (Family Assistance)

In regard to the strategy for nutrition of the national government, a new program called "Asignaciones Familiares" was developed to improve living conditions of the more needy sector of the population, especially for those living in rural areas. Special attention is being given to nutrition, and the plan is to feed 500,000 children up to the age of 12 by March 1977, giving them two meals a day. The government looks at this program not only as being directed toward malnourished children (an INCAP study estimated that 54% of children 0 to 6 years of age suffer from some degree of malnutrition), but also as being a vehicle for income redistribution for families of children in the program. Except for a relatively small number of serious cases of malnutrition, each child will receive 30% of its protein requirements and 70% of its caloric requirements through the program. These percentages are in line with the results of studies carried out by Dr. Leonardo Mata, of the University of Costa Rica and formerly of INCAP, and by CARE. Dr. Mata also emphasizes the importance of adequate sanitation in obtaining maximum impact for feeding programs. He believes that Costa Rica, through an effective rural health program which includes the installation of pumps by organizations like CARE, has given a good example of the interrelationship between sanitation and nutrition.

The LEC within the Context of Governmental Planning

In order for the government to reach its goal of 500,000 children by March 1977, it is essential that the machine be operational by that time and that it provides 2,600,000 pounds of CSB and other soy products or mixtures for the remainder of the calendar year 1977. If we add to this the approximately 4,000,000 pounds of P.L. 480 commodities tentatively approved by Washington for preschool feeding in nutrition centers and canteens, then the combined input will provide almost all of the protein requirements and a substantial part of the caloric requirements for about 200,000 school and preschool children.



Brady extruder ready for testing in Costa Rica

With funds available to the government as part of the "Asignaciones Familiares" (Family Assistance) program, it should then be able to finance the feeding of the remaining 300,000 children for the calendar years 1977-1979, provided all of the other inputs remain the same.

One of CARE/Costa Rica's main concerns will be to keep in close contact with Colorado State University so that they will be aware of any production problem we may face in the extrusion process. We also need to be kept informed of the results of other LEC projects as they relate to the Costa Rica program.

As we look back on CARE's activities related to child feeding during 20 years in Costa Rica, we would seem to be justified in saying that the feeding programs have been a tool for development.

Food Production Applications in Costa Rica

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The proposed scheme for the utilization of the Brady Crop Cooker in Costa Rica, and as I understand it for other countries as well, involves the use of raw materials produced locally. For that reason, at this point, I will briefly touch on aspects other than the utilization of an agricultural product or factors relating to consumer acceptability or quality; rather, I will talk about the potential for soybean production in the humid tropics, specifically in Costa Rica.

It is a well-known fact that for thousands of years soybeans have been the main source of protein for millions of people in Asia. Since the introduction of soybeans to the Western Hemisphere at the turn of the 20th century, soybean cultivation has expanded from a crop of minor importance to become a major cash crop for most of North America and Brazil. For reasons that will be considered later, soybean production in the tropical areas of the world has not expanded at the same rate as it did in the temperate zones.

In recent years the extremely rapid population expansion that has occurred in most LDC's, coupled with the prevailing primitive agricultural systems used in producing staple crops in those countries, has created a rather difficult situation.

Traditionally, the main source of protein available to the inhabitants of tropical America has been the common bean (*Phaseolus vulgaris*), and the advantages that could result from the cultivation of soybeans are, among others: increased yields as a result of a greater production capacity of the soybean plant, higher protein content and the production of oil.

DEMAND FOR SOYBEAN PRODUCTS IN COSTA RICA

As was already stated, Costa Rica because of its location 10° north of the equator, has not yet benefited from the expanded cultivation of soybeans. Therefore, the local demand for high-protein products to be used in the preparation of formulations for humans and animals is now satisfied with imported soybean products (Table I).

SOYBEAN PRODUCTION IN COSTA RICA AND OTHER TROPICAL AREAS OF THE WORLD

For the reasons mentioned before there is no doubt that there is a place for soybeans in the tropics. However, much work still remains to be done before we can state that soybeans have been successfully transferred from the temperate zone environment, in which they originated, to the tropics.

Table I. Importation of Soybean Products to Costa Rica in Metric Tons[1]

Year	Cake	Product Flour	Oil
1964	1,293	6.42	173.22
1967	9,419	0.46	46.56
1970	23,190	5.36	812.34
1973	22,118	42.63	280.12

[1]Source: Ministry of Agriculture, San Jose, Costa Rica.

A large number of factors affect soybean cultivation in the tropics, of which the most important probably are:

1. Daylength sensitivity

   In my opinion, a major factor in limiting the expansion of soybean cultivation in the tropics has been and still continues to be--daylength sensitivity.

2. Production program organization

   Soybeans are a crop that demand a high level of technology from the farmer as well as from the technical support groups. Therefore, a country's decision to launch a soybean production program has to be planned on the basis of the expertise available locally and certainly has to take into consideration such factors as:

   a. choice of cultivar or variety

   b. source of seed to cover the needs

   c. ecology of the production areas in relation to adaptation and harvesting

   d. land holding and distribution

   e. farmers' technical skill

   f. present and potential market

   g. potential use of product

   h. cost of production

PRESENT SITUATION

After evaluation of several hundred soybean accessions and crosses made locally under field conditions in Costa Rica, it has become evident that only a small number appear to adapt well to the humid tropics. Even though workers in other areas of the world are also doing their share of breeding new cultivars, with few exceptions the varieties now used for commercial production in tropical area are cultivars which were developed for the temperate zones.

The yields recorded for those cultivars which are well adapted are sufficiently high to permit stating that soybeans can be produced economically in the humid tropics when all of the requirements for a program, which were mentioned earlier, are met (Table II).

Table II. Yields in kg/ha Soybean Cultivars Under Two Different Ecological Conditions in Costa Rica in 1975

Cultivar	San Carlos	Palmar
Nanda	4,720	2,527
Indonesia	4,840	1,860
Capelican	5,200	2,269
138-Mandarin	4,640	2,350
206-6-M(2)18M	5,000	2,391
Velstate	1,780	2,445

IMPORTANCE OF THE BRADY CROP COOKER IN RELATION TO SOYBEAN PRODUCTION

To a great extent the expansion of soybean cultivation in tropical areas will depend mainly on the existence of a market for the crop.

Often soybean products regularly imported by tropical countries include primarily processed products--a situation which retards the development of soybean agriculture. Often the local food industry is not interested in installing the necessary equipment to process soybeans until it can be certain that local production reaches a volume which can guarantee a safe supply of raw material.

Under the above-described circumstances, the installation of a Brady extruder helps create a demand for soybeans, which in turn serves to promote the crop at least until additional industrial demand for soybeans develops.

Food Production Applications in Bolivia

Pedro Bleyer
Maisoy
Santa Cruz, Bolivia

INTRODUCTION

I am honored by the privilege to talk to a very select audience, among which are personalities of a very high level in the areas of nutrition and food technology. I would like to make it clear to you that my own professional area is economics, and that my activity is feed manufacturing.

At the beginning of 1973 I came to the U.S.A. with the purpose of obtaining information in technology for the production of vegetable mixtures for human nutrition. I was inspired by two principal circumstances: my knowledge of poultry nutrition and of the socioeconomic effects of the world's shortage of food. These facts made me think that in a not-very-far future, we should think of providing protein directly from the land to the human.

After visiting several places in the U.S.A., I was told by Mr. Oak Smith of Wenger that it would be worthwhile for me to visit Dr. Ricardo Bressani at INCAP in Guatemala. Thanks to Dr. Bressani's cooperation, I received a clear picture of the basic goals to be accomplished. As a result of a long process of experimentation with corn and soybean mixtures, one was developed which he named "Maisoy."

We agreed to use the Brady Crop Cooker, which we had in our factory, for the processing of soybeans on an experimental basis. As available technology was limited, and the equipment was already assigned to the feed plant, we dedicated only free time to the development of the process itself.

In 1974 I visited Dr. Hornstein of AID and Mr. Crowley of USDA with the intention of seeking technical assistance. Thanks to that contact, last April I received the invaluable visit of Drs. Harper and Bogyo, sent by the Agency for International Development, to give us special assistance on our Maisoy project. Thanks to their efficient cooperation, the industry is now in production and has started to deliver Maisoy to the Bolivian Health Ministry with the intent to substitute it gradually for the international aid that has started to diminish.

OBJECTIVES OF THE MAISOY PROJECT IN SANTA CRUZ, BOLIVIA

The basic objectives are summarized as follows:

1. To produce a vegetable mixture with abundant local raw materials; to get the highest biological value at the least possible cost; and to achieve a product accepted by our people.

The biological value of this mixture is known over the world, and while Dr. Bressani's experiments have shown that a mixture of 72% corn and 28% soybean has a higher biological value, a practical ratio is 70:30. The corn used is named "yellow Cuban corn" and is used for poultry nutrition. It is considered the high-yield crop of the country, with two yearly crops: one at the end of summer, and one at the end of spring called "Helping Corn." This grain is not used for human consumption as are other varieties, and it is at this point where technology comes in to make that possible.

Soybean cultivation began in Bolivia in an intensive form only two years ago. The level of production should increase annually because of the demand for oil-producing grains required by the industry, but I do not think that this demand will cause supply problems for the production of Maisoy.

Evidently a mixture like Incaparina might be cheaper than Maisoy, but the poor sanitary conditions and controls which exist in the oil industry and its low palatability would limit its acceptability by the Bolivian people. Therefore, its introduction into the country would represent too high a risk for private industry to assume.

I hope to be successful in the project due to various factors: (1) the taste of Maisoy is basically that of corn and is familiar to Bolivians; (2) in the past, various cultures, such as the Quechuas, the Mayas and the Aztecs, based their daily diets on corn. As a result of this, some authors say they all belong to the "corn culture." At the present time--and since the above mentioned cultures still exist in our country--I must say all we Bolivians use corn and consider it a very important component of the daily diet. It is important to note that, thanks to the extrusion process, the beany flavor of the soybean is totally lost, keeping a 100%-corn flavor. Concerning its cost, corn is the cheapest grain in the country. Other economic aspects in reference to the industrial process will be mentioned later.

The production of Maisoy must provide a reasonable return on investment to permit its continuation. The past experiences of others give us a lesson that--after many failures in numerous projects--it is not possible to

develop new food products if they are not feasible for the company. I consider a production program feasible for a company when it has the following characteristics:

a. Enough national supply of raw materials.

b. The product is liked by the consumer (tests, quality, etc.).

c. The product has a guaranteed stability, based on packing that efficiently preserves it, is appealing to the consumer and maintains a price range within the purchasing capacity of the people.

d. Ability to obtain an institutional market that guarantees a certain sales level, allowing the industry to approach the break-even point. (I refer to government purchase, not subsidy.)

e. Product can be substituted for international donations. Otherwise, it is impossible to compete with them.

f. Company can obtain tax advantages from the government.

g. Government acceptance of the reality that no industry is feasible without appropriate marketing. Therefore, prices can not be political, and distribution and sales costs, publicity, and wholesale and retail profits are to be considered essentials.

h. A company already working with cereals should undertake the development of such a project in order to reduce fixed costs.

i. Those products with a high biological value must have specific characteristics that will permit the manufacturer to obtain profits from sales to those who can pay more, thereby compensating for other products that would benefit the poor.

2. To contribute to the nutritional improvement of the country.

The company has to be motivated to take into account the social importance of nutritional problems of its countrymen without forgetting its responsibility to the shareholders. In the particular case of Bolivia, I do not yet have a study of the effect that Maisoy will have on the improvement of the country's nutritional level. However, when we analyze Table I from "Programs for a Feeding & Nutrition Policy to be Integrated in the Economic and Social Development of Bolivia, 1976-1980" (Commission for the Planning of Nutrition and Feeding Policies, February 1976), we can clearly see that any rational attempt will be positive.

ACCOMPLISHMENTS TO DATE WITH THE BRADY CROP COOKER

The Brady Crop Cooker processes the Maisoy blend extremely well. I will not refer to the technological aspects, because this subject was fully covered by Dr. Harper. I want to refer only to the experience that we have had with a blend of rice and soybean. The more enthusiastic Maisoy consumers did not show any interest in consuming the blend based on rice. This stems from the fact that the cost of rice is four times that of corn.

It is worth noting that we have two possibilities in carrying out the process. The choice is between the use of dehulled or whole corn. In the case of dehulled corn, we obtain a product previous to the pulverization that is expanded better and of a higher quality. The cost is much higher, because in the dehulling process the losses are about 40% of the total weight of the corn, and because more energy and labor are consumed. Moreover, the micropulverizer is not capable of continuous milling of the output of extruded product. In the case of whole corn, the product is less expanded but equally cooked, and the micropulverizer has an easier time matching extrusion production. Both final pulverized products taste and look alike.

Table I. Energy and Protein Intake

Median Daily Ration	Average of Country	(Altiplano) High Platuau	Valleys	Plains
Calories				
Intake	1,890	1,883	1,894	1,892
Recommended[1]	2,213	2,274	2,248	2,117
Deficit (absolute)	323	391	354	225
Deficit (relative)	14.6%	17.2%	15.7%	10.6%
Animal Protein (actual)				
Intake	18 g	15 g	16 g	24 g
Recommended[1]	27	29	23	28
Deficit (absolute)	9	14	7	4
Deficit (relative)	33.4%	48.3%	31.7%	14.3%

[1]Adapted for the studied area, starting from the accepted value of the ICNND.

FUTURE PLANS FOR THE OPERATION

Future plans are rather ambitious. I can see two main lines of products:

1. Maisoy Flour - This product is based on processing the whole corn and leftovers from the dehulled corn process. It will be marketed in a first stage as a base product for various predetermined uses at the institutional level in bags of about 46 kilograms, or 100 pounds. Bags presently used for deliveries to the Ministry of Social Welfare and Public Health are made of polyethylene and are covered by a second bag of polypropylene. For open market sales we will use smaller packaging, details of which will be determined by a market survey. In a second stage, while maintaining the original product in the market, other, more sophisticated products will be launched which will include flavors, coloring, vitamins, etc., and which will be destined for consumers with higher purchasing power.

2. Maisoy Flakes - The product will be sold as snacks and as a replacement for low-protein cereals. The second stage will give the flakes more sophisticated characteristics for a public that can pay higher prices.

Additional assistance is necessary to better develop the missing stages for developing and marketing the products.

APPLICATION OF EXTRUDER COOKERS IN BOLIVIA TO PRODUCE LOW-COST NUTRITIOUS FOODS

At this moment, ours is the only real project in our country and, so far as I understand, our firm was the first one to experiment with the Brady Crop Cooker in Latin America. The adaptability of the extruder cooker has been perfect, because Maisoy flour is almost the same as another product known as PITO (toasted powdered corn), and Maisoy Flakes are similar to PASANKALLA (much like popcorn), another very popular product.

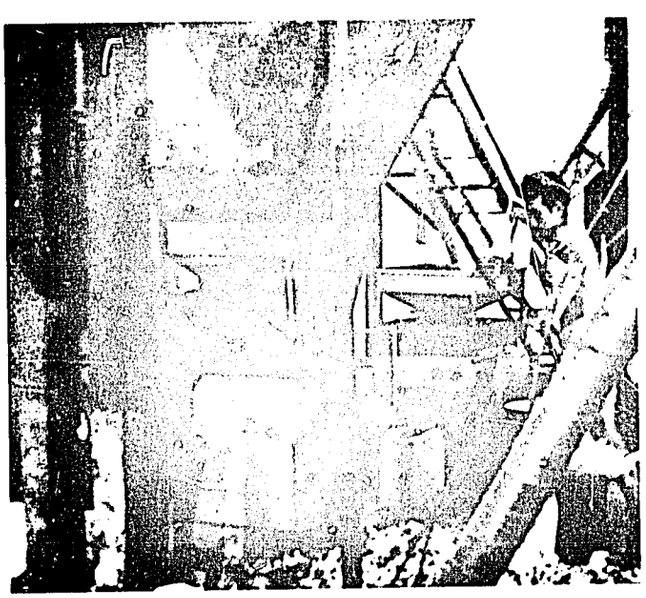
I am sure that all that has been done by the Brady Crop Cooker is only the beginning and that evolving technology and imagination will develop many more possibilities. I hope the manufacturers of this equipment will focus their efforts of these possibilities, so as to improve the equipment and to simplify its operation even more.

Mr. Fox:

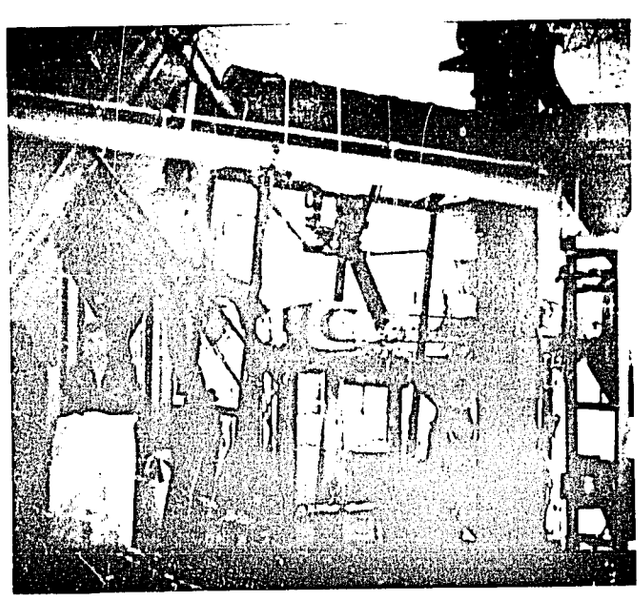
What is your Maisoy mixture?

Mr. Bleyer:

Maisoy is a mixture of 70/30 corn/soy. You saw that mixture last night at the extrusion demonstration and that is the best mixture for cereals and oil seeds that I know.



Brady extruder manufacturing Maisoy flakes.



Cooker and Micropulverizer used in production of Maisoy.

Food Production Applications in Tanzania

Aleck Mosha
Tanzania Food and Nutrition Center
Dar es Salaam, Tanzania

INTRODUCTION

The malnutrition problem is a big one in Tanzania, especially among vulnerable groups--the young, and expectant and lactating women (Maletnlema, 1975). The main causes are aspects of food production and utilization, low income, ignorance and disease. Among the usual results, poor brain development, morbidity, infant mortality and overall low productivity are most serious. A weaning food program has for some time been under development as a possible intervention measure. The case history covered in this paper deals mainly with a commercial product primarily for urban and semiurban areas, though homemade weaning foods have a big role to play among the rural populace.

FOOD PRODUCTION STATISTICS

Tanzania's official policy of self-sufficiency in food production implies that local raw materials must be used in the program. Food production varies much from year-to-year due to fluctuations in total rainfall and its distribution. The year 1972 has been chosen as an average year during the period from 1965 to 1975, thus giving a fair indication of food production.

As is evident in Table I, the supply of cereals and legumes--the major ingredients in the case under consideration--is adequate, and some of the commercially processed portion has been recommended for processing into weaning foods. Meanwhile, the consumption of legumes is limited by the lengthy process involved before consumption. It therefore follows that processing the high protein legumes and incorporating them into readily and commonly eaten forms would increase intake. The data for soybeans were not available, but 500 tons could be regarded as an average figure (since 1972 a large expansion program has been undertaken).

Table I. Harvested Food Production of Major Crops in 1972[1]

Food Crop	Tons
Maize	880,886
Millet	128,198
Sorghum	190,822
Wheat	98,285
Rice (Paddy)	170,903
Mixed beans	152,835
Cassava	792,850
Irish potatoes	113,132
Sweet potatoes	234,151
Groundnuts	29,331
Sesame	8,015
Bananas	1,205,743
Soybeans	776

[1]Source: Ministry of Agriculture, Dar es Salaam

BACKGROUND

A review of "Human Nutritior Activities in Tanzania" (Mohamed and McKeag, 1970) shows that in the early 1960's the enrichment of sembe (60% locally extracted maize flour), as well as the fortification of other local staple foods with high protein sources (such as dry meat powder, groundnut flour and soy flour) were advocated and limited attempts were made. It was realized that the undertaking was desirable to alleviate malnutrition but the use of animal products was expensive, placing the product beyond the means of the low-income group, so the use of vegetable protein sources was advocated.

LOW-COST, HIGH-PROTEIN PRODUCT DEVELOPMENT

Preliminary trials of feed maize-soy flour mixtures to adults and children in educational institutions showed that 5% soy could be added undetected to uji and ugali (local thin maize gruel and thick maize flour paste, respectively). Higher amounts gave objectional color and taste. However, among needy young children, amounts of soy up to 25% were acceptable as shown by quantities of USAID corn-soy blended mixtures consumed in supplementary feeding programs.

WORK IN LOCAL RESEARCH INSTITUTES

Systematic high-protein product development was undertaken by the Ministry of Agriculture, including cereals, legumes (soy and local beans) and dry skimmed milk powder, in the late 60's.

Mixtures of maize and sorghum flour containing up to 25% soy flour were acceptable in child-feeding trials. Fish protein concentrate (FPC) produced locally was acceptable up to 10% FPC. Local bean flour was well accepted with up to 15% additions.

A village-level soy processing project (in which the villagers used hand-operated equipment for processing soybeans into full-fat flour, soy milk and curd) was started. The products were incorporated into local cereal staples, which were very well accepted. The project is still in progress, but it has been hampered by difficulties arising from the large labor input required by the hand-operated equipment. The use of power mills for decorticating and grinding the soybeans has been recommended.

BISCUIT LINE APPROACH BY FAO

Later FAO (Herz, 1972-1975) carried out feasibility studies on high-protein weaning foods, and the undertaking was found viable. An initial product containing maize, soy, local beans, milk powder and a vitamin-mineral mix was processed in Italy and tested. It posed clinical and acceptability problems. The formula was later modified to exclude the local beans. The composition now contains 55% maize, 21% soy flour, 9.5% wheat, 5% dry skimmed milk powder, 5% sugar and 0.5% vitamin-mineral mix. It is processed like biscuits after pretreatment with α-amylase and ground into flour. It contained 19% protein with a Net Protein Utilization (NPU) value of 34. Preliminary trials indicated that the product was acceptable, but more extensive tests are being undertaken.

DRUM (ROLLER) DRIED FORMULATIONS

Drum-drying processing of maize-soy-dry skimmed milk powder was carried out by the author (1971). The most acceptable mixture contained 80% maize, 10% full-fat soy four, 5% dry skimmed milk powder and 5% sugar and had 14% protein. The color and flavor were not significantly different from the traditional maize products consumed locally.

BRADY COOKER PRODUCTS

Other formulas developed by the author were successfully processed through the Brady cooker in Nairobi. With help from Colorado State University, a mixture containing 70% maize flour and 30% soy flour and having 16% protein and an NPU of 47 was produced. Another mixture containing 80% maize flour and 20% soy flour, with 13% protein and an NPU of 40, was also produced. The products were of good color and flavor. Preliminary feeding trials have shown that the products are acceptable to an adult taste panel and to children in local primary schools.

CURRENT ACTIVITIES WITH THE BRADY PRODUCT

Nutritional evaluation, including routine analysis, animal tests for biological value determination and processing condition effects, and actual clinical trials are underway. Large-scale acceptability and tolerance trials have been started. Physical tests, including texture, other rheological tests, packaging and shelf life have also begun. If successful (as is likely), trial marketing plans will be made. In the meantime, the National Milling Corporation, on behalf of the government, has submitted a project proposal to USAID for a Brady extruder-cooker for production of the successful mixtures.

POTENTIAL IMPACT

If the aforementioned is completed, it is planned to go into full-scale production of a weaning product to replace commercial imports and USAID-donated corn-soy blended mixtures currently coming from the United States for supplementary government feeding programs. This will certainly prove to be an effective nutrition intervention measure, especially among needy groups with low incomes and, in particular, hospitalized children, children attending Mother-Child-Health (MCH) Centers and Day Care Centers (a nationwide network exists) and school children through lunch programs.

OBSTACLES TO FINAL GOALS

Raw Materials

Presently the supply of maize is adequate, but soybeans--now averaging about 500 tons annually--may pose a problem. However, plans to produce large amounts of soybeans using parastatals are being implemented, and a realistic production target of over 2,000 tons is assured. Should dry skimmed milk be added, a spray-drying plant has been installed in the country, and a FAO-funded dairy development program will replace milk powder imports from abroad.

Securing a Brady Crop Cooker

Efforts are underway to bring the crop cooker now in Nairobi to Tanzania. If this fails, it is hoped USAID will provide a machine for installation at National Milling, whose staff is prepared to make more product for countrywide testing and full-scale production, should the proposed aid project go through successfully.

The Tanzanian Food and Nutrition Center logo in Figure 1 illustrates a new systems program we have which is aimed at reducing losses of products as they finally reach the village-level consumer.

CONCLUSION

In conclusion, we in Tanzania feel that previous attempts at producing local high-protein weaning foods elsewhere in the world were hampered by high processing costs caused by the type of equipment used. The use of low-cost extrusion equipment may provide the answer, since the final cost of the product will be within the reach of the low-income needy group, hence alleviating the malnutrition problem.

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THE SYSTEMS (TOTAL PACKAGE) APPROACH

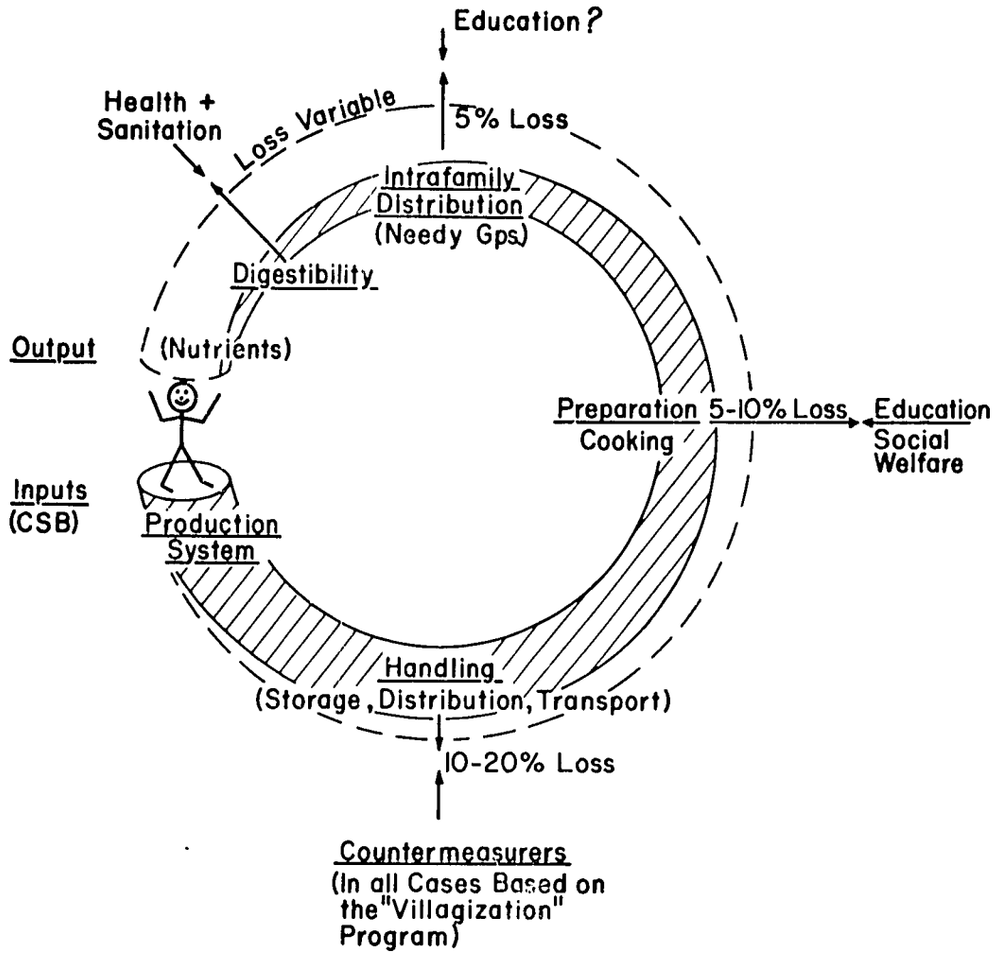

Figure 1. The Tanzanian Food and Nutrition Center logo.

Low-cost Extrusion Food Production Applications in Tanzania - A Case Study

Maurice N. Samaan
National Milling Corporation
Dar es Salaam, Tanzania

BACKGROUND

The National Milling Corporation (NMC) is a parastatal Tanzanian Government agency acting as a commercial organization. Its basic function is to feed the nation by procuring all surplus food grains from the growers and processing them into finished products which they market through a national marketing infrastructure network. NMC is the sole authorized body that controls the marketing of all agricultural grain products. As a sideline, it also cans fruits, juices and squash and produces wines.

Its role bridges the gap between the grower and the consumer. NMC operates through a national headquarters in Dar es Salaam, 23 branches and 40 depots throughout the country.

STATISTICAL DATA

The population of Tanzania is approximately 15 million people, with a net population increase of 2.7% per annum. About 50% of the population is under 16 years of age, and life expectancy is about 40 years. The estimated number of children under 5 years of age is 2.5 million, of which 840,000 are between 6 months and 2 years. Per capita income is estimated at an average of $150 per year.

The main staple foods are maize (corn), cassava, bananas and sweet potatoes. Secondary in importance are wheat, rice, millet and sorghum.

Malnutrition is a widely spread problem at the various stages of growth from infancy through adolescence to adulthood. The hardest-hit group is that between the ages of one to two years, which suffers from protein deficiency. The main two causes of malnutrition are poor production of crops and improper preparation of foods at the family level, coupled with the lack of knowledge of parents about preparation of nutritious food for family members from locally available ingredients. As Tanzania does not manufacture any baby foods, it depends on the importation of such commodities which, due to their high costs, satisfy only the high-income groups of the population--which comprises a very minor portion of the entire population. Thus a wholesome nutritious diet is a dire necessity, particularly during the formative years, to insure the healthy growth of Tanzania.

TANZANIA GOVERNMENT NEEDS AND POLICY

To combat the malnutrition problem the government is at present sponsoring the following feeding programs:

1. Preschool child feeding aimed at children between 6 months and 7 years of age who are suffering from malnutrition or who are potential candidates for malnutrition.

2. Primary school feeding programs for children between the ages of 7 and 14.

3. In-clinic feeding programs for nursing mothers.

The above programs are only a start to resolve the problem and are limited by available resources.

At present available resources are:

1. Ten thousand tons per year of USAID- (through Catholic Relief Services) donated foods--mainly corn/soy blend, bulgur wheat and oil. The bulk of these foods is distributed through preschool feeding programs to about 150,000 children. Another portion is distributed through primary school feeding programs to about 75,000 children, and the balance is used for other child-feeding programs reaching about 25,000 children.

2. Tanzania Government contributions from its own limited resources.

3. Local community organizations operating under a self-reliance program to combat malnutrition.

At present the number of children needing urgent special nutrition attention in Tanzania is about 500,000. Donated foods are reaching only 50% of that number--representing the critically needy ones. The balance of about 250,000 children depends on the other available resources, which are very limited.

Of the total population, 2.5 million children under 5 years of age experience malnutrition at various stages and in varying degrees. Present donated foods provide only about 10% of these children with 20% of their nutritional requirements.

The Government has adopted the policy of self-reliance and is requesting donor countries supplying foods to consider their donations as part of a program to develop a production capability within Tanzania, whereby materials locally grown or produced could be utilized to manufacture nutritious foods at a low cost.

USAID is at present seriously considering the initiation of a pilot project in Tanzania to extrude soy-fortified cereals for baby food. Another line of action adopted by the government is a mass educational

program that would reach all levels of the society, particularly in the rural areas. The objective of such an effort is to educate the mothers in simple food preparation that would result in improved nutrition by utilizing home-grown agricultural and dairy products. However, such a program is in dire need of adequate logistical support and qualified manpower.

THE ROLE OF LEC TECHNOLOGY

About 50% of the population earns less than $300 per annum per family. Accordingly, the lower the cost of extruded foods, the greater a market penetration would be expected to reach down to the base of the income pyramid, thus offering a low-cost commodity to the lower-income groups.

At present the country imports about 2,000 tons of baby food at a cost close to $5 million. Such imports are sold at about $4.00 per kilo and therefore are purchased by a very small percentage of the population (high-income groups). USAID's pilot project of LEC anticipates production to be sold at $0.50 per kilo. However, this project will only produce about 1,200 tons per year on an eight-hour-shift-per-day basis.

The implementation of LEC technology in Tanzania would serve a dual purpose:

1. To produce a low-cost nutritious food, using local materials, to be channelled to government feeding programs, thereby permitting greater coverage in reaching needy children. However, the government lacks the financial resources to support the costs of such production.

2. To satisfy the commercial market--particularly in urban areas--by offering a low-cost product, thus reducing (if not eliminating) imports and encouraging middle-income groups to utilize nutritious foods.

At present about 1% of families with children depend on imported baby foods. The potential of LEC foods could be as high as 30% of such families.

ASSISTANCE SOUGHT

1. Financial and technical assistance to expedite the development of a local extrusion production facility capable of satisfying national needs.

2. Donated foods to bridge the gap until such a production capability is developed in-country to reach self-sufficiency.

3. Fortification of local available raw materials through added components that would produce vitamin-rich nutritious foods.

4. Technical assistance for mass food application programs using formulas that include materials grown locally.

Food Production Applications in Mexico

Richard P. Mommer
Uniscope, Inc.
Johnstown, Colorado

INTRODUCTION

Uniscope, Inc., Johnstown, Colorado, U.S.A., and Uniscope, S.A., San Luis Potosi, Mexico, are agribusinesses founded and operating under a free enterprise environment. Since these agribusinesses receive no government financial support, our objectives are to self-perpetuate the businesses through a profit-earning system of operation. The question may be raised here, then, as to how a profit-oriented business can provide low-cost nutritious foods to those in need. The answer to this question is stated under our plan of objectives for Uniscope, S.A., in San Luis Potosi.

FIRST YEAR PLAN

First Objective

To manufacture and market a high-protein snack food to the consumer market. This will be a high-profit-type business selling snack foods to those people in Mexico who can easily afford this luxury. At the same time, the high-protein snack will certainly upgrade the protein level, especially for children who, even though they are among the more affluent members of society, may be suffering from protein deficiencies due to the shortage of meats and milk products in the country. We estimate that the profits from the snack food business will financially support the business and allow Uniscope, Inc. and Uniscope, S.A. to pursue the second and third objectives stated herein.

To accomplish our first year objectives, Uniscope, S.A., Mexico, acquired an import permit for a low-cost Brady extrusion cooker unit. Uniscope, Inc., Johnstown, has ordered this unit, which will be in operation the first week in June in Johnstown. Uniscope in Johnstown will operate the extruder experimentally to arrive at the best possible high-protein snack with seasonings, etc. The extruder then will be forwarded to Mexico about July 30. Uniscope, Johnstown, personnel will go to Mexico to assist with the set-up, early production, and product testing.

Second Objective

Concurrently with the high-protein snack project for the consumer market development, to offer the same product for sale at our manufacturing cost to the government agencies on a non-profit basis for school children and to charitable organizations for distribution to the needy.

During the week of May 17, Uniscope, Johnstown, personnel conducted a market survey in San Luis Potosi in Mexico to evaluate the high-protein snack food market potential. General results of the survey are favorable in this area. Also, contact with the government was made and some initial data gathered as to what is now being done to upgrade nutritional levels of the school children. A breakfast program is in operation which provides one banana, one orange, and one dried milk-based nutritional high-protein candy-like block to all public school children. The Catholic Church in Mexico also buys these blocks manufactured by the government and distributes them to the needy. The small block is called "Nutrimpi" and is made by the Mexican Institute for Infancy and the Family. The block's net weight is 22 grams and it is approximately 1½" square by ½" thick. The basic ingredients are: 60% nonfat dry milk, 17% sugar, 4% soy flour, 0.82% of banana, strawberry, and chocolate flavorings, 1,200 International Units (I.U.) of vitamin A per unit, 216 I.U. per unit of vitamin D., 4.4 mg per unit of niacin, 0.035 mg per unit of riboflavin and 0.20 mg per unit of vitamin B_6.

Without more investigation, we feel that the low-cost extrusion snack using a high-protein legume-grain source will be more economical than a milk protein source and will provide more protein for more people.

SECOND YEAR PLAN

Third Objective

Uniscope, Johnstown, is to immediately purchase a second extruder to begin development work on increasing the percentage of gelatinization of whole-cooked grains and other starch sources. Pregelatinous starches are being used commercially as thickeners in foods, binders in tablets, adhesives, and as sizing on textiles, etc. It is our objective to manufacture and market during the second year of operation an industrial pregelatinized starch product to help augment Uniscope's business financial requirements. Much work needs to be done with the extruders to produce a highly soluble starch product. Listed in Table I are the percentage of starch and percentage of gelatinization by analysis of commercially available pregelatinized starches and of Brady extruded wheat, rice, and sorghum products.

Table I. Comparison of CSU Brady-extruded Grains with Commerical Pre-gelatinized Starch[1]

	% of Starch	% Gelatinized
Wheat	58.8	29.0
Rice	65.5	33.0
Corn	65.2	33.0
Sorghum	64.5	32.0
Paygel 90 (General Mills starch)	79.2	71.0
GM-30 (General Mill starch)	74.1	67.0

[1] Lab Number: 9140

In the fall of 1976 at Uniscope, Inc., research and development work will be initiated on a laboratory pilot basis to manufacture single-cell protein by synthesis of carbohydrates with microorganisms. Since protein is a major worldwide nutritional deficiency, and in view of the current population explosion, we do not see how it will be possible for agricultural methods of today to provide enough food for the people. The personnel at Uniscope have some ideas on how to more efficiently produce protein from carbohydrates on a small, regional or local geographical basis. We realize that taste and product acceptance will undoubtedly be a problem with synthesized protein. If we can develop the proper technology for single-cell protein manufacturing, we will target a pilot plant protein operation in Mexico and incorporate the microorganism protein product into grains through the extrusion process to improve protein levels and food acceptability.

We feel strongly that the development of single-cell protein production, in combination with an all-out food production effort through existing agricultural methods, can reduce world hunger significantly. The grain-extruder method of food processing lends itself as a means through which single-cell proteins can achieve acceptability by people.

Transferal and Adaptation of LEC Technology in Chile[1]

Fernando Sanchez-Arellano
Instituto de Investigaciones Technologicas/CORFO
Santiago, Chile

Since 1969 the Technological Research Institute of Chile (INTEC), with the cooperation of AID, has carried out an extensive program of research and development on extrusion cooking of foods, utilizing a Wenger X-25 on a semi-industrial line.

The program of work has been oriented to take into account certain factors in Chile such as:

1. Utilization of indigenous raw materials.
2. Flexibility on producing extruded food products since the limited market existing in Chile does not permit operation of an extrusion plant in a single production way.
3. Development of nutritious food products based on the consumption habits of the population.
4. Selection of extruded food products with convenient advantages such as: low cost, direct consumption, easy preparation, high acceptability, good commercial image, etc.

Based on the above mentioned factors the following extruded food products have been developed:

1. Precooked cereal and legume flour mixtures to be used as easy-to-prepare soups
2. Development of infant food mixture based on cereal and legume flours enzymatically treated on a modified extrusion line
3. Production and use of pregelatinized pure starches in formulating instant desserts for institutional market
4. Production and use of meat extender based on texturized vegetable protein
5. Bread crumbs to be used as industrial intermediate products for breading fish and meat goods
6. Snack and breakfast cereal for research

A multifaceted production of extruded products has enabled the industrial cooking extrusion plant to be economically feasible, and it is therefore being installed at the present time in Chile.

The development of extruded products has been carried out in a series of steps:

1. Experimental trials in order to optimize the extrusion cooking process for each raw materials
2. Development of formulas for products
3. Sensory evaluation studies
4. Acceptability tests
5. Packaging and storage studies
6. Nutritional evaluations
7. Technical and economical feasibilities studies

This program of research and development on extrusion technology has permitted INTEC to improve its professional capability by gaining experience not only in the extrusion field but in other technological topics related with extrusion, such as technology of proteins; processing of grains; new analytical techniques; chemical toxicology and physical properties of extruded products, etc.

This transferal and adaptation of technology in Chile has permitted us to achieve several important goals such as:

1. To give appropriate diffusion of this technology throughout the country
2. To train highly qualified Chilean professional staff capable of providing technical service
3. Technical assistance in operation of extrusion plant
4. Technical and economic evaluations of extrusion technology
5. Capability in evaluating extruded food products

The success of this research and development program on extrusion has been demonstrated with the installation of an industrial extrusion cooking plant as a private enterprise. For the last two years, they have contracted the services of INTEC.

An infant food product called Fortesan, originally processed by extrusion in the United States, has been successfully launched in Chile for both institutional and commercial markets.

This example of transferal and adaptation of the technology has been done with the cooperation of AID and, in our opinion, it is one way to help resolve in part the nutritional problems of less developed countries.

[1] A paper distributed, but not presented at the Workshop.

Discussion - Thursday Afternoon

Moderator:

Dav.. A. Fellers
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Dr. Harper:

Dr. Bressani, I have a question concerning the data on soybeans and high extrusion temperatures. In our experience with both the extruders, we have not been able to achieve on pure soybean a temperature of 325°F. Yet you indicated having had some problem in the deactivation of the trypsin inhibitor. Would you please comment on that in more detail?

Dr. Bressani:

It is possible that the person who actually extruded the two or three bags of soybeans gave me erroneous data on the conditions of processing. I just reported the temperature of the treatment and it probably represents the temperature in the last pass when we have the lowest value of trypsin inhibitor.

One of our problems has been in working with *Phaseolus vulgaris* which also has a very high level of trypsin inhibitor. We tried unsuccessfully to eliminate the trypsin inhibitor by just temperature without any water addition. In this case, we destroyed the quality of the protein as we promoted the initiation of the browning reaction involving lysine. When analyses have been run, we will have a more complete picture. At the present time, I cannot give you a good explanation.

We have also tested the product on baby chicks, and their performance is not what you would expect from a wet process of food extrusion. So there are several issues as yet unresolved.

Dr. Hanson:

I would like to comment on this, because it might be pertinent to the problem. When we first started processing soybeans we collected product directly from the extruder and in the process gathered steam along with it. When we analyzed the material we found that it had a high urease activity, so we made every attempt to draw off the steam immediately after the material left the extruder. When we did that, we lowered the urease activity significantly. Last night you saw the Brady product pass up a tube where it is actually rolled around in the steam, and the steam is leaving the auger at that point. I think it would be very interesting to take that steam off at the end of the extruder to determine whether that experience would correspond to ours. In both cases, there may be some volatilization of the inhibitors at the time the soy is being extruded.

Dr. Bressani:

We have made a corn/soy product with very good physical characteristics. It suspends very well, and we decided to use it as a milk displacer for calf feeding.

The baby calf is a very peculiar animal. It has tremendous limitations in terms of amylytic enzymes and enteric enzymes, especially during the first four weeks of life. After that, the animal begins to develop a rumen, and the enzymes begin to function. The initial system consists of replacing milk protein with plant protein. In the beginning the animal's system seems to handle this very well when the amount of the cow's milk is very high. At the end of the third week, when the amount of plant protein begins to increase in proportion to the amount of food consumed, the animal develops tremendous diarrhea. You feed them so many grams of protein, and you collect on the other end so many grams of protein.

We have consulted the University of North Carolina State University because they have been working with the particular problem of the animal's inability to digest protein. They have changed the pH of their product to an alkaline pH or an acid pH and then back to neutral. This apparently enables the animals to digest the protein. They have shown also that this treatment will even decrease the substance they are calling trypsin inhibitor. We believe that maybe they have changed the structure of the food and have made it more accessible to the animal. These are some of the areas needing more extensive investigation.

Mr. Bleyer:

I was very worried this morning when I heard about the extrusion of soybeans at 325°F and that it was passed three times through the extruder. In our experience, it is impossible to get 325°F with soybeans because soybeans have 20% fat and that fat is a lubricant which makes it impossible to exceed 280 degrees. There must be a mistake by the operator of the extruder at INCAP.

But in any case, Dr. Bressani says that multiple extrusion of soybeans--twice or three times--gives better results for chickens. Well, that is very important to me because chickens are my business. I can tell you that for many years we have been using single pass extrussion at 280°F and it has been working very well for chickens. Dr. Bressani, can you comment on your experiences in relation to ours?

Dr. Bressani:

At the moment we are looking at the chemical analysis only, and we have been concentrating on trypsin inhibitor and urease activity. We have gotten zero urease activity. I don't know yet how the chickens themselves are going to be affected because the experiment is now in progress. The first week of the experiment indicates that we getting much better performance from the cottonseed meal than from the food legumes in flour, even though we have adjusted the calorie intake to be the same level. As I said, I don't know what the results will be at the end of the 10-week experiment, but the chicken is not so sensitive as other animals with respect to the trypsin inhibitor.

Dr. Trier:

This morning we were presented with some cost figures and the speaker quoted the life expectancy of the Brady extruder as 10 years and 10% maintenance costs per annum. I would like to ask Mr. Bleyer or Mr. Jackson what maintenance would be required.

Mr. Bleyer:

I haven't noticed any major problem with the machine in three years. It has been working three years without trouble in Santa Cruz, Bolivia. I expect that it will work perhaps 8 or 10 years.

Our experience with maintenance has shown it to be very small. Our machines run 8 to 10 hours a day. In such a case, we are buying $4,000 worth of spare parts each year. A year's supply of 4 or 5 rotor weldments at $2,500, and perhaps 6 cones and cups plus miscellaneous supplies.

Mr. Jackson:

We have only been in production for about two months so we are not in a position to accurately answer the question. We have had some startup problems particularly with the rotor weldments which indicated, as I said, that we might have to use up to 25 of them each year. This would make it very expensive. But, in general, I agree with the $4,000 per year estimate--I think that is in the ballpark after we get into production.

Dr. Harper:

Let us look critically at the maintenance cost estimate CSU presented. Ten percent may sound like a large figure, but you have to remember in the cost estimates how the maintenance affected the product price. Assuming we were off by a factor of 10 in the actual costs of depreciation and repair on the machines, it would still be only a very small fraction of the total production costs. This is the cost the nutritious blended foods in-country are going to be dominated by the costs of the raw ingredients. Fifty to 60% of the total cost of the final product will be raw ingredients. So there can be some error in those estimates, but I don't think it is going to make a major effect on the final product costs and the potential of nutritious foods produced on LEC's.

Mr. Jackson:

I would like to ask Mr. Bleyer what amount of his replacement for repairs is he able to make locally--opposed to imports. We are concerned about the foreign exchange element.

Mr. Bleyer:

When I was saying $4,000 for spare parts this was the foreign exchange portion. You will spend some money making your own parts and I am sure you can get somebody to make them very well locally. For example, welding on the rotor weldments can be done as many as two times. In our experience, the blend, Maisoy, uses more rotor weldments than the soybeans because the soybeans have a much larger percentage of oil which is a very good lubricant. Maisoy is a mixture of 70% corn and 30% soybean and so you would expect more wear.

Dr. Bogyo:

I have not worked with the Brady, but I suspect that much depends on how well you have cleaned your grain.

Dr. Harper:

Clean grain is essential for the production of food products as well as the increased life of the extruder.

Mr. Zeller:

First of all, I would have to disagree with Mr. Bleyer on the soybean versus the corn. The soybean hull is probably the most abrasive substance that you will run through the extruder. You can wear the insides of an extruder out faster with them than you can almost with sand. I can't really answer for the Brady as my only exposure to it has been here. As for the Insta-Pro, we normally figure $1.50 per ton. Of course, there are people that do just like they do with the Bradys. They have a local person make repairs and they will get additional tonnage. I don't think on a regular labor market that you could to this, but in some locales you can.

I would like to state that we have processed hundreds of thousands of tons of soybeans and have never encountered all of these problems. I am sure Dr. Hanson, our nutritionist, could cite a number of questions about feeding that don't have anything to do with the soybean itself. As for extrusion temperature, I can't see how anybody could ever get it up to 320 degrees. Our range has always been from 235 degrees to a top of 280 degrees--maybe 300°F.

It is a matter of observation over a period of time that explosion gases and water vapor have to be taken away from the product immediately, because if they aren't, the product is going to reabsorb the trypsin inhibitor or urease. When we first began processing high-energy soybean meal, we had difficulty obtaining acceptable levels of urease activity. We concluded that the reason was that the main processing in the Wenger was done in a heat-exchange autoclave with the moisture raised to 35%. The product

went through the Wenger mainly as a expander--just compressed and released--so there was enough of an explosion to deal with release gases. Using that method we never did achieve a lower level of urease activity than about 1.0 and the level in the raw bean is 2.0.

Dr. Lee:

I would like to make one further comment regarding the relationship of color formation to the nutritional effect of cooked soy. A key solution of this problem may be that the browning reaction occurred during extrusion cooking. Our group has been working on non-enzymatic browning reaction research for many years and recently studied its affect on the nutritional values of protein. When the browning reaction occurs, a loss of lysine has been indicated as well as a decline of PER value. Our work has further shown that supplementing the browned diet with lysine cannot fully recover the nutritive value of protein. This means that there are perhaps some physiologically active compounds formed during the browning reaction. When a mixture of egg albumin and glucose is stored at 37°C and 68% RH, the brown color can generally be detected visually after one month of storage. However, biological measurement by *in vivo* methods show that the nutritional quality of the mixture is decreased after 10 days (in some cases, after only 3 days) of storage with a 30 to 50% loss in nutritional value. It is also possible that extrusion processing causes a severe browning reaction when attempts are made to eliminate trypsin inhibition in soy through high temperature extrusion. Another general observation is that when rats are fed browned protein, diarrhea occurs at an abnormal rate. After two weeks of feeding, the weight gain of rats fed the browned protein significantly declines when compared with a control group. Presently, we are investigating the effect of extrusion on the browning reaction and hopefully, over the next several months, we will obtain some significant results. In addition, we will determine the pepsin-pancreatin digest index of various extruded products. We also plant to use various *in vitro* methods, to determine the extent of the browning reaction on protein-sugar mixtures under different extrusion cooking conditions.

Food for Peace Program - Past, Present and Future

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THE PAST AND PRESENT[1]

Public Law 480, the Agricultural Trade Development and Assistance Act of 1954, authorizes the United States Government to finance long-term credit sales of U. S. agricultural commodities to friendly countries that cannot pay on normal commercial terms. It also authorizes donation of commodities to feed underfed, undernourished, and disaster-stricken populations of developing nations. The overall P. L. 480 Program is generally referred to as Food For Peace. In recent years, it has accounted for U. S. agricultural exports valued at approximately $1 billion a year.

The sales program is authorized by Title I of the Act. Sales of food and fiber are made through private trade channels, generally from privately owned commodity stocks. The Commodity Credit Corporation (CCC) of the United States Department of Agriculture (USDA) finances the sales and is reimbursed through appropriations.

The donation program authorized under Title II of the Act is administered by the Agency for International Development (AID), with the Department of Agriculture determining commodity availability and purchasing the commodities for overseas shipment. Actual foreign distribution is made by voluntary agencies (PVO's), international organizations, or foreign goverments and is monitored by AID.

As originally enacted, P. L. 480 stated as its general purpose "To increase coasumption of United States agricultural commodities in foreign countries, to improve foreign relations of the United States, and for other purposes." The original law was not substantially changed until 1966. During the first 12 years of the program, the period from 1955-1966, United States surplus stocks played a major role in maintaining the balance between world food consumption and world food production. It was in this period that the U. S. food aid program reached its highest volume levels. From 1955 to 1966 the total food aid program, i.e., donations and concessional sales, averaged 14 million tons per year with a peak of 18.8 million tons in 1962. Of this amount, the donation program averaged about 2 million metric tons per year, reaching the peak of 2.9 million tons in 1962. The principal commodities shipped under the donation program during this period were wheat, feed grains, rice, nonfat dry milk (NFDM) and oil. Since these were surplus years in the United States, the program served the dual purpose of feeding the hungry while at the same time reducing surplus commodities held in U. S. warehouses and grain elevators. The quantity of food aid available for shipment under P. L. 480 during this period was limited by a legislative dollar ceiling of $1.9 billion for concessional sales and $600 million for donations. During the early part of this period, there was not a great deal of emphasis placed on the development of fortified foods; nor was the development potential of food aid fully recognized.

In 1966 there were major shifts in P. L. 480 policy. The commodities are now determined by the Secretary of Agriculture to be "available" if using them for food aid purposes will not reduce the supply needed for domestic consumption, carry-over and commercial export needs. The 1966 Amendment added reference to self-help efforts on the part of the recipient country. It is required, before an agreement is made, that an evaluation be done of the country's attempt to achieve self-reliance, including its efforts to meet food production and population growth problems. Since 1967, agreements have included self-help measures. The Congress also included a requirement in the 1966 legislation that a progressive transition be made from foreign currency sales to long-term credit sales. This transition was completed at the end of 1971. In addition, an amendment to Section 203 authorized the CCC "To pay, with respect to commodities made available under Title II of the Act, cost for packaging, enrichment, preservation, fortification, processing, transportation, handling and other incidental costs up to the time of their delivery free on board vessels in the United States ports. . ."

These changes in P. L. 480 legislation added a dimension to the Food For Peace Program. It enabled the Food For Peace Office of AID and the U. S. Department of Agriculture, in cooperation with food processors and trade associations--such as The Miller Federation, The Wheat Associates and Bulgur Associates--to develop low-cost fortified foods specifically engineered to overcome serious dietary deficiencies of recipients in developing countries.

For several years prior to the change in the legislation, there was a growing awareness of the need to provide more nutritious foods through the donation program. In December of 1961, the Secretary of Agriculture established the "Committee on Food Processing

[1]The factual and background material presented in this section represents a combination of several documents prepared recently by the AID Office of Food For Peace. In particular, a paper dealing with U. S. Public Law 480 foods recently presented to the United Nations Committee on Food Aid Policies in Rome by Peggy Sheehan, Chief, Food For Peace Program Operations Division, has been heavily drawn upon.

in Developing Countries." The members of the committee included several agencies of the USDA and the AID Offices of Food For Peace and of Nutrition. The committee's function was to "consider specific research and development in or for developing countries and to recommend appropriate courses of action." It worked very closely with United States private industry and international organizations such as UNICEF and the Protein Advisory Group (now the Protein-Calorie Advisory Group) of the United Nations.

Through the combined efforts of the United States Government, private industry, universities, voluntary agencies and the international community, the U. S. donation program has evolved from a program which provided only whole-grain cereals, nonfat dry milk and vegetable oils into a program which, in the fiscal year 1975, provided almost 50 percent of its volume in the form of enriched, fortified and/or blended foods.

This change did not take place overnight. There have been successes and false starts. In the early 1960's numerous studies and experiments were conducted to produce low-cost nutritious foods which would meet caloric, protein, and vitamin-mineral requirements of the undernourished and the malnourished. As a result of 15 years of research and field testing, there are three blended foods and six fortified foods currently available under the P. L. 480 Title II Program. A blended food can be defined as a blend of ingredients generally consisting of a cereal-based flour or sweet whey, a protein-fortifying agent (such as soy flour or NFDM), vitamins and minerals. In particular, the blends have been engineered to meet the nutritional requirements of the young child or pregnant and lactating women. The blends have about 20% protein with a PER range of 2.1-2.4. A fortified food is a cereal product to which either soy flour or soy grits has been added to increase the protein level of the base cereal. The end product appears much the same as the nonfortified cereal. The cooking properties and recipes of the fortified cereal are usually the same as those of the nonfortified version.

In December 1975, the Foreign Assistance Act of 1961 was amended to include significant changes in the P.L. 480 legislation. The new foreign assistance act was renamed the "International Development and Food Assistance Act of 1975" and amended certain sections of the Agricultural and Trade Development Assistance Act of 1954 (P.L. 480). The new act makes specific reference to goals set by the World Food Conference and amends P.L. 480 to read "Pursuant to the World Food Conference recommendation that donor countries provide a total of 10 million tons of food assistance to needy countries annually, the President is urged to maintain a significant contribution to this goal and to encourage other countries to maintain and increase their contributions as well." Another amendment of particular significance to the Title II Donation Program is the addition of a minimum tonnage requirement giving priority to Title II activities. The law reads "The minimum quantity of agricultural commodities distributed under this Title (Title II Donations) shall be 1,300,000 tons, of which the minimum distributed through nonprofit voluntary agencies and the World Food Program shall be one million tons in each fiscal year, unless the President determines and reports to the Congress, together with his reasons, that such quantity cannot be used effectively to carry out the purposes of the Title: provided that such minimum quantity shall not exceed the total quantity of commodities determined to be available under this act pursuant to Section 401, less the quantity of commodities required to meet famine or other urgent or extraordinary relief requirements." Additional amendments to Title I require that 75% of all Title I resources go to countries with an annual per capita income of $300 or less; added a 15% "loan forgiveness" provision; and tightened certain reporting requirements.

The legislative minimum of 1.3 million tons annually will provide the Donation Program of P.L. 480 with an assured availability of commodities. The minimum requirement eliminates the uncertainty of the quantity of food aid available to the Donation Program of P.L. 480. This provision should lead to more effective program implementation, which in past years was disrupted due to the lack of an assured availability. However, the law does not specify types of commodities to be supplied, and the program may still be faced with temporary shortages of a specific commodity which will require substitutions where feasible.

Obviously, the United States will continue to explore the use of new technology in order to improve current commodities. In addition, research is underway to develop new sources of calories and protein. New fortifying agents and improved packaging are also under review.

It is a continuing goal of United States food aid donation activities to provide recipient countries with commodities which are nutritious; which meet strict specification standards; and which complement recipient countries' efforts to develop their own blended and fortified foods. In this context, a brief review of P.L. 480 blended food development may be in order.

A forerunner of present day blended foods was CEPLAPRO. This product was a cereal grain and plant protein food designed specifically for the preschooler. It was a combination of degermed cornmeal, wheat flour, nonfat dry milk, processed soy grits, soy oil and a vitamin/mineral mix.

CEPLAPRO was soon replaced by CSM Formula #2. The orginal corn-soy-milk blend (CSM) consisted of 68% gelatinized cornmeal, 25% defatted soy flour, and 5% NFDM enriched with 2% vitamins and minerals. The present formulation consists of 59.2% precooked cornmeal, 17.5% defatted soy flour, 15% NFDM, 5.5% soy oil, and 2.8% vitamin and minerals. CSM contains 20% protein, and it has a protein efficiency ratio nearly equal to the 2.5 PER of NFDM. CSM is almost completely precooked and can easily be incorporated in the food of most countries. It can be added to soups and gruels, unleavened bread, desserts, or, being highly soluble in water, used as a beverage.

Instant CSM, a fully precooked modification of CSM, was developed primarily as a weaning food for use in child-feeding programs. It also extends the usefulness of CSM to situations where cooking facilities are limited or non-existent.

Another blended food is wheat-soy blend (WSB). WSB was introduced in 1969 and is popular in areas where wheat products are already prominent in diets. WSB includes 73% wheat-based products (such as bulgur flour and wheat-protein concentrate, 20% defatted soy flour, 4% soy oil, and 2.6% vitamins and minerals. It has a 2.4 PER as compared to 2.5 for casein and is more than 20% protein. WSB is also precooked and can be used as a beverage, in soups and gruels, or in bakery products such as cookies, snacks or cakes.

A recently developed nutritious food is the whey-soy beverage mix developed through the efforts of AID, industry, and, in particular, the USDA Nutrition and Agribusiness Group. This is a product also designed for the preschooler. It consists of 41% sweet whey, 36% full-fat soy flour, 12% soy oil and 9% corn syrup solids. The nutritional value per 100 grams of commodity is 435 calories and 20 grams of protein, with a PER of 2.1.

In addition to the blended foods, there have been a number of other foods especially engineered for the FFP Program. For example, bulgur wheat is produced by boiling whole-grain wheat, drying it, removing some of the outside brand particles and cracking the kernel. Some might know bulgur wheat as wheat pilaf. In Syria, Lebanon, Egypt, Turkey and other Middle Eastern countries, bulgur has been the mainstay of the diet for many centuries. Bulgur is even referred to in the New Testament as "Arisah" and has been known for many centuries as bulgor, bulgur and burghoe. While regular (nonfortified) bulgur is very nutritious and provides 354 calories and 11.2 grams of protein per 100 grams and has a PER of 1.0, the United States Government sought to further enhance the product through enrichment. The first attempt was with lysine fortification. This improved the PER of the commodity, but production problems ensued due to the limited supply of lysine. Soy-fortified bulgur replaced the lysine-fortified version, and it provides 350 calories and 17.3 grams of protein per 100 grams, with a PER of 2.3. In the Title II Donation Program soy-fortified bulgur now "outsells" regular bulgur by a ratio of 2 to 1. In fiscal year 1975, 423 million pounds of soy-fortified bulgur were shipped, as compared to 178 million pounds of regular bulgur.

Another newly developed fortified cereal is soy-fortified sorghum grits (SFSG). The product was first introduced in the sorghum-consuming area of Africa, principally the Sahel. During the 1974 drought several thousand tons of SFSG were distributed to the victims. The product provides 359 calories and 16 grams of protein per 100 grams of product and has a PER of 2.3.

Standard cereals such as wheat flour, cornmeal, and rolled oats have also been fortified, and the donation program now supplies soy-fortified flour (6% and 12%), soy-fortified cornmeal and soy-fortified rolled oats.

In every case where a new commodity has been designed, developed and finally introduced into the Food For Peace Program, very careful analysis and planning preceded this introduction. For every new commodity added to the program, hundreds may have been reviewed and determined to be unacceptable. As noted earlier, the group responsible for this review is the Processed Foods Committee of USDA. Members of this committee include representatives from USDA/ASCS, FAS, ARS, as well as from AID/FFP and AID Office of Nutrition. Only after a commodity has passed the preliminary evaluation of this committee is it tested in the field. The committee attempts to certify (1) that there is a need for that commodity to meet a specific program objective; (2) that the cost factors are justified in terms of delivered nutrition and product versatility; (3) that the supply outlook for basic ingredients is good; (4) that the commodity has an acceptable shelf-life; (5) that there are sufficient potential suppliers ready to produce the product; and (6) that the commodity is legally exportable under the provisions of the P. L. 480 legislation. If this preliminary review of the new product is positive, AID/FFP then asks USDA/ASCS to buy small quantities for testing by program sponsors such as CARE, CRS, and WFP. The tests are generally conducted in ongoing projects in selected countries around the world. The product is evaluated in terms of recipient acceptability, shipment and storage qualities, and adaptability to local conditions and taste patterns. In some cases, FFP specifies that a particular product should be distributed to one category only, such as maternal-child feeding programs, or in other cases, FFP makes the product available to all program types. If, at this stage of testing, the results are still positive, FFP then asks that the commodity be added to the P. L. 480 availability list. After final approval by the Secretary of Agriculture, the commodity is available for worldwide use.

The U. S. Government, U. S. industry, international agencies, and university teams have also assisted developing countries in the development, production and marketing of fortified indigenous foods. The objective of developing highly nutritious fortified foods locally is to reduce the dependence on food aid, make better use of expanding local production and eventually eliminate the need for food aid. Examples of locally produced and enriched fortified foods include Incaparina in Central America, Modern Bread in India, Puma in Guyana, fortified Atta in India, and Balahar in India. In many of these cases, Title II donation foods were prototypes for the locally produced food. In such cases, foreign donations have led to the development and marketing of locally produced nutritious foods rather than to dependence.

THE FUTURE

While this paper does not deal with the specific operational aspects of the P.L. 480 program, it is important to keep in mind that Title II donation programs are totally dependent on accurate planning and field management. Cooperating sponsors such as American voluntary agencies have long recognized this fact, and it is in my opinion axiomatic that regardless of any new directions the program might take, management is particularly important in the area of nutrition delivery, whether imported Title II foods or locally processed foods are used.

This emphasis on management in nutrition delivery focuses on the fact that available resources, whether imported or indigenous, must be properly used. The Title II program has been the primary direct nutrition delivery program--in the sense of actually delivering a nutritious food supplement--that the United States Government has supported on a consistent basis as a part of its overseas foreign assistance activities. Direct nutrition intervention, for most hungry people, means food--immediately and in consistent supply. For malnourished people, it also means nutritious food--often processed, fortified and high in both protein and calories. Our Title II program delivers such food. Therefore, if someone said to me: "Show me previously malnourished people who have been made well by the prompt and direct intervention of U.S. aid," I could show that person millions of Title II recipients.

We know that a number of countries are interested in developing their own processed foods for feeding program activities. Many already have done so, and others would like to in the near future. We also know that often such desires are not always based on economy or cost efficiency; rather, they are based on a desire to "do it themselves." Our approach in such

cases should be to support interested countries in achieving their own goals. I would cite as an excellent example of this, the work of the Nutrition and Agribusiness Group and Colorado State University in adapting extusion techniques to such needs.

In the context of the Title II feeding program, locally available, low-cost extrusion facilities meet several needs: First, they allow a country to supplement or mix imported foods with locally processed foods (this is important because it gives that country a chance to try out such techniques and utilize any recent technology in agricultural production). Second, they allow for a stretching of imported food resources to meet wider requirements. Third, a great deal of on-site technical training and infrastructure-building is accomplished with the introduction of such a facility. Fourth, the use of local extrusion facilities may require a change in Title II commodity composition for a particular program, but it will not necessarily mean a loss of the "market" from the U. S. supplier's point of view. Finally, the development of extrusion facilities can easily become an important element in rural development on a micro-scale: serving as an extension of the agricultural marketing process, training technicians and providing employment, generating funds for local health and nutrition activities and strengthening local involvement in feeding programs.

So, as I look to the future, I see a number of possible changes in P.L. 480 directions--some the result of legislative changes; some the result of changes in approach; some the result of changes in need; and nearly all relating in one or another to local processing or extrusion of food:

1. With the possible exception of disaster relief activities, Title II recipients should not receive whole grains. This means that such food must be fortified and processed here in the United States, extruded or processed in the recipient country, or blended and fortified with other local ingredients, to achieve higher nutrition levels.

2. The legislative minimum of 1.3 million tons annually for Title II programs insures that, to the extent any food is available for P.L. 480, Title II receives its share first. This means that further work and progress on locally extruded foods can proceed on a much more positive basis. We no longer have to justify local extrusion because of the danger that Title II inputs might disappear due to supply or money problems. No, due to the fact that an assured supply exists, Title II can be used as a "pump primer" to mix imported foods with local foods to begin an extrusion facility's operations. Title II programs in other sectors of a country can be used as a "sweetener" or incentive for a government to support and experiment with extrusion activities. Finally, continued use of Title II delivery systems can allow for an easy transition to the use of locally processed foods.

3. I see the potential for a wider use of fortified and textured products. This might take the form of fortification of imported grains such as Title I or commercial imports; it might be the fortification of locally produced commodities; or it might be their use alone in feeding, nutrition or commercial marketing programs. Whatever the potential use, the implications for employing extrusion techniques are immense in this regard.

4. With regard to host-country funding and support for extrusion activities, the recent changes in the P.L. 480 Title I legislation calling for "loan forgiveness" and added emphasis on self-help and developmental relationships between food aid and other forms of development assistance should be examined carefully. These provisions may allow for more support of and interest in locally processed food activities than has been the case to date.

5. The attention of the World Food Conference, international organizations, prominent experts and many other factors have prompted the United States Congress to focus America's foreign aid on the "poorest of the poor." Food aid and complementary activities such as those carried out by the groups represented here fit the framework of these "new directions" perfectly. As a result, opportunities now exist to link activities such as local extrusion to broaden programs of assistance where they will both strengthen and be strengthened by a wider scope of program action.

In summary, I see several changes in food aid taking place in the next five years. Without exception, each will provide opportunities and difficulties. However, each will benefit by forward planning, innovation and local incentive. The time to start is now.

Discussion - Friday Morning

Moderator:

G. Richard Jansen
Department of Food Science and Nutrition
Colorado State University
Fort Collins, Colorado

Mr. Samaan:

You made the comment that Title II commodities are also given to initiate local competency in developing these foods by manufacturing them locally. This is precisely what most developing countries are interested in. How do you envision this if all commodities under Title II are donated and distributed free to the needy? You don't have cash supplements, and if the country does not have Title I monies, what other sources of finance could be made available? Another thing is that in countries with Title I funds, the money usually is programmed by the recipient country and USAID in the agricultural sector. It does not appear to address nutrition or to develop that self-sufficiency.

Mr. Shaughnessy:

Let me take the second point first. That is a very good point: the emphasis has been on programming local currency proceeds under Title I in agricultural development activities. It was very clearly stated by Congress in the legislative amendments passed last December--when it talked about a loan forgiveness provision and increased self-help efforts--that it wants to see more programming of Title I currency proceeds in areas such as nutrition and family planning. Indeed, it is my opinion that approval of a loan forgiveness provision will come through very quickly if it does include certain activities in these areas.

With regard to your first question, I would cite as an example of how to use Title II foods in the beginning of a processing activity--the Bal Ahar program in India. Although every potential existed for the Indian Government to use its own commodities to mix and blend a fortified food, there was a need to get the program started by bringing in commodities such as soy flour and bulgur wheat. This is what I meant when I mentioned the use of Title II commodities as a "pump primer": mix them with locally processed and available ingredients. Now, obviously, if you are going to mix a corn-based blended food, the argument in the United States would be why mix it over there, when we can just send them CSM. The point that I am making again is that there is an interest to do these things on one's own. A related point that I made was that we have to be aware of the fact that U. S. industries that provide these commodities are not interested in losing markets, but I think there are a few manufacturers of CSM, which, when given the choice of either shipping cornmeal or nothing, will ship cornmeal. I believe that Title II activities can be used to get these programs underway.

Mr. Samaan:

Are saying that provided it is for relief programs or for free distribution?

Mr. Shaugnessy:

No, I think it can be in any fairly well-defined and planned program activity. I would not even rule out the possibility of developing a commercial weaning food, for example. There are certain provisions in the legislation that it would be technically possible to waive. It requires fairly rigorous approvals, but it can be done. There is also a new provision in the Title II legislation that allows for Title II sales under certain circumstances.

Mr. Cregger:

On the loan forgiveness provision: is that usually negotiated at the time the sale is negotiated, or can it be done later?

Mr. Shaugnessy:

The legislation provides that the loan forgiveness provision now in effect can be retroactive to agreements signed after December. In other words, if you have a Title I agreement that was signed after December 27, or whenever the law was passed, you could go back and negotiate a loan forgiveness provision in in those agreements. From this point forward, the loan forgiveness provision is negotiated at the same time as the total Title I package.

Mr. Sterner:

Is there any definition to the number of activities, or can you elaborate on the kinds of activities that are included?

Mr. Shaugnessy:

When the Congress passed the loan forgiveness provision, it said loans would be forgiven for activities similar to those provided for under Section 106 of the Foreign Assistance Legislation--basically, the traditional catalog of self-help activities ranging from agriculture to nutrition, family planning, health and so on.

Mr. Van Hoogstraten:

You have not mentioned the matter of ocean freight reimbursement for those items which are not provided under P.L. 480--in other words, agency-supplied technical aids, supplies, etc. We will need to know whether this continues or not.

Mr. Shaugnessy:

As you know, the ocean freight reimbursement program administered for non-P.L. 480 products is administered from funds made available under the Foreign Assistance Act and not under the P.L. 480 legislation. There is a statutory limitation on how much money is available. I think it was recently increased this past year; in fact, I think it was doubled, if I am not mistaken. That amount of money is certainly available to agencies to be used for shipment of extruder equipment, etc.

Mr. Van Hoogstraten:

I simply wanted to make sure that everybody understood that those funds are available, and that they are an important part of each process.

Mr. Shaughnessy:

Absolutely.

Mr. Goodyear:

I would like to question your statement that long-term program planning would be made for AER requests for P.L. 480. First, when will that process begin, and second, can you make a competent statement that local aid mission will continue to support MCH preschool feeding, as opposed to school or other feeding programs?

Mr. Shaughnessy:

Programs are being reviewed right now with a multi-year concept in mind. We have specific program requirements listed for fiscal '77, and in that pattern of documentation there are also projections for '78 and so on. We are not looking at just the single-year program but at a program's direction, and the review results will be transmitted to our missions in the field with this concept in mind. We are not looking for radical changes in the next couple of years, and if we have a fairly good, supportive program for a feeding activity--hopefully, one which will include some combination with extrusion techniques or relationships to agricultural development or something similar--that is going to be firm.

Dr. Trier:

You mentioned the importance of local entities. Do you mean local governments, local private enterprise, local universities or USAID missions in the country?

Mr. Shaughnessy:

It could be any of them. We who work in Washington and are familiar with the opportunities available have the responsibility to get more information out. When you have an opportunity to combine local processing or an extrusion facility with an existing Title II program, or to move it into an existing network of distribution, you should take advantage of people already involved, whether they be in ministries, voluntary agencies or whatever. Now is the time to bring ideas forward--I venture to say that 80% of really good program ideas comes from the field.

Dr. Fellers:

A number of blended food products contain special ingredients; for example, vitamins and antioxidants. If these products are to be produced in developing countries, is there a mechanism whereby USAID can provide help in obtaining these ingredients?

Mr. Shaughnessy:

I think one of the evolutions that could well take place in our program is to begin supplying vitamin-mineral premixes and other nutritional ingredients. An important point to remember is that the entire P.L. 480 legislation expires December 30, 1977. That means that there will be a full Congressional review of the program next year, and I would urge any of you who have suggestions for legislative changes to make them known to me, to your voluntary agency headquarters, etc. It was demonstrated last fall that we can make some significant changes in the program with support from people on the hill.

Dr. Fellers:

But currently no mechanism exists?

Mr. Shaughnessy:

The closest we have come is providing a specific ingredient, such as soy flour.

Discussion - Friday Afternoon

Moderator:

Judson M. Harper
Department of Agricultural Engineering
Colorado State University
Fort Collins, Colorado

This working group mechanism is designed to allow for the feedback and exchange of information among participants. Each of you has an outline and the name of your particular working group. We have assigned you that group based on your background, interest and expertise. The groups are as follow: "Additional Potential Food Applications;" group leader, Dr. Stephen Bogyo. The second group is entitled "Research to Improve Manufacturing Operations;" group leader, Mr. Justin Jackson. The third group is entitled "Programming Assistance;" group leader, Mr. F. Merton Cregger. The fourth group is "Product Evaluation - Nutritional and Physical Properties;" group leader, Dr. Ricardo Bressani.

The outline for each group is meant to stimulate thought and focus attention on issues which have arisen throughout the workshop, and we hope you will amplify it. There are four items that you need to consider: potential, problems, perspective and priorities. We need to examine the potential of this intermediate technology and what it takes to move it into the field. Next, we need to identify problems from the point of view of things that need to be done and questions that need to be answered so that we can turn them into answers and opportunities. Next, each of you has a particular perspective as a result of your backgrounds as economists, nutritionists, food scientists, engineers, planners, etc. We want you then to lend that perspective to the items discussed in the working groups. Lastly, I want you to focus on priorities. There are many things that can and should be done. Your task is to focus on those items plus any you care to add and to establish the order in which they should be undertaken.

Each of the working group leaders will report to this group as a whole the recommendations of his group. Finally, we will all discuss the particular recommendations and develop a group consensus.

Additional Potential Food Applications

DR. STEPHEN BOGYO, GROUP LEADER

Our group discussions were restricted to potential food applications of low-cost cooker extruders. Before we dealt with specific recommendations, we decided that certain preliminary, general recommendations were in order. They are:

1. A review of all the currently available blended foods within or without the AID program would be valuable.

   a. What are they?

   b. How can they be used functionally and nutritionally?

   c. How much do they cost?

   d. Can the low-cost cooker extruder produce these products?

2. A technical information center is needed to whom all those working in extrusion could report what they are doing, problems encountered and solutions devised. Such information dissemination would help avoid duplication of effort and already identified pitfalls.

3. It would be very useful for Colorado State University to prepare a general operations manual--the basic do's and don'ts--for people working with the machines who are not trained engineers but have the potential to do more trouble-shooting themselves. Information on auxiliary processing, such as technology for grain cleaning, and basic quality control procedures without sophisticated instrumentation should be part of this manual.

We then identified four potential food application priorities:

1. We felt that the most important priority for food application is in the area of weaning foods, which included both ready-to-eat products and protein-vitamin supplements which could be used with other indigenous materials. It is important to determine whether ready-to-eat weaning foods could be made available that would not require any cooking at all but could simply be put into banana, mango or other foods.

2. The second priority was multi-purpose family foods. In this group are soups, gruels and fortified flours to replace products presently consumed.

3. Third was institutional applications. In this category were extruded foods that required minimal or no further preparation and that gave relatively good economy in terms of calorie and protein content.

4. Fourth were those products with a good chance for commercial success. The number one category was snack foods, followed by breakfast cereals and beverage bases--malted milk or other types.

Dr. Harper:

Are there minority opinions from this group?

Dr. Trier:

This is not a minority opinion. I just wanted to express the hope that this work will continue but with more emphasis on food technology aspects, since the main interest until now has been in engineering aspects.

Mr. Crowley:

In connection with your considering additional applications, were your discussions in the context of a sequence of events eventually leading to manufacturing operations? Was there a consensus as to which one or two specific forms had the greatest potential for successful translation into practice?

Dr. Bogyo:

We felt that when you tried to define priority in terms of nutritional need, the possibilities for technical success, acceptance and making an impact on malnutrition were greatest with a weaning food. The secondary choice was multi-purpose family food. We assigned institutional foods the third priority, and we listed commercial applications last because they usually do not need much outside financial aid.

Dr. Harper:

One of the things that you didn't mention was the commercial value of ingredients such as full-fat soybeans, textured vegetable proteins or other protein foods. The reason I bring this up is that our group wasn't very specific in this area, and I would like to hear what the group as a whole feels about these items as potential new food applications.

Mr. Crowley:

I think my question relates to this. I don't believe the category of snacks is a specific application. Specific applications are such things as cooking sorghum to mix with wheat-soy blend to make Thriposha in Sri Lanka, cooking soybeans to make flour which would be used in fortifying bread in Costa Rica, and making CSB to supplement the CSB in Tanzania. These are specific applications for which you know there is a need, so you can develop products to meet that need.

Dr. Harper:

One of the things that was discussed in the group is a need to develop prototype products that would illustrate snack potential, ready-to-eat cereal potential, textured vegetable protein potential, blended flour potential, protein ingredient potential, etc., but specific applications are difficult except in the in-country context. In other words, we can give people ideas to raise their horizons as to the potentials of the machine and some ways to solve some of the general technological problems, but specific product work for a specific country needs to be done in that country in the context of indigenous ingredients, flavor preferences, etc.

Dr. Trier:

I think one can make some specific application--for example, the partially precooked corn flour or meal for pasta production in Colombia. They are not doing it by extrusion, and it would be interesting to learn whether you can do it with this method.

Mr. Conway:

I have made pasta-type products from blended food product Formula I--that is, the original CSM which is only partially cooked. You can run it through a spaghetti machine beautifully, and it holds together. As far as your general approach, I think prototype products are definitely a way of expanding the horizons of people who are unfamiliar with our technology, but unless the product is acceptable to the consumer, it is going to end up being fed to livestock or rotting.

Mr. Crowley:

The point of view that I have had for quite some time is that extrusion cooking is not a new technology. It has been in existence for several years, it has been done with various kinds of equipment, and prototype products have been developed on many different kinds of equipment. People have looked for markets for those products, and some have fallen by the wayside, as always happens in a product development program. Others have been outstanding successes.

We have mentioned some of those products which seem to have applicability in less-developed countries, just as they have applicability in the United States. For example, textured vegetable protein is produced and used in the United States as well as in Colombia and other countries. To repeat this work with prototypes to me is not good use of resources--funds or time. I think if we build our work on the body of knowledge already acquired on prototype products rather than spend time experimenting with other possibilities, we would be using those resources more effectively.

Mr. Sterner:

I agree. However, basically we have been talking about the performance of two machines, and within the context of the restrictions of those machines, you need to determine what can be produced on them.

Mr. Samaan:

I would see the next natural step as the application of all the experience you have gained to each country's eating habits. This is the key. For example, the white corn in Tanzania is completely different from any other corn in the world. So I think the next step is on-the-scene application of these foods utilizing the same methods and formulas that you have used and to see how you can incorporate locally produced legumes and crops into them.

Dr. Harper:

I might say that what we are trying to do here is to work with some basic ingredients that would exist nearly everywhere. There are differences in genetic variety to be sure, but if you combine corn, wheat, rice, sorghum or cassava as basic ingredients with soybeans, cottonseed or other edible legumes, you can gain some basic experience with those ingredients. You can determine the capabilities of the machine, appropriate quality control tests, utility and stability of the equipment, functionality of the end products, and so forth. At the same time you can work in specific locations with local ingredients, applying what you learned elsewhere and adapting it to that particular situation. We have spent very little time here on prototype products in the classical sense, because that has not been the philosophy of the program.

Product Evaluation - Nutritional and Physical Properties

DR. RICARDO BRESSANI, GROUP LEADER

In order to provide a context for our discussion we first defined extrusion cooking and what it does to products. We then defined the product that we wanted to make and the target population. On this basis we determined a need to control the operation in three areas.

1. Quality control standards of ingredients should be established by the USDA or by the countries themselves.

   a. Often we don't know what the products should contain in terms of moisture, protein or fiber and so we must know what the material is before it goes into the machine.

   b. We must have standards to insure no contamination of the ingredients so as to guarantee a contamination-free product.

2. Control of the process and related processes

   a. Colorado State University, having had the most experience with the equipment and what it can do, should prepare a set of methodologies that anybody could use to control what is going on in the machine and to thereby standardize the physical characteristics of the product.

   b. It was suggested that some new methodology should be introduced--like high lysine determination--to determine the extent of its degradation.

3. Finished product evaluation

   a. There was no need to propose anything new because this work has been done in the past by the Protein Advisory Group (PAG), and they have established recommendations for quality standards of ingredients and finished products. They also have established a methodology to evaluate these products in animals and in humans, including acceptability tests.

   b. We recommend that Colorado State University publish a bulletin describing the methods used in the sensory and physical characteristics evaluations of products here.

      1) The protein efficiency ratio (PER) is one such measurement.

      2) The bulletin should be sent to all laboratories working with this technology and should point out those methods which are essential to maintain a certain quality of the product.

   c. It was suggested that regional laboratories be set up to evaluate the products that could not be evaluated locally for lack of facilities for amino acid analysis, biological testing with infants or adults, etc. There is a guideline also published by the Protein Advisory Group on what is to be done when you have a breeding program to introduce, for example, high lysine into corn; when you should do the chemical analysis; and when you should do biological testing, etc. Colorado State Unviersity might also include in its bulletin similar information on specific product processing.

Dr. Harper:

Processing costs in terms of ingredients, equipment and so on in manufacturing blended foods vary a great deal. For example, the dehulling step in processing adds significant ingredient and processing costs. Should work be undertaken to determine if such processing is necessary?

Dr. Bressani:

That is a problem that was considered by the Protein Advisory Group, and it depends on what you want to do. For example, if you want to produce a food that is to be used for weaning children, you reduce the fiber content as much as you can. In most of the products we have been discussing, for example, corn and soybeans, fiber content is minimal--and here we mean chemical fiber as opposed to biological fiber, about which we know very little. If you want to utilize some of these high fiber products by incorporating them into other, more expensive products, for example, pastas or breads, then fiber could present some problems.

One thing that really is impressive about extrusion cooking is that you sometimes get a quality you didn't expect. A specific example is higher digestibility. You can hypothesize why, but there is no real evidence to explain it. Also, in beans we have obtained protein quality values beyond what we expected. If we established the reasons, we could exploit this technology even more than it is being exploited at the present time.

Mr. Van Hoogstraten:

I would suggest that a synopsis of extrusion technology be made available in French, Spanish and other basic languages used in less-developed countries.

Mr. Mommer:

Where can we get more information on this Protein Advisory Group?

Dr. Bressani:

You can contact them at the United Nations in New York and subscribe to their bulletin, which has information on developments in processing, raw materials, products, etc.

Research to Improve Manufacturing Operations

MR. JUSTIN JACKSON, GROUP LEADER

The group initially concurred that concentration should be focused on problems identified through the use of these extruders. The first items were problems and modifications that applied to each extruder. Listed below are the modifications that were discussed:

1. Brady

   a. Sanitation as applied to the discharge enclosure

      1) New box design - a new design was felt to be of high priority, especially in a production system. The use of a cowling that could be disassembled upon cleaning and that would contain only single pieces of steel so that internal surfaces were smooth was discussed.

      2) Box sanitation - it was felt that this box should be cleaned with a dry air system to prevent accumulation of water in hard-to-get-at places, thus preventing the proliferation of organisms in these areas.

      3) Steam problem - because the steam that occurs when extruding is a problem, it has been suggested that the box be vented in such a way as to be able to remove the steam, yet permitting easy access to the extruder internals.

   b. Transition zone

      1) Plugging of the transition zone between the feed screw and extruder auger was discussed intermittently during the conference, indicating a need to be able to have immediate accessibility to the zone (in an emergency plug).

      2) One solution was to have a plate on the side which would be taken off to clean the zone when plugged.

      3) The idea of decreasing the size of the hopper was discussed. Because of the present use of the hopper, it was felt that the front half of the hopper could be removed or a new cowling with hinges could be made to improve accessibility.

      4) It was concluded that the accessibility to the transition zone was the priority, and that how this was achieved would rely mainly on the manufacturer. However, a need is prevalent on existing units to solve this problem.

   c. Wear on screw

      1) Wear on the screw was discussed in terms of the high price and rate replacement.

      2) Bolivia reported that a screw will last 400 tons, whereas Sri Lanka was getting 100 tons. Bolivia made alterations and welded screws up to four times to achieve these results.

      3) It was discussed that a high priority would be to redesign the screw so that the portion which wears (the last 8-12 inches) could be replaced instead of the entire screw. This would reduce the cost of replacement and the associated costs of shipment due to weight.

   d. Bolt torque specifications - specifications for the torque of critical bolts in the system are needed so that they can be checked periodically.

2. Insta-Pro - because the Brady has been used in most situations overseas, the discussion was mainly based on the experience between Triple "F" and CSU.

   a. The new multiple-die head has one basic problem. This is the high pressure that occurs in the screw, should the dies plug. A need was determined to have a pressure release device to relieve the pressure before the head is taken off.

   b. The new die arrangement has taken away the ability to trim the final product temperature while running. The machine must be disassembled in order to change these conditions. It was discussed that users have been using the older outlet head as the total control of temperature.

However, for countries using this machine as a test machine, the lack of control during running would be a disadvantage.

c. Because of the combinations of steam locks, dies and number of dies, there is a considerable number of configurations possible. Discussion concluded that both Triple "F" and CSU could make recommendations for configurations of different products.

3. Extruder control

a. Steady power source - it was discussed that a steady power source is required to operate an extruder properly. Problems of plugging can be alleviated if there is a constant power source.

b. Electrical power sources were discussed with respect to installations. Such things as the possibility of installing an emergency power generator might prove beneficial.

c. Some discussion took place regarding realistic uses of extruders in countries and the idea of multiple versus single use of extruders. No conclusions were drawn.

4. Modifications of LEC subsystems

a. Cleaning - the problem of having grain 100% free from foreign material was discussed. The priority set up was that more information is required on equipment that cleans grains of stones, iron, dirt, chaff, etc., so as to reduce wear on the machines.

b. Dehulling - several ideas were exchanged on dehulling. Such things as impact and aspiration and cracking rolls were discussed. Separation of hulls from beans was suggested by washing. It was pointed out that commercial machines were generally too large. More information is needed as to availability, capacity and cost of this equipment.

c. Grinding and proportioning

1) Accuracy - the accuracy of the volumetric feeding method was questioned as applied to a manufacturing operation. Triple "F" indicated that for these machines used for constant manufacturing, a vertical batch mixer is used to insure that the mixture does not change.

2) Volumetric feeders are fine if they are calibrated frequently (as much as daily) and if they are for a system where accuracy and economics are not key factors.

3) Economics when using a high-price grain plays an important role in an extrusion facility. If the volumetric system is not accurate, the cost could be high.

4) Although Triple "F" had indicated that volumetric feeding is inaccurate, they conveyed information on tests that showed the accuracy to be within 3%.

5) It was discussed briefly that the solution to this problem would lie in further investigations of accuracy checks, and that quality control would be useful in this regard. Again, additional information on different types of equipment is needed.

d. Milling - evaluations of milling equipment capacities and systems, including the use of hammer versus pin mills, are needed.

5. Problems and experience - due to the time factor, many items could not be covered, however, the last few minutes were used for general discussions pertaining either to the outline or to some previous experience. The following topics were discussed briefly.

a. Spare parts - in-country purchase of parts from the U.S. is a problem because of foreign exchange and time loss. A maintenance schedule should be drawn up to assure that sufficient spare parts are on hand when equipment is installed.

b. Local equipment manufacturing - it was suggested that local equipment be considered in future installations to reduce problems with spare parts, etc. This would apply if:

1) Equipment was available

2) Equipment manufactured would be able to meet recommended specifications for a product.

c. Freight - shipping spare parts overseas was considered from an economic standpoint. Again, if local manufacturing is possible, cost could be reduced.

d. Rebuilding and/or refurbishing existing parts - the number of times a part could be rebuilt was discussed. Two points were considered:

1) Capability of rebuilding

2) Effect of rebuilding on product quality.

It was established that most countries would have the capability to rebuild worn parts. However, it was pointed out that a part can only be rebuilt short of the point where it becomes a new alteration affecting product quality.

e. Physical appearance - it was felt that equipment specifically made for food installations should be painted with an industrial food grade (or comparable type) of paint to add to the aesthetics of the equipment. Additionally, equipment identification tags should refrain

from connotations of livestock and related feeding systems.

f. Enrobing or blending equipment for fortification - the major conclusion was that information is required for this equipment. The need to include it in a given system will depend on the ultimate use and product required.

Dr. Harper:

Are there any comments from the audience concerning the recommendations from this particular group?

Mr. Sterner:

I think there was a comment made regarding the dehulling, destoning and other equipment indicating that there are many different systems that could be used at a low cost. I believe there was a consensus that there needs to be some way of making more of this information available--a viewpoint which ties in with Dr. Bogyo's recommendation for information gathering and dissemination.

Mr. Mosha:

It seems to me the consensus might be that it is better to mix fortifiers and flavors after extrusion. Is it possible to mix them prior to extrusion?

Dr. Harper:

I think we need to examine techniques for adding vitamins, minerals, flavors and other things so as to determine the most appropriate technique, whether it be mixing subsequently or adding directly to the extruder.

How do people feel about the data presented by Mr. Stone on general processing systems and their costs? Is additional information needed?

Mr. Samaan:

I think the data you provided are vital in a country where the technology has not been introduced. The information serves as a basis for cost estimates as modified by your own local framework.

Dr. Harper:

Is that information sufficiently complete, or do you think additional work needs to be done in order to provide additional bases for comparison costs?

Mr. Samaan:

I believe it is complete.

Dr. Trier:

I would agree that it is complete. Maybe it will have to be revised a bit as we gain more experience, particularly the maintenance. The cost per kilogram is very important--or maybe more important--than capital investment.

Dr. Harper:

In all the estimates we have done so far, the cost per kilogram is primarily affected by the ingredient costs.

Mr. Goodyear:

In our programming assistance group we discussed this and suggested that regional information on product design, costing, etc., would have more applicability to interested people in those regions.

Dr. Harper:

In order for these systems to be most acceptable in developing countries, we should attempt to use locally available equipment and techniques to the greatest possible extent. We are familiar with what is available in the United States, but how can we best collect information about auxiliary equipment such as that needed for cleaning, destoning, dehulling or grinding, which is available locally? Certainly there would be some real advantages in terms of spare parts, replacement and understanding of technology. Are there any suggestions?

Mr. Sterner:

I think there needs to be a repository for information on not only commercially available equipment, but also on extremely simple systems for dehulling, destoning and so forth. Such information could save thousands of dollars.

Mr. Kelly:

I think it is incumbent on the people who are requesting CSU's help to find out what is available in terms of the criteria you give them for what is needed. But it has to come from the field to you.

Dr. Harper:

What you are suggesting is that you need more specifications for processing steps, so that the requesting party can determine whether local equipment is available that can meet those specifications.

Mr. Kelly:

Then the CSU technician could evaluate it more thoroughly in-country.

Mr. Van Hoogstraten:

There are several places which already function as repositories, but they don't cover everything--VITA, LIFE, TAICH, and so on. In the area of low-cost extrusion, it seems to me that CSU has to continue to be the main instigator.

Mr. Samaan:

If we consider CSU as the information bank, it might also be a good idea for all of the countries involved in the technology to feed into you their own experiences. If they develop a way to repair a part, for example, this type of information should be sent to you for evaluation. If it could be adapted to other countries, you would put it in a bulletin to those countries.

Mr. Mosha:

Is it possible to make the equipment elsewhere with a license or a franchise?

Mr. Van Peursem:

This is tied to the potential sales volume that a manufacturer would perceive. As for licensing, we would examine the opportunity to do so strictly on an individual basis. It may be that in the years to come, as experience and need develop, those options can be considered.

Programming Assistance

MR. F. MERTON CREGGER, GROUP LEADER

1. Programming assistance priorities

   a. Establishment of the need for this intervention. How does an agency determine whether it ought to use this intervention to solve its particular problems?

      1) This determination requires more detailed information on LEC capabilities, costs, limits and applications, so that someone in-country with some technical background can analyze it in terms of meeting his needs.

      2) Which nutritional problems does this technology best address?

      3) Under what conditions does it best solve these problems?

   b. Availability of low-cost in-country testing programs - once you have chosen this mechanism, you need to learn how it functions in your milieu.

   c. Program design, including strategy and management - there is a need for knowledge as to how best to develop a program to utilize this technology.

   d. Availability of funding for capital shortfalls in the development of the program - although our goal is to develop a self-reliant program to the greatest extent possible, we recognize that we are working in areas that are short of resources. Certain things are likely to be needed from the outside, and there needs to be a flexible funding source available for that. We are thinking of the advisability of establishing a special funding source which would permit organizations the knowledge that once they have taken certain kinds of steps up to the point of requesting assistance, they have some assurance of receiving it. Flexible criteria are necessary because these programs are going to have many different working arrangements. Guidelines for qualification for such funding should be established well in advance.

2. Specific programming assistance recommendations

   a. The basic principle in development of programs should be to achieve eventual self-sustenance.

   b. There should be maximum local involvement at all levels from the outset of even the planning phase prior to program approval and throughout the duration of the program. This joint venture approach should be applied in commercial and government programs.

3. Specific technical assistance recommendations

   a. There should be a clearinghouse for information.

      1) The clearinghouse should not attempt to be self-sufficient or all-encompassing but should coordinate the collection and dissemination of information with already existing organizations involved in similar endeavors, such as TAICH, LIFE, Meals for Millions, VITA, etc.

      2) There should be rather formalized relationships established with these on-going information services for purposes of input dissemination.

      3) A systematic format for reporting should be developed for use in the field to help the clearinghouse collect and disseminate the information to current, new and potential users in a concise form. The summarized information should provide a referral source for more details.

   b. Audio-visual communications should be developed to use with written communications. These should be used to define capabilities, to demonstrate systems and installation procedures and to promote them to decision-makers. The use of these materials would cut costs by reducing the need for foreign experts.

   c. Guidelines for the identification of factors needed for project successes and project assessment criteria should be established.

   d. An effort should be made to identify and utilize third-country technical assistance capabilities.

e. Work should be done to maximize the flexibility and adaptability of plant design and equipment, with particular emphasis on development of gradients, i.e., starting with the simplest design available and the minimal requirements for a production facility.

1) There should be greater feedback on existing operations, how they are working, and how a particular piece of equipment finally arrived, for example, to assist others in the process of program development.

2) In the design of plants and systems there should also be emphasis on labor-intensive systems and alternative energy sources.

f. In the area of backstopping, CSU should establish a pool of resources, not only of people, but also interested and experienced organizations, such as CARE and those available in the LDC's. These resources should be named and identified as to capabilities, how to apply for their assistance and costs involved, if any.

g. Technical assistance for installation and start-up should be designed to minimize the need for foreign assistance. Installation and start-up technical assistance should concentrate on training rather than on physically setting up the installation--an unnecessary expense in most cases because there are people in-country who are capable of doing that. Training should include operation and use of the equipment and the system, etc., and should emphasize the development of local sources of replacement parts.

Dr. Harper:

With regard to your point that assistance is necessary to establish need for this intervention, it seemed to me that a number of our speakers yesterday documented a need for intervention of some type very strongly. They were stating a need for some sort of food supplement or special nutritious food to meet the nutritional requirements of a specific target group. Is your point that it is necessary to document whether or not low-cost extrusion cooker technology is the most appropriate way to fill that need?

Mr. Cregger:

That is correct. We are pre-supposing a nutrition problem or an economic assistance program in which food processing or food would play a part.

Incidentally, I think it is a mistake to think of nutrition as the only application of extruder technology. There are ways in which the introduction of this technology--particularly at the village, small town or provincial town levels--could constitute the introduction of a small industry. This would be a fine economic development input--which may or may not meet a tremendous nutritional need--which would provide greater income, jobs, etc. However you approach it, you still need to establish that an intervention involving food of some sort is required.

Dr. Harper:

Is it accurate to say that you don't think there is enough information available as to what alternatives exist relative to providing nutritious foods for given people?

Mr. Cregger:

That's part of it, although it's not our purpose here to provide people with alternative programs. In terms of this program, though, there were some in our group who felt they didn't know enough about its strengths, weaknesses, possible applications, equipment capabilities and limitations, etc., to make a sound judgment of it.

Mr. Goodyear.

We also talked about product testing and whether Colorado State University can fill the need for a central testing facility to act as a backup to people involved in LEC technology. Perhaps some guidelines need to be developed in terms of what services Colorado State University can provide. Also, if it is determined that guidelines are necessary for analysis and evaluation of testing, we need to know what we can do in-country using semi-skilled, local personnel.

Mr. Kelley:

I think that real emphasis has to be placed on the search for alternatives to the capital input on these extruder systems.

Dr. Harper:

Just a point of clarification there. What are appropriate capital requirements? A truck that is used to transport goods in a LDC is worth between $10,000 and $40,000, and an agricultural tractor between $20,000 and $40,000. Those are two examples of capital equipment that already exist in these countries. I don't know whether or not they are classified as low-cost, but it seems to me that between the extremes of village-level processing with a stone and a multi-million dollar plant, there is a level of intermediate capital input and appropriate technology. With this level comes a consistency of manufacture, quality control, sanitation, etc.

Mr. Kelley:

But for me personally, the village-level technology is the appropriate one.

Mr. Sterner:

What is appropriate in the way of capital investment depends on the return on capital which varies by the country and the situation.

Mr. Crowley:

During the course of this meeting we have discussed potential applications, and it was stated that the capacity of these units ranges from 200 tons to 2,000 tons per year. If you need a capacity in that range, this seems to be an appropriate mechanism for cooking certain things.

Dr. Harper:

It is difficult to summarize the recommendations, but I think the key point that was reiterated several times is the need for additional information-gathering and dissemination so that decisions can be made and programs implemented.

I would like to ask Dr. Richard Jansen to talk briefly about our near-term plans at Colorado State University for the evaluation and utilization of low-cost extrusion cookers.

Dr. Jansen:

These have been three very educational and informative days, and our first task is to digest what has been said here and to review all the papers and transcripts. There have been a number of specific recommendations as to the kinds of assistance we can provide, and they will help us to interact with you.

As to the immediate future, we are replicating on the Insta-Pro the series of corn-soy blends produced on the Brady. We will repeat the physical, chemical and sensory evaluations and rat-feeding studies to determine its capabilities. We also want to repeat on it some of the tests made on the Brady to determine product quality and characteristics.

We will begin working with other ingredients, such as cottonseed, other cereals and cassava.

Dr. Harper:

In addition, we will work in the near future to develop some of the guidelines you have alluded to today relative to operational manuals, maintenance manuals and minor machine modifications, based on observations and experiences to date, to make the equipment easier to operate and more adaptable to the LDC situation. We also will publish a proceedings of this workshop, which will include your individual papers, comments, and so on.

During the summer months we will also be preparing a slide/tape presentation covering key issues, some of which have been discussed here. It will give people in the United States and around the world a better appreciation of extrusion technology and how it can be applied. The three days of information we have had here are going to be difficult to distill into meaningful, hard-hitting data, but we have had experience doing this before and are optimistic that we will be able to do a good job.

I now ask Mr. Crowley for his closing remarks.

Mr. Crowley:

I have just talked by telephone with Dr. Martin Forman, Director of the Office of Nutrition. He asked me to convey to you his greetings.

During these three days we have been exposed to a lot of valuable substantive information. Beyond the substantive, it is the personal interaction made possible by workshops like this that leads to much more effective programs in the future.

Dr. Harper:

Thank you very much for your kind attention, participation and suggestions. We have enjoyed meeting and knowing each one of you and are looking forward to future contact.

Appendix I

PARTICIPANTS

LOW-COST EXTRUSION COOKERS WORKSHOP

Colorado State University
Fort Collins, Colorado 80523
June 2-4, 1976

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[1] Although Mr. Bachmann was unable to attend the workshop, a presentation was given in his behalf, and a formal paper is included in these proceedings.

[2] Although Mr. Okorio was unable to attend the workshop, his formal paper is included in these proceedings.

[3] Dr. Shah was unable to attend the workshop.

Appendix II

PROGRAM

LOW-COST EXTRUSION COOKERS WORKSHOP

Colorado State University
Fort Collins, Colorado 80523
June 2-4, 1976

Wednesday, June 2

8:45 a.m.	Pick up all participants at Ramada Inn

Wednesday morning session -- Dr. Judson M. Harper, presiding
Gifford Building, Room 113 Department of Agricultural Engineering
Colorado State University

9:00 - 9:15	Registration	
9:15 - 9:20	Opening Remarks	- Dr. Judson M. Harper Department of Agricultural Engineering Colorado State University
9:20 - 9:35	Welcome	- Dr. A. R. Chamberlain President Colorado State University
9:35 - 9:45	Objectives of Conference	- Dr. Judson M. Harper Department of Agricultural Engineering Colorado State University
9:45 - 10:15	The AID Nutrition Program	- Ms. Amy Pound Agency for International Development Technical Assistance Bureau Office of Nutrition Washington, D. C.
10:15 - 10:30	Coffee	
10:30 - 11:00	Extrusion Cooking as a Utilizable Technology to Produce Nutritious Foods	- Mr. P. R. Crowley USDA/ERS Nutrition and Agribusiness Group Washington, D. C.
11:00 - 11:30	The AID Program to Utilize LEC's in LDC's	- Dr. Alfred Lachmann USDA/ERS Nutrition and Agribusiness Group Washington, D. C.
11:30 - 12:00	Discussion of AID's Nutrition Program and its Use in LDC's	
12:00 - 1:00	Lunch at Colorado State University Student Center	

Workshop program (continued)

Wednesday afternoon session -- Dr. Stephen Bogyo, presiding
Gifford Building, Room 113 Consultant
Tarrytown, New York

1:00 - 1:30	Goals and Activities of the Colorado State University LEC Program - Dr. Judson M. Harper Department of Agricultural Engineering Colorado State University
1:30 - 1:55	Manufacturers' Experiences with LEC's a) Brady Crop Cooker - Mr. Marvin Van Peursem Koehring Farm Division P. O. Box 1456 Des Moines, Iowa
1:55 - 2:20	b) Insta-Pro Extruder - Dr. Leroy Hanson P. O. Box 3600 Urbandale Branch Des Moines, Iowa
2:20 - 2:45	Colorado State University Extrusion Facilities and Systems - Mr. Ronald Tribelhorn Department of Agricultural Engineering Colorado State University
2:45 - 3:00	Coffee
3:00 - 3:30	LEC Systems and Costs - Mr. Marvin Stone Department of Agricultural Engineering Colorado State University
3:30 - 4:00	Physical, Chemical, Sensory Evaluation of Extruded Products - Drs. Klaus Lorenz and Joseph Maga Department of Food Science & Nutrition Colorado State University
4:00 - 4:45	Nutritional Evaluation of Extruded Products - Dr. G. Richard Jansen Department of Food Science & Nutrition Colorado State University
4:45 - 5:15	Discussion of afternoon papers
5:15	Participants return to Ramada Inn
6:15	Pick up at Ramada Inn for dinner at Colorado State University Student Center
6:30 - 7:30	Dinner at Student Center
7:30 - 9:30	Demonstration of LEC's at Agricultural Engineering Research Center. Refreshments served after demonstrations.
9:30	Return to Ramada Inn

Workshop program (continued)

Thursday, June 3

8:45 a.m.	Pick up all participants at Ramada Inn	
	Thursday morning session -- Gifford Building, Room 113	Prof. Alvin I. Nelson, presiding Department of Food Science & Nutrition University of Illinois
9:00 - 9:30	Discussion of LEC Demonstrations at Agricultural Engineering Research Center	- Dr. Judson M. Harper Department of Agricultural Engineering Colorado State University
	Exploration of Potential of LEC	
9:30 - 10:15	Central and South America	- Dr. Ricardo Bressani Institute of Nutrition for Central America and Panama Guatemala City, Guatemala
10:15 - 10:30	Coffee	
10:30 - 11:00	East Africa	- Mr. John Okorio East African Industrial Research Organization Nairobi, Kenya
11:00 - 11:30	India	- Prof. Sunit Mukhopadhyay Jadavpur University Calcutta, India - Mr. D. K. Gupta CARE/India Uttar Pradesh, India
11:30 - 12:00	Worldwide	- Mr. Mark Sterner Meals for Millions Santa Monica, California
12:00 - 1:30	Lunch at the Colorado State University Student Center and free time.	
	Thursday afternoon session -- Gifford Building, Room 113	Dr. David Fellers, presiding USDA/ARS Berkeley, California
	Food Production Applications	
1:30 - 2:15	Sri Lanka	- Mr. Justin R. Jackson CARE/Sri Lanka Colombo, Sri Lanka - Dr. Beatrice De Mel Government of Sri Lanka Colombo, Sri Lanka

Workshop program (continued)

2:15 - 2:35	Indonesia	- Mr. Earl Goodyear CARE/Indonesia - Mr. Atjeng Muchlis Institut Pertanian Bogor Bogor, West Java, Indonesia
2:35 - 2:55	Costa Rica	- Mr. Kurt Bachmann CARE/Costa Rica San José, Costa Rica - Dr. Ronald Echandi Z. Universidad de Costa Rica San José, Costa Rica
2:55 - 3:15	Bolivia	- Mr. Pedro Bleyer Maisoy Santa Cruz, Bolivia
3:15 - 3:30	Coffee	
3:30 - 3:50	Tanzania	- Dr. Aleck Mosha Tanzania Food and Nutrition Center Dar es Salaam, Tanzania
3:50 - 4:10	Mexico	- Mr. Richard P. Mommer Uniscope, Inc. San Luis Potosi, Mexico
4:10 - 5:00	Discussion of LEC and Production Application Potential	- Dr. Judson M. Harper Department of Agricultural Engineering Colorado State University
5:00	Return participants to Ramada Inn -- Evening is free with no scheduled activities	

Friday, June 4

8:30 a.m.	Pick up participants at Ramada Inn

Friday morning session -- Dr. G. Richard Jansen, presiding
Gifford Building, Room 113 Department of Food Science & Nutrition
Colorado State University

8:45 - 9:30	Food for Peace Program - Past, Present and Future	- Mr. Daniel Shaughnessy Food for Peace Washington, D. C.
9:30 - 9:45	Working Group Objectives and Procedures	- Dr. Judson M. Harper Department of Agricultural Engineering Colorado State University
9:45 - 12:00 noon	Working groups to develop suggestions for future activities. All groups will meet in the Gifford Building.	

1. Additional Potential Food Applications, room 113

- Dr. Stephen Bogyo, leader
  Consultant
  Tarrytown, New York

Workshop program (continued)

2. Research to Improve Manufacturing Operations, room 146

- Mr. Justin R. Jackson, leader
  CARE/Sri Lanka
  Colombo, Sri Lanka

3. Programming Assistance, room 147

- Mr. F. Merton Cregger, leader
  CARE/New York
  New York, New York

4. Product Evaluation - Nutritional and Physical Properties, room 148

- Dr. Ricardo Bressani, leader
  Institute of Nutrition for Central America and Panama
  Guatemala City, Guatemala

12:00 - 1:30 Lunch at Colorado State University Student Center

Friday afternoon session -- Dr. Judson M. Harper, presiding
Gifford Building, Room 113 Department of Agricultural Engineering
Colorado State University

1:30 - 3:15 Presentations and Discussion of Working Group Recommendations

- Dr. Judson M. Harper
  Department of Agricultural Engineering
  Colorado State University

3:15 - 3:30 Future Project Activities at Colorado State University

- Dr. G. Richard Jansen
  Department of Food Science & Nutrition
  Colorado State University

3:30 - 3:45 Closing Remarks - Mr. P. R. Crowley
USDA/ERS
Nutrition and Agribusiness Group
Washington, D. C.

Appendix III

PROGRAM FOR DEMONSTRATION OF LEC's

For the demonstration of the two low-cost extrusion cookers at the Agricultural Engineering Research Center, this program will serve as a guide for products to be made.

The Modern Mill has been calibrated for all combinations of cereals with soybeans. Due to time constraints, not all combinations will be tested. First, the mill is set for the cereal/soy combination desired and flow is matched between the mill and the extruder, using the variable speed control located on the right hand side of the mill.

During operation of the extruders, attention should be given to the following:

1. Temperature sensors on the extruders
2. Controls adjusted on each extruder
3. Torque and speed traces
4. Changes in product with time

The following program will demonstrate the capabilities of these LEC's:

I. Insta-Pro Model 500 Cooker Extruder

A. General Information

1. Internal configuration

a) Steam locks, 10P-10-8
b) Orifice - 6 hole, 5/16" diameter each
c) Water application, direct injection into barrel
d) Segmented double helix screw

B. Warm-up Sequence

1. Material - 100% soybean
2. Ultimate volumetric feed setting - 40
3. Mill grind - 40 mesh
4. Feed rate - 500 lb/hr
5. Water added - 0 gph
6. Ultimate temperature - 260°F

C. Product 1

1. Material - 50% corn/50% soybean
2. Volumetric feed setting - 40
3. Mill grind - 40 mesh
4. Feed rate - 512 lb/hr
5. Water added - 0 gph
6. Ultimate temperature - 300°F

D. Product 2

1. Material - 70% corn/30% soybean
2. Volumetric feed setting - 40
3. Mill grind - 40 mesh
4. Feed rate - 507 lb/hr
5. Water added - 1.92 gph
6. Ultimate temperature - 300°F

E. Product 3

1. Material - 70% sorghum/30% soybean
2. Volumetric feed setting - 40
3. Mill grind - 40 mesh
4. Feed rate - 575 lb/hr
5. Water added - 8.4 gph
6. Ultimate temperature - 300°F

F. Product 4

1. Material - 70% wheat/30% soybean
2. Volumetric feed setting - 40
3. Mill grind - 40 mesh
4. Feed rate - 550 lb/hr
5. Water added - 2.4 ghp
6. Ultimate temperature - 300°F

G. Product 5

1. Material - 70% rice/30% soybean
2. Volumetric feed setting - 40
3. Mill grind - 40 mesh
4. Feed rate - 525 lb/hr
5. Water added - 2.4 gph
6. Ultimate temperature - 300°F

H. Shut Down - soybean used to cool extruder

After cool down, the extruder will be disassembled. Due to pressure that exists sometimes within the screw, it will be necessary that all observers stand clear of the equipment at this time.

II. Intermission

III. Brady #206 Crop Cooker

A. General Information

1. Internal configurations

a) Single helix, one piece screw
b) Annular orifice
c) Water application - direct into feed external to screw

B. Warm-up Sequence

1. Material - 100% soybean
2. Ultimate cone setting - <1.0 out from closed (<0.020" clearance)
3. Feed auger setting - 2.0
4. Feed rate - 1,000 lb/hr
5. Ultimate temperature - 280°F
6. Mill grind - 40 mesh
7. Water applied - 0 gph

III. Brady #206 Crop Cooker (continued)

C. Product 1

1. Material - 50% corn/50% soybean
2. Ultimate cone setting - 1.5
3. Feed auger setting - 2.0
4. Feed rate - 1,000 lb/hr
5. Ultimate temperature - 315°F
6. Mill grind - 40 mesh
7. Water applied - 0 gph

D. Product 2

1. Material - 70% corn/30% soybean
2. Ultimate cone setting - 2.0
3. Feed auger setting - 2.0
4. Feed rate - 1,050 lb/hr
5. Ultimate temperature - 325°F
6. Mill grind - 40 mesh
7. Water applied - 0 gph

E. Product 3

1. Material - 100% corn
2. Ultimate cone setting - 3.0
3. Feed auger setting - 2.0
4. Feed rate - 1,000 lb/hr
5. Ultimate temperature - 340°F
6. Mill grind - 40 mesh
7. Water applied - <1.0 gph

F. Product 4

1. Material - 100% sorghum
2. Ultimate cone setting - 3.5
3. Feed auger setting - 2.0
4. Feed rate - 900 lbs/hr
5. Ultimate temperature - 340°F
6. Mill grind - 40 mesh
7. Water applied - 0.9 gph

G. Product 5

1. Material - 100% rice
2. Ultimate cone setting - 3.5
3. Feed auger setting - 2.0
4. Feed rate - 880 lb/hr
5. Ultimate temperature - 340°F
6. Mill grind - 40 mesh
7. Water applied - 1.13 gph

H. Product 6

1. Material - 70% rice/30% soybean
2. Ultimate cone setting - 2.0
3. Feed auger setting - 2.0
4. Feed rate - 950 lb/hr
5. Ultimate temperature - 330°F
6. Mill grind - 40 mesh
7. Water applied - 0 gph

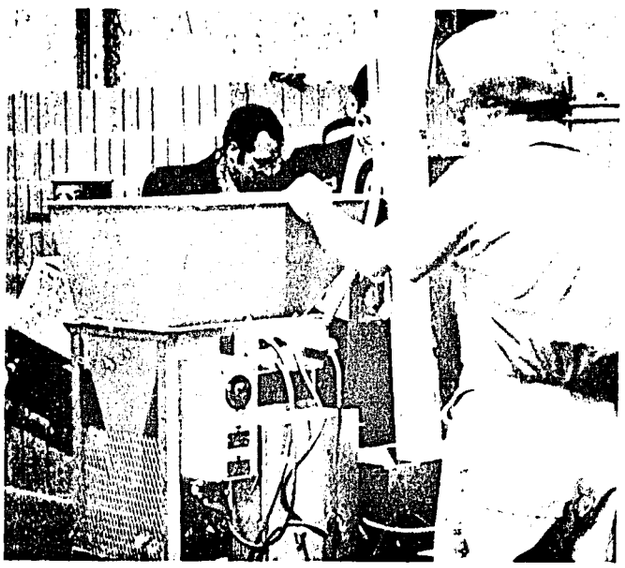
I. Product 7

1. Material - 70% wheat/30% soybean
2. Ultimate cone setting - 2.0
3. Feed auger setting - 2.0
4. Feed rate - 1,000 lb/hr
5. Ultimate temperature - 325°F
6. Mill grind - 40 mesh
7. Water applied - 0 gph

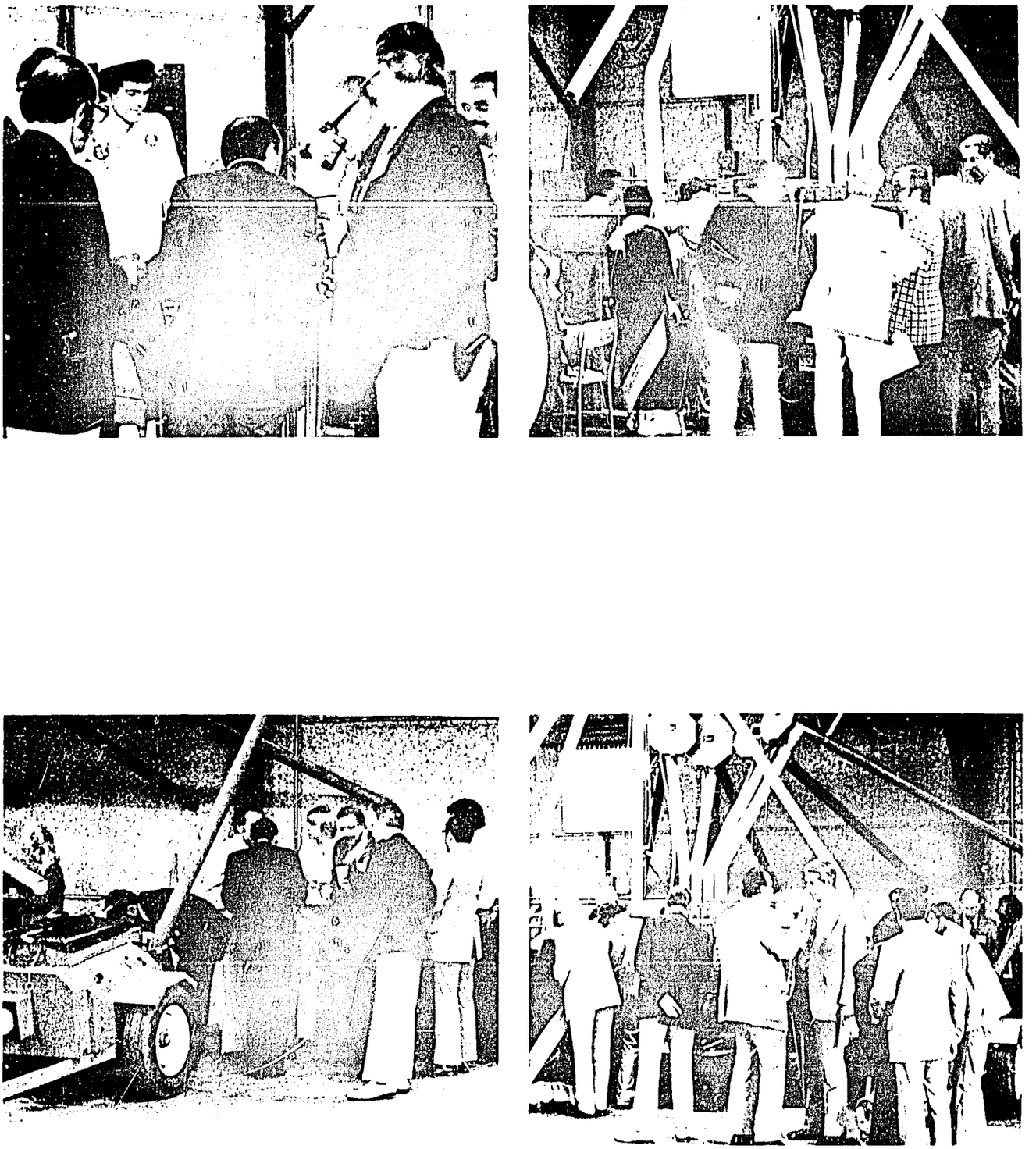
J. Shut-down Sequence - soybean used

IV. Discussion

V. Refreshments



Participants viewing demonstration of LEC's



Participants viewing demonstration of LEC's

Appendix IV

WORKING GROUP MEMBERS AND OUTLINES

ADDITIONAL POTENTIAL FOOD APPLICATIONS

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Mr. Jacques Lauriac
Dr. T. C. Lee
Dr. Klaus Lorenz
Dr. Joseph Maga
Mr. Atjeng Muchlis
Prof. Alvin I. Nelson
Mr. Maurice N. Samaan
Mr. Armando E. Sonaggere
Dr. Alex Trier
Dr. Cho C. Tsen

1. Ingredients and partially processed food blends
   (a) Food fortifiers
   (b) Fortified flours
   (c) Cereal blends with oil seeds, beans, etc.
   (d) Dairy products
2. Finished foods
   (a) Baked products
   (b) Snacks
   (c) Gruels
   (d) Weaning foods
   (e) Beverages
   (f) Soups
   (g) Dairy products
3. Program applications
   (a) School food
   (b) Maternal/child care
   (c) Food for work
   (d) Relief programs
   (e) Commercial foods

PRODUCT EVALUATION - NUTRITIONAL AND PHYSICAL PROPERTIES

Dr. Ricardo Bressani, INCAP - Group Leader

Dr. Beatrice De Mel
Mr. José Gonzalez
Dr. George G. Graham
Dr. G. Richard Jansen
Dr. Alfred Lachmann
Dr. Aleck Mosha
Prof. Sunit Mukhopadhyay
Ms. Amy Pound
Mrs. Darline Ramage

1. Nutritional evaluation procedures
   (a) Rat feeding
   (b) Human feeding
   (c) Requirements for nutrition evaluation
   (d) Quality control
   (e) Digestibility
2. Nutritional requirements for LEC foods
   (a) Site
   (b) Target group
   (c) Use
   (d) Determination
      -proteins, carbohydrates, fats
      -vitamins, minerals
3. Physical and chemical properties evaluation
   (a) Procedures
   (b) Raw ingredients
   (c) Finished products
   (d) Quality control
   (e) Storage testing
4. Functional property evaluation
   (a) Model foods
   (b) Acceptability
5. Nutritional concerns

RESEARCH TO IMPROVE MANUFACTURING OPERATIONS

Mr. Justin Jackson, CARE/Sri Lanka - Group Leader

Mr. Pedro Bleyer

Mr. Howard Conway

Mr. P. R. Crowley

Dr. Ronald Echandi

Mr. Wayne Fox

Mr. Richard P. Mommer

Mr. Fernando Sanchez-Arellano

Mr. Mark Sterner

Mr. Ronald Tribelhorn

Mr. Marvin Van Peursem

Mr. Z. Zeller

1. Simple modifications of LEC
   - (a) Cleaning and sanitation
   - (b) Operations
   - (c) Control
2. Simple modifications of LEC subsystems
   - (a) Grain cleaning
     - -requirements
     - -equipment
   - (b) Cleaning of other raw materials
     - -requirements
     - -equipment
     - -procedures
   - (c) Dehulling
     - -requirements
     - -equipment
   - (d) Grinding and proportioning
     - -requirements
     - -procedures
     - -equipment
   - (e) Extrusion
     - -requirements
     - -procedures
     - -equipment
   - (f) Cooling
     - -requirements
     - -procedures
     - -equipment
   - (g) Packaging
     - -requirements
     - -procedures
     - -equipment
     - -materials
3. Alternative subsequent subsystems
   - (a) Product regrinding
     - -requirements
     - -equipment
     - -procedures
   - (b) Mixing and blending
     - -requirements
     - -equipment
     - -procedures
   - (c) Fortification
     - -requirements
     - -ingredients
     - -equipment
     - -procedures
     - -analysis
   - (d) Enrobing and coating
     - -requirements
     - -ingredients
     - -equipment
     - -procedures
     - -analysis
4. Preventive maintenance
   - (a) Requirements
   - (b) Equipment (lubriation, tools)
     - -procedures
     - -schedules
   - (c) Spare parts
     - -procedures
     - -schedules
5. Sanitation
   - (a) Requirements
   - (b) Equipment
   - (c) Procedures
   - (d) Ingredients
6. Quality assurance
   - (a) Requirement
   - (b) Quality control
     - -physical
     - -chemical
     - -nutrition
     - -sensory

PROGRAMMING ASSISTANCE

Mr. F. Merton Cregger, CARE/NY - Group Leader

Mr. G. Sidney Ambrose

Mr. Earl Goodyear

Dr. Leroy Hanson

Mr. Thomas Kelly

Dr. Ignacio S. Pablo

Mr. Daniel Shaughnessy

Mr. Marvin Stone

Mr. Jan S. F. Van Hoogstraten

Mr. David Wilson

1. Technical assistance--How can assistance be improved, provided? Who should provide assistance?

   (a) Information
   -collection from users and researchers
   -dissemination

   (b) Project assessment
   -needs
   -improvements

   (c) Plant design

   (d) Backstopping
   -evaluation sites
   -others

   (e) Purchasing equipment

   (f) Installation and start-up

2. Program development

   (a) Guidelines--requirements for assistance (technical and financial)

   (b) Proposal development--for assistance

   (c) Financial plan

   (d) Market plan

3. Monetary assistance (What are the needs? How can agencies best provide assistance? What guidelines should be followed?)

   (a) AID/Washington

   (b) USAID Missions

   (c) OPG's, DPG's

   (d) Local inputs

   (e) PVO's

4. Product testing--Is a central facility required? Are guidelines needed? Who should cover costs?

   (a) Analysis

   (b) Evaluation

   (c) Testing

5. Guidelines for program assistance--How are projects to be selected for assistance?