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9. ABSTRACT

The report of a workshop on the Tunesian project adding lysine (a synthetic amino acid) to centrally milled wheat in order to improve its protein content (also discussed in PN-AAC-684). Included here are the opening speeches, papers presented on the project itself, the technology of fortification, the costs of fortification, and alternative techniques of improvement of protein in wheat qualities. Finally, there are the workshop's conclusions and recommendations. It was seen that even if fortification is not imminent in a country, its general consideration should be within proper perspectives: 1) fortification should be part of an overall food and nutrition plan; 2) implementing bodies should exist to determine status of nutrition requirements and alternative courses for meeting them, including the improvement of a population's wheat supply; 3) responsibilities for fortification should be distributed between industry and government; 4) costs must be met; and 5) further research must be undertaken.

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WHEAT FORTIFICATION WORKSHOP

Tunis, Tunisia

September 10-14, 1973

THE NATIONAL INSTITUTE OF NUTRITION
GOVERNMENT OF TUNISIA

Co-Sponsored by
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TECHNICAL ASSISTANCE BUREAU
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I. OPENING REMARKS

A. Welcome Speech

by Mr. Hedi Khefacha, Acting Minister of Public Health
Government of Tunisia

This opportunity which has made of Tunisia a meeting place of research workers, technicians, and officers concerned with Man's nutrition and health from various countries and continents give us reason to pride ourselves on, express our gratefulness and render homage for the work achieved through applying fortified wheat to a large fraction of the population in Southern Tunisia.

Your presence in Tunisia reflects the importance your Governments attach to the trials now underway for improving staple foods in an effort to fill, adequately and without excessive costs, the physiological requirements of the Tunisian and turn him into a productive and enterprising man in a society constantly threatened by two severe plagues, that is an excessively high population increase and under-production which are the two attributes of all underdeveloped nations of the Third World.

The field survey, now underway in Tunisia, using lysine fortified wheat, amino acids, vitamins and minerals which are most essential for growth, was initiated four years ago by our young National Institute for Nutrition and Food Technology, in close cooperation with the Nutrition Department of the School of Public Health of the Harvard University with the Agency For International Development's unreserved support.

Thus this fruitful cooperation between these three organizations has permitted Tunisia to gain great advantages that are sure to benefit the young

generations in the field of public health. The results already achieved will not fail to interest many other countries, especially those represented here by highly qualified delegates.

Each delegate's contribution to the work of this conference during these few days of studies and exchanges of views marks a victory in our common struggle against under-development and physiological poverty which are indeed the disgrace of this 20th Century, the era of atome energy, of mind's victory over the matter and Man's conquest of outer space.

Our government's support to mutual aide in this field offers promise of a brighter future which will be further strengthened by the results of your work to which Tunisia is proud to bring her little contribution.

It is on the harmonious unity of all our efforts that depend the health, happiness and development of our populations in a world where economic and social disparities should not be as wide and flagrant as they actually are.

It is already a well-known truth that nutritional problems in developing countries are mainly due to serious deficiencies of proteins of animal origin, vitamins and minerals. Cereals which are a staple food in our national diet, cannot supply the essential nutrients our people need. For that, it is essential to make every endeavor to develop stock-farming, poultry, and fish breeding according to a well-planned production scheme.

The present trials which cover a large fraction of the population in Southern Tunisia will enable us to avoid most of these obstacles and to attain with the use of wheat fortified with lysine, vitamins and minerals the improvements needed to fill our populations physiological requirements.

With this project as well as to the Tunisian Government's effort to slow down population increase, it will be soon possible for each Tunisian to have a well-balanced ration to fill his essential physiological needs. If nutrition is regarded as a problem of public health with both its curative and preventive aspects, it is only logical that nutritional improvements should fall within the scope of medical and social sciences and food technology.

The Government of Tunisia is pleased to express gratefulness to each of you for his observations and conclusions made after long years of research and for his contribution to the success of the Tunisian experiment in the field of wheat fortification which will make it possible to alleviate the adverse effects protein deficiencies had on the health of our laborious people for decades.

Our efforts aim at improving Man's physical and physiological qualities so as to be a driving force for social, economic, and cultural progress in a society which should be more hospitable and enterprising in a developing world.

With this promising prospect, without which no lasting progress can be achieved, I wish your conference full success and each of you an enjoyable and enriching stay in this country.

B. Remarks by Ambassador Talcott W. Seelye
American Embassy, Tunis

I am pleased and honored to join with His Excellency, Mr. Hedi Khefacha to welcome you to Tunis to participate in an international conference to consider the quality of food for the sustenance of human life. In 1973, for the first time in over 20 years, my country has had to suspend -- hopefully only on a temporary basis - a large portion of its foreign deliveries of agricultural products considered surplus to our needs. At the same time, the hunger which always stalks the world has struck with particular viciousness in the Sahel region to the south of us in Africa, in South Asia, parts of Latin America, and in Southeast Asia. It is symbolic of the problems we face that you are gathered here from many different continents to consider how the world can make better use of the food it currently produces to meet its growing needs.

"Fortification" of food during processing through the addition of amino acids, protein concentrates, vitamins and minerals offers promise as one way of alleviating the protein malnutrition that is endemic in the developing countries. I am glad that the United States has played a role in furthering the technology of increasing usable protein in cereal and root crops. My government, through the Agency For International Development, is currently supporting projects to determine the effectiveness and practicality of applying food "fortification" techniques to large populations. As you know, field trials are being conducted with corn in Guatemala, rice in Thailand, cassava in Brazil, as well as with wheat here in Tunisia.

I am pleased to learn that the field trials with wheat in southern Tunisia being conducted by the Tunisian Institute of Nutrition and Food

Technology under its capable director, Dr. Zouhair Kallal, are progressing very well. Your scheduled visit to this project I am confident will give you the opportunity of determining the progress made to date and the possible benefits and problems of conducting similar trials in your own country.

I am pleased to welcome representatives of Harvard University and the Pillsbury Company at this conference. Harvard is participating with the Government of Tunisia and the USAID in conducting the wheat fortification project in this country. Pillsbury as well as the Japanese Ajinomoto Company and three other American firms are making important donations to this Project.

I also wish to express my appreciation to the governors of Gabes and Gafsa, the delegates of Kebili, Douz and Degache (all of whom I have the privilege of knowing), the Office of Cereals and the many private owners and managers of flour mills and the pasta factory in the area. Without the cooperation and dedication of these many people, the implementation and success of this wheat fortification project would not have been possible.

Please accept my best wishes for a successful conference which I know can be of benefit to people everywhere.

C. Keynote Address

by Dr. Zouhair Kallal, Director,
Tunisian Institute of Nutrition

The subject of this conference is a most serious one. There is hardly any subject that requires more serious consideration than food, especially protein supply. In recent months the decision by the American Government first to embargo its exports of soybean and soybean protein concentrate and then to control them are sufficient reminder to all of us that protein supply is a major factor in the political and economic considerations of all governments, rich or poor.

Therefore, as an introduction, and as my contribution to this meeting, I want to discuss the question of protein supply, present a picture of how we see this problem in Tunisia, and describe how the fortification trials in my country, which are the subjects of your meeting, relate to our understanding and ability to solve food and nutrition problems in the future.

The matter of improving the protein value of cereals is a complicated technical subject. But this does not absolve any of us from trying to understand it sufficiently to be able to incorporate this understanding into development of policy. Therefore, I will, to begin with, convey my understanding of the problem of protein in cereals. There are a small number of basic principles upon which this discussion rests; let me list them as I see them:

1. All life requires protein for existence. Without sufficient protein in the diet, life ceases. Even if there are enough food calories but inadequate protein, as is found in sugar or root starches or in oils, life must cease.

2. Proteins in food come in many forms: from cereals, from legumes, from animals such as meat, milk, fish, and eggs. Cereals are the major source of protein in the world. In my country wheat is the major cereal.
3. Cereal protein is incomplete from a nutritionist's standpoint; it is not used as effectively by the human as is protein from animals.
4. Cereal protein is improved by eating it in mixtures with legumes. or in mixtures with meat or milk or eggs, or in mixtures with newer products such as oilseed concentrate or fish protein concentrate.
5. Mixing wheat with other kinds of protein sources of the type mentioned above serves to correct the deficiency in wheat protein. A similar correction can be achieved by supplementing the wheat with the specific protein component which is deficient in wheat. This component is called an amino acid, lysine, which is white powder and can be mixed with wheat flour and imparts no taste or off-color to the products made with wheat.
6. The idea that wheat can be made an almost complete food by fortification is an exciting and dramatic idea. It does not eliminate the need for legumes or animal products because these not only supply protein and other nutrients, they also supply variety and pleasure in the diet. But a fortified wheat provides a government with unparalleled flexibility in food policy. It allows a nation the security of knowing that major uncontrolled fluctuations in supply of legumes and animal products will not upset

the basic nutrition of a population. It allows a nation to upgrade nutrition of the pregnant women and children at lowest cost. It allows a nation broader options for organizing food supply both for maximum nutrition and maximum pleasure from food.

With these principles as a background let me analyze our own nutrition situation as it impinges on the need for new technology. The key to our food strategy and to having an adequate food supply is our supply of wheat. In this connection we have made great progress. We are producing more soft wheat; we have brought in new varieties; we have improved our agricultural practice; we have increased the use of fertilizer. As a result, our total and per capita supply of wheat has increased and the consumption of cereals has indeed increased from over 600 thousand tons in 1965 to just one million tons in 1971.

A second great source of food, a major source of protein to balance the protein of the wheat, is legumes. Our legume supply has increased from 19,000 tons in 1965 to about 27,000 tons in 1972. But this increase just barely served to keep up with the increase in population.

Our animal - that is meat - production has actually decreased from 82,000 tons in 1965 to 59,000 tons in 1971, even though our consumption of meat has risen, primarily because we are importing more meat. And so, although we are eating more food, we must seriously consider ways of maintaining our food and protein supply, of increasing it, and of finding ways of providing not only proteins for nutrition but protein foods, that add to the enjoyment of the diet. As we look to the future we have to consider our food supply in three lights:

a. What are we doing to keep up with population growth which is growing at a rate of 3% and which brings so many more mouths to feed annually.

b. Our economy is improving: our gross national product has increased since 1968. This increased income stimulates an increased demand for more food and more protein food, and for foods that contribute to better food quality in terms of taste and enjoyment.

c. Aside from the first two factors, our government is committed to improve the quality of life under any circumstances, and that means better nutrition. It means better nutrition for pregnant women so that children will be born stronger and healthier. It means better nutrition for infants so as to reduce the dangers of infant mortality that comes with poor nutrition. It means better nutrition for growing children so that they will develop to the utmost their physical and mental capacities to be useful citizens of this country and useful individuals for themselves. We want people to be able to live to the best of their capacity and work to the best of their capacity, unimpeded by inadequate nutrition.

With all of these concerns in mind, we first of all must continue progress on increased production of wheat at all costs. This means better agricultural practice and varieties, better irrigation, more use of fertilizer, and, perhaps, increased acreage devoted to wheat.

For the near future we cannot predict the availability of excesses of grain to support an increased animal production. This is the way this is done in most countries that are great animal producers, with the exception of those that have great amounts of pasture land. This we do not foresee in the near future.

We must turn to new technologies to aid us in overcoming these problems. In this connection, we must consider seriously every opportunity for non-agricultural protein. Lysine, which can be produced from petrochemicals or by fermentation, does not constitute a drain on our agricultural resources. The additional amount of protein which can be added to the Tunisian diet by the fortification of all of the wheat that is consumed will be the equivalent of 2,000 tons of protein and this could be done without in any way injuring our efforts to find the highest yielding wheats and to increase our total wheat production. We are cognizant of the possibility of breeding high protein wheats. But this is not yet a reality; the addition of amino acids is a reality that could be put into practice now.

While not the subject of this conference, we must not overlook the fact that food is not merely nutrition. People eat food for enjoyment; while meat and meat products are a great source of nutrition, they are equally a great source of pleasure. As the ability to obtain meat products is reduced, we must be aware of other technologies. We are particularly interested in and are following the great new development of textured vegetable protein which provides meat-like products directly from oilseed protein.

We are not committed to any particular approach or to any particular mixture of approaches but are convinced that the present agricultural capabilities in this country - as well as others - will be inadequate for the expected population and the expected food demands. Although we are aware of the problems caused by rapidly expanding population, until population is stabilized we must exhaust every possibility, agricultural or otherwise to maintain adequate nutrition, and the best possible enjoyment value in our foods.

Accordingly, over four years ago our Institute of Nutrition together with the Department of Nutrition of Harvard University School of Public Health and with the support of the Agency For International Development instituted an in-depth real-life study of fortification of wheat with the amino acid lysine and with certain vitamins and iron. We are studying this, as you will see, in Southern Tunisia. We want to observe the improvements; how difficult is it to do; how much does it cost; how is it accepted; what effects can be observed; how can it be introduced as a matter of national policy. I will not dwell on these questions because these are the subjects of this conference. I would only want to point out some characteristics of our approach:

1. This is obviously not a laboratory exercise totally removed from reality. We are certainly learning about the process of improving wheat and its effects on the populations that are being examined. But we are also learning a lot about the people in these areas, much more than is generally learned by undirected nutrition surveys or by census statistics. We will be able to help these people and all of Tunisia better in all respects because of this information, not only in nutrition. So as this program continues, and particularly after this meeting, we intend to ask ourselves how this new technology can be introduced into national policy and what steps must be taken now to provide for a rational introduction of this kind of technology into our food economy.

2. Tunisia is unique, and shares this property with a few other countries, in that the major and almost single cereal crop eaten is wheat. Therefore, the fortification of wheat affects all the inhabitants. It would add, as I stated earlier, 2,000 tons of protein equivalent to our diet. Further fortification with other vitamins and minerals could eliminate major nutritional problems totally from our diet.
3. We think that we have had the luxury of being able to undertake field trials of the magnitude that you will observe as we plan national program commitments. We know that our national decisions will be better because of this experience, because of our opportunity to examine in depth the operation and consequences of a new technology.

You, our guests from other countries, might ponder our experience as your meeting progresses. You might ask yourselves whether you have the luxury of field trials or whether events are moving so rapidly that you must make decisions on protein policy without direct benefits of field trials. If the latter situation is more correct, then perhaps very close study of our experience will help you, even though you may not be able to have such in-depth experience in your own country. If you insist on your own field trials, as well you might, how long can you afford to wait before starting such trials?

I wonder, as I talk to you, how much longer International Agencies and donor countries can afford to overlook the opportunity to increase protein supply in the world without a burden on shipping space and without increasing

agricultural demands, by maximizing the protein in grain shipments by fortification. This can be done at the point of shipment or by making provisions for fortifying cereals in convenient locations within the recipient country. Countries that are faced with problems of food shortages and famine are not only short of total calories, they are equally short of protein. Any means of reducing this problem contributes to helping these countries weather the storm.

We are meeting at a time of critical re-evaluation of protein policy in every country. We are proud that Tunisia has taken leadership in providing a window through which to observe the practice of a new technology.

Use it well.

And may your deliberation meet with every success.

D. Introduction and Workshop Purpose

by Dr. Martin J. Forman
Director, Office of Nutrition
U.S. Agency For International Development

Before social problems stimulate a relevant response, there is usually a sequence of events which occur. First, there is usually a generation of increased awareness of the problem. This usually leads to greater concern. Little will happen, however, unless this concern is translated into a commitment. Many social problems remain unresolved because of a lack of commitment.

With regard to the world malnutrition problem, soaring population growth rates and knowledge of the impact of malnutrition on human physical and mental growth have brought about increased awareness and concern, and in the past several years, the world has seen the beginning of a real commitment by governments to attack this problem.

As a commitment is achieved, decision makers will seek solutions to the problem. Each of these potential solutions will be considered in terms of three inter-related feasibility questions -- those of technology, economics and politics.

The nutritional improvement of wheat or wheat flour by fortification or blending is a technique which gives great promise of applicability in the fight against malnutrition in wheat eating countries. (It has the added benefit of providing additional nutrition without any added demand on agricultural resources.) It would also appear to meet the tests of technological, economic, and political feasibility.

The purpose of the Wheat Fortification Workshop is to examine these issues in depth. The research and development project on wheat fortification in the Kebili area of Tunisia is the world's first such effort and offers an opportunity to examine at first hand the meticulous study design which is intended to corroborate earlier results on human subjects and animals which demonstrated the health benefits of eating fortified wheat products. Visits to the mill in Tunisia will afford an opportunity to examine the techniques used to meter in and control fortification amounts. Discussion with fellow millers, scientists, and cereals policy makers will provide insights into the adaptability of this technique into other country environments.

This workshop is geared to the issue of implementation. It brings together those officials in the public and private sectors who will need to implement wheat fortification programs. It is intended to offer such personnel an opportunity to learn the latest state of the art and to contribute to answering the question of where we go from here.

Among other things, the following questions need to be addressed:

A. Technological

-- How to supply ingredients. Can and should a local capability be developed, or should they be imported?

-- How to mix fortificants in proper amounts.

-- How to ensure stability (and how to adapt to different climatic and other conditions).

-- What changes are needed at the mills and how can fortification be adapted to local milling conditions.

-- To what degree must milling be central -- can fortification be carried out if mills are small and widely dispersed.

-- What fortification standards should be established -- can they be monitored.

B. Economic

-- How to calculate costs -- What else besides money needs to be considered?

-- How does the cost of fortification compare with other alternatives to problem solving?

-- How can the added costs be absorbed -- by industry? by consumers? by government? by combinations?

C. Political

-- Are there any political impediments to fortification?

-- Should fortification be done without public knowledge or should it be publicized to encourage people to expect and "demand" an improved product.

-- Can government get "credit" for bringing about a nutritionally improved wheat for the people -- or will there be negative reaction and distrust.

The answers to questions such as these will determine the future of wheat fortification. This is the reason this workshop is of paramount importance.

E. Health Improvement via Fortification

by Dr. Frederick Stare
Chairman, Department of Nutrition
Harvard School of Public Health

The history of nutrition can be described as changing a singular noun-nutrient to a plural noun-nutrients. It was approximately 1840 that chemists found that foods could be separated into three main chemical classes, fat, protein, and carbohydrate, whereas previously there was only nutrient in foods. Minerals as essential components of nutrition were discovered only about 100 years ago. Vitamins came along at the turn of the century. Today, we know of some 50 nutrients required in the diet for good nutrition, and no single food, not even mothers milk contains them all in adequate amounts, and that is the physiologic reason why we need a variety of foods in the diet.

For the past 30 or more years nutrition educators in various countries have been classifying local foods into various Basic Food Groups, groups that provide primarily certain types of nutrients and then recommending that people should eat one or more foods from each group, the reason being to provide the proper variety of foods in the diet that will supply all of the 50 some nutrients needed for good health. In the United States we use what we call the Basic Four Food Groups. These are the meat group composed of meat, poultry, fish, eggs, and legumes; the milk group composed of milk and cheese; the fruit and vegetable group, and the cereal group.

But despite the best efforts of nutrition education, we haven't made too many in-roads in changing food habits, in getting people to eat a wide variety of foods from the various food groups. And if we have had little

success in getting variety into U.S. diets, with the great variety of foods available to those who can afford them, how will one ever get the masses of mankind in the developing areas of the world to get variety into their diets, particularly when not much variety is even available?

With an expanding population in the world, and with a desire for less work in the kitchen, that is in the preparation of foods, I think the way we will meet and overcome most of these nutritional challenges is through an expansion of the intelligent and continual safe use of preservatives, food additives, and the fortification of foods, particularly the three cereal grains that nourish most of mankind. These are rice, wheat, and corn, and they can be fortified with appropriate vitamins, minerals, and amino acids. They can also be supplemented with various legumes or fish protein concentrates.

By fortification of foods, all that is meant is simply the addition to the food of one or more key nutrients that the food is low in, or that the total diet is low in.

The rationale for fortification of foods is two fold:

(1) Too many people do not consume a sufficiently and properly varied selection of foods to provide them with the desired amounts of the some 50 known nutrients;

(2) To prepare, preserve, and store foods from harvest until they are consumed, requires a certain amount of processing and refining with some loss of nutrient content.

Both of these situations provide the rationale, and indeed the necessity, for fortification which has been an important practical development for improved

nutrition, and which I think will be more important in the years to come. The classic examples of fortification in the United States are the addition of iodine to salt, vitamin D to milk, vitamin A to margarine, three B-vitamins and iron to white flour used for bread, and fluoride to water. More recently the amino acid lysine has been added to some wheat products to improve the nutritional quality.

Fortification of a few basic staples helps give assurance that good nutrition is readily available to all. Since most of mankind lives off cereals primarily rice, wheat, and corn the production of more of these foods is important in the near future, as well as the improvement of the nutritional quality of their protein.

The so called "green revolution", meaning mainly higher yielding strains of the basic cereals, is a big step forward. But the protein of these cereals, in fact of all cereals, is low in one or more essential amino acids -- rice protein is low in lysine and threonine, wheat protein is low in lysine, and corn is low in lysine and trytophane.

Genetic research may in time develop new strains not only with greater yield but improved protein quality and quantity. But today, not tomorrow, with the help of synthetic amino acids made by fermentation or chemical synthesis, it is possible to make a bread, or any other wheat product, with protein of good nutritional quality by the addition of the single missing amino acid, lysine. Wheat products made with lysine do have improved protein quality and are economically feasible. Taste and cooking qualities are not affected. Food habits do not have to be changed. The same can be said for rice and corn.

Thus, I feel quite strongly that man's nutrition in the coming years -- with far more people -- will depend more and more on fortified foods, particularly fortified cereal products. I might add fortified potatoes and fortified sugar, cheap and efficient sources of energy -- and energy is a basic need, perhaps after water, the most basic requirement of our diet. We will be fortifying these basic foods, possibly even tea, coffee, and soft drinks, not only with vitamins and minerals but also possibly with amino acids. With tea, coffee, and soft drinks we would be using these beverages as carriers of these nutrients, because these beverages are widely consumed.

All of this fortification of food involves the addition of chemicals to foods, but this should not disturb intelligent people. After all we are made up of various chemicals, body tissues are all chemicals, foods are chemicals. Some of the chemicals added to foods are not nutrients but are added to preserve the nutrients of the food, or as in the case of monosodium glutamate, modify the taste, and hence acceptability and enjoyment. Please remember that eating is one of the pleasures of life as well as a necessity.

Food and nutrition are certainly important to our health -- yours, mine, and the rest of mankind. Food and nutrition will be increasingly important in the years to come, with more people to feed, requiring more ingenuity on the part of technicians in agriculture and food technology to feed them. Physicians in medicine and public health must become more aware of the importance of food and nutrition in man in his new life environment. Governments and politicians must not only permit but encourage the food industry to respond with nutritionally improved foods for our changing and modern world.

We can do a better job in feeding man in the future than we have in the past if our food industry is encouraged by governments around the world to take advantage of progress in nutrition and agriculture, and much of this will be by the fortification of various foods, particularly the cereals. The farmer and the chemist working together, and with the support of the government, can do a better job, and do it more economically than either working alone. Thank you for your attention.

II. PROJECT ANTAR (Lysine Fortification Program in Tunisia)

by Mr. Moshen Turki — Project Antar
Dr. Elizabeth Boutourline — " "
Dr. Mohamed Ghamry — " "
Dr. Mohamed El Lozy — " "
Dr. Gino Tesi — " "

Published information on Project Antar has appeared or will appear as follows:

Human Biology	44, 433	1972.
Growth	36, 407	1972.
"	37	in press

Selected for study was a pre-school population of 3,000 from three villages in Southern Tunisia in the area surrounding the large salt lake, Chott El Djerid. Population of the wheat-staple villages of Douz, Kebili and Lakache is some 80,000. Fifty percent of the wheat consumed is locally grown; the rest comes from the North. Wheat accounts for 80% of the protein consumed in the region. Wheat supplies are channelled through a single Southern Tunisian Cooperative and therefore can be controlled (with the help of color coded tags and strict surveillance by project personnel). Three groups of 0-6 years olds, 1,000 from each village, are being tested for the effects of: fortification of wheat products with vitamins and iron; and fortification of wheat products with lysine, vitamins and iron. The third village serves as a control. The villages were chosen for their similarities of ethnic composition and of socio-economic stratification, and their isolation from each other.

Basic data were taken two years prior to the start of the fortification program (in fact, two baseline studies were done because of delays in getting

the results of the first one). The 1966 Tunisian census was used as background and then updated by on-the-spot revisions. Studies were made of stores in the area. A dietary survey of food consumption was also performed on sampling of children representative of the area. Fortification has now been in effect for two years, starting in August 1971. This followed the two baseline studies and a July 1970-July 1971 dry run to test the mechanism and carry out a nutrition survey which would reflect seasonal dietary patterns, such as Ramadhan (Moslem fasting month). The standard anthropometric measures bone maturation and linear growth, dental development, physical examination, hematologic status and urinary and serum measurements of nutritional status are taken at six-month intervals. Data interpretations are made in Tunis, Italy and Boston, and require six to nine months. Thus, while fortification has been in effect for two years, and four assessments completed, the results now available reveal information for the first year only, based on the data from two of the six-month interval measures.

The results are inconclusive at this early date, but show a favorable trend in the group receiving lysine/vitamin/iron fortified wheat products:

- The measurements of linear growth and head circumference showed progress, particularly in girls;
- Weight increments were above standard in both boys and girls;
- Riboflavin in urine had doubled in lysine group;
- Iron fortification showing up favorably in absence of anemia;
- There was general improvement in the health of the children.

Discussion

As to the possible need of other limiting amino acids in the diet, it was pointed out that 80% of the protein comes from cereal products; in a wheat-based diet, the amino acid that will give the biggest increase in protein utilization is lysine.

There might be a problem in showing lysine benefits in calorie-short group such as this -- e.g. is protein used for energy?

It would be interesting to investigate from the day of birth and then follow progression even beyond pre-school period.

The Antar project will continue for three years. In the last year, it is planned to take data on pregnant women.

III. THE TECHNOLOGY OF FORTIFICATION

by Mr. Robert Wooden,
Pillsbury Company

Fortification is the improvement of nutritional quality by the addition of one or more nutrients to a basic food. As has been discussed previously, the choice of the fortifying material is based upon consideration of a number of factors. These factors include such things as:

1. The needs of the population consuming the food.
2. Economics of buying the fortificant, adding it to the basic food and re-selling the entire mixture.
3. Compatability of the nutrient with the basic food technology of the item to be fortified.

One method of fortifying especially the protein level in a population's diet is the addition of rather large amounts of soybean or fish meal. Such fortification programs generally deal in the addition of a significant percentage of fortification to the base food. Depending upon the circumstances we could be talking in the area of 5 or 10% and even higher. This subject will be covered in greater detail by Dr. Hoover.

Our considerations at this time will be limited to the addition of micronutrient fortificants to basic foods. When we speak of micro-nutrients we are speaking mainly of vitamins and minerals. The addition of amino acids such as l-lysine monohydrochloride can also be considered in the area of micro-nutrient fortification. In terms of bulk the materials added in micro-nutrient fortification are generally not too significant. For example, in many flour

mills today Vitamins B_1, B_2, Niacin and Iron are added to wheat flour at a level of .0001562% or about 9 grams for every 50 kilograms of flour. This is probably the lowest practical limit to be used in fortifying flour. The upper limit of micro-nutrient fortification could conceivably run as high as 400 or 500 grams per 50 kilograms. The highest level that I am aware of in current usage in a production situation is the one that we are using in the mills here in Tunisia. In situations where we are adding lysine as well as the vitamins and minerals to the wheat products, we are using a fortification level of .5% or 250 grams per 50 kilograms of wheat product.

There are a number of ways that one can go about accomplishing the physical addition of micro-nutrients to basic food products.

One way is by the addition of a tablet of micro-nutrients to a wet dough while it is in the process of being mixed. Such tablets, of course, must be formulated for specific sized batches of dough and the size of the batch of dough must never vary or else the level of fortification will be something other than what was planned.

A second method used in fortifying certain kinds of materials is that of spraying a very concentrated liquid preparation onto the surface of particular products after these products have been heat processed. One of the reasons for doing this is, of course, to avoid the degradation of vitamins or amino acids that would occur during a harsh heat process.

A third method, although one that is not quite as satisfactory, is the addition of a packet of vitamin powder to a consumer size package of food. This method depends upon the housewife using the material properly in the preparation of the food and the feeding of her family.

A fourth method of micro-nutrient fortification is the impregnation of a particle like the food to be fortified with a very highly concentrated level of the micro-nutrients. These very highly fortified particles are then blended back into the basic food at a predetermined rate and the food thus becomes fortified. Depending upon the basic food, this method can take several forms.

In the case of dried potato products, the vitamins are encapsulated in a special mixture of high melting point fats, thinly flaked and then blended into the dried potato in much the same way that flour is fortified in a flour mill. In the case of rice, a kernel of imitation rice can be manufactured using rice starch as a base and including whatever micro-nutrients a given population might need. These imitation pellets are then added to the milled rice at a predetermined rate and the entire batch of material becomes fortified at the proper level.

The last method of micro-nutrient fortification that I'd like to talk about today is the one that has been used in the fortification program here in Tunisia. This is the addition of dry powder by means of a mechanical feeder to the mill stream during the milling operation.

Before discussing the dry powder/mechanical feeder method of micro-nutrient fortification we should point out that one of the major advantages of using micro-nutrient fortification over other means of fortification lies in the fact that normally the flavor, color, texture and general eating quality of the food being fortified is not altered by the fortificant. Because of this, micro-nutrient fortification programs usually do not have to concern themselves

with re-education of the housewives and cooks or the sales and marketing problems associated with introducing a food item that has an unfamiliar taste, texture or color. I'm not suggesting that any fortification program should deceive the population consuming the food by their not knowing if there are fortificants present but rather that being able to deal with a familiar food certainly makes the job a lot easier.

On the screen before you, you see pictures of the feeders which you observed in the mills that you visited yesterday. The hoppers on top of these feeders are kept filled with the premix blend. The feeders are set to add the vitamin and lysine mixtures to the flour or semolina at a pre-determined rate. This rate is determined mainly by the rate of flow of the flour or semolina in the mill stream. If the speed of the mill stream is increased, then the rate of fortificant premix must be increased. If the rate of flow of the mill stream is decreased, then the rate of addition of the vitamins and lysine must be decreased in order to maintain a constant level of fortification. This is one point in the fortification of milled wheat products that cannot be emphasized too strongly. The rate of addition of the fortificant must be kept constant with the rate of the mill stream. Any variation in either of these rates will result in either over-fortification or under-fortification and this is bad for both economic and nutritional reasons.

During your tour of the mill yesterday, you noticed that the feeders were located on conveyor lines just a short distance from either the holding bin or packaging bin or from the packaging operation itself. The fortificant premix is a very free-flowing, dusty powder. Because of this, we wanted to be

very careful that it travelled through the conveyor system only far enough to become well blended with the flour, but not far enough to dust out in the different parts of the milling operation.

The fortification levels used in Project Antar are providing approximately all of the Vitamins A, D, B_1, B_2, Niacin, Iron and Lysine that the people require on a daily basis assuming a consumption of approximately 400 grams of wheat based product per day. Formulation of a fortificant can be easily varied to meet the needs of an individual population taking into account both nutritional and economic factors.

Once the nutritional needs of a population are identified, it is usually a rather easy matter to formulate a fortifying mixture for them. However, this can be a little bit tricky from time to time. For example, in the fortification of wheat flour one must be careful about the iron source that is chosen. In terms of biological availability ferrous sulphate is the iron source of choice. However, when ferrous sulphate is used it causes the fortified flour to become rancid and virtually inedible in a very short period of time. Therefore, one would choose a different iron source such as ferrick orthophosphate or in the case of the Tunisian program reduced iron powder. Other unexpected situations such as this can show themselves also. When fortifying rice, one must be careful about the use of riboflavin because it will turn the rice a yellow color. This, of course, is undesirable in terms of eating quality by the consumer.

Two further things to keep in mind when formulating a nutritional premix to be added to flour are that the moisture level should be kept fairly low, both for shelf life reasons and for flowability reasons; and, secondly that

the bulk density and particle size of the materials used in the premix should be similar to that of the flour or semolina being fortified. If they are not similar, then they should be tested in advance of a production situation to make sure that separation of the fortificant from the fortified product will not occur during distribution of the product. It would not be good, for example, to find all of the vitamins and lysine at the top or bottom of the bag of flour with very little in the flour itself.

A final subject for consideration in the fortification of flour is that of quality assurance. Over-fortification with such things as Vitamin A or D if done extensively and over a long period of time could be medically harmful to individuals in the population. In addition, any over-fortification would be economically undesirable to say the least. Care must be taken to make sure that the premixes used are what they should be in the first place in terms of nutrient content. Any company who manufactures and supplies vitamin and amino acid premixes will have a chemical laboratory capable of doing a thorough analysis of the premixes. Such an analysis should be done before the premix is shipped to the mill where it is to be used, and a certification of the content of the material should be delivered to the miller along with the premix. This will give the miller some assurance of what he is working with.

Two quick and easy quality assurance methods that can be used at the mill level are as follows: First, a careful inventory of the amount of fortified material that is manufactured and the amount of fortificant that is used in a given period of time should be kept. If the usage of premix is approximately what it should have been to fortify a given amount of flour or

semolina, then you are probably on the right track. Second, constant checks should be run on the rate of flow of the mill stream and the rate of flow of the vitamin premix feeder. The miller should work with his people to prevent any variability in either of these flow rates.

Beyond such simple techniques, there are further tests that can be run on fortified flour and, in fact, have been used for years in the milling industry. These are a wet slick test under long wave ultra-violet light to check for riboflavin, and a wet chemical analysis for thiamine. The wet slick test under ultra-violet light for riboflavin is a very easy and quick one to accomplish. The only thing that is really necessary by way of equipment is the long wave-length ultra-violet light source. The operator merely wets a slick which he has prepared of fortified material next to unfortified control material, dries it and then examines it under ultra-violet light. The riboflavin particles will be scattered throughout the fortified material and will fluoresce a kind of yellow green color. They are very easy to see and a skilled operator can make pretty good quantitative determinations of the riboflavin content of the material. The wet chemical thiamine analysis is a much more involved process and an analytical chemist can usually accomplish only about 15 such tests in a full day in a well equipped laboratory. Since well trained analytical chemists are expensive to hire and maintain in a laboratory, it would be suggested that instead of each mill maintaining one, perhaps a central laboratory could be used to service many mills in the area of thiamine determinations. Further, thiamine determinations probably need not be run nearly as often as the riboflavin determinations or the weight checks.

In summary then we can think about five major points:

First, what can be fortified? Almost anything that needs to be fortified can be. Dry milled cereal grain products such as wheat flour or

semolina lend themselves very readily to fortification with a wide range of nutrients including vitamins, minerals and amino acids.

Second, what are some potential fortificants? Potential fortificants can be divided into two areas as defined by the amount of material that would be added. One is the micro-nutrient fortification of vitamins, minerals, and amino acids which usually would not range over a half percent by weight of the finished food. The other as discussed by Dr. Hoover is the addition of large amounts of materials usually added for their protein value such as soy meal or soy flour or fish meal. These would be added at rates of 5 or 10% or even higher of the finished food. Fortificant that would be used, of course, would depend upon the needs of the target group, the restrictions imposed in the manufacturing operation in terms of heat processing, moisture levels, etc., and the restrictions imposed by the distribution system through which the product must travel.

The third area to be considered has been the point of intervention. As you have seen in the case of project Antar, the invervention point chosen was at the manufacturing site in the flour mill. The closer you can get to a large scale manufacturing operation with the fortification intervention, the easier the whole program will be, and the more assured you will be of having a proper level of fortification in the finished food.

Another area of consideration has been that of techniques of fortification. Dry tablets, liquid sprays, packets enclosed in the consumer package and dry powder addition in the manufacturing process have been discussed. Finally, we have discussed the quality assurance programs that might be necessary when

running a fortification program. Again, the larger the scale on which the entire operation can be conducted and the simpler it can be kept in terms of steps in the operation, the less expensive it will be to operate and the more assured you will be of having the finished food product that you planned on.

IV. THE COSTS OF FORTIFICATION

Introduction

The ANTAR program is designed to measure benefits of fortification of wheat. Other programs will undoubtedly be conducted in other countries to further document the amount of benefits from these approaches to nutrition improvement.

Governments and the people of these countries correctly ask, "How much does it cost to obtain these benefits?" It is a communication that crosses all language difficulty. Resources are scarce in all countries. Other programs, even other nutrition programs, "need" more money -- resources. And, choices need to be made.

One can be very specific regarding some costs because of the nature of the items involved. On others it is not possible to be specific. The costs vary widely among countries and are not known.

This session will focus on (1) direct costs -- ingredients and machinery required for fortifying wheat products, (2) other costs of fortification programs, and (3) who pays?

A. Direct Costs of Fortification

by Mr. Paul R. Crowley, Director
Nutrition and Agribusiness Group
Economic Research Service
U.S. Dept. of Agriculture

The direct costs considered were made up of ingredient costs and processing costs. And for the sake of simplification, only the major cost factors in these categories were examined.

Costs of fortificants vary significantly with the types and amounts of fortification used, and these in turn vary with the particular dietary deficiencies occuring in the target groups and the amount of food sample consumed. Generalizations, then, regarding costs are not really meaningful. Nevertheless, for illustrative purposes, three sets of conditions were assumed and the direct costs of fortification estimated.

In all three cases, it was assumed that the target population received one-half of its RDA (Recommended Dietary Allowance) of calories from wheat, and that the RDAs of other nutrients and the price of the nutrients were as listed, respectively, in Tables I and II that follow. It was also assumed that the levels of fortification are based on requirements for the individuals needing the maximum proportion of each nutrient. (E.g., the level of lysine was based on the requirement for lysine in the diets of infants rather than of adults.)

Costs of Vitamins and Minerals. It was assumed that one-half of the RDA for Vitamin A, thiamine, niacin and riboflavin should be supplied. For the nutrients only, costs would be about U.S. $0.70 per ton of wheat. In addition, approximately U.S. $0.70 (for 100% of ingredients) should be allowed for manufacture, distribution and sales of vitamin/mineral premixes, and another U.S. $0.70

(50% of premix) should be allowed for import duties, taxes and clearing and forwarding charges. Total costs, therefore, were estimated to be about U.S. $2.00 per ton of wheat. Obviously, costs could be reduced if fewer vitamins and minerals, and smaller amounts, were used; costs could also be greater. It was estimated that the range of direct costs would be from U.S. $0.50 - 4.00 per ton of wheat.

Costs of Lysine. It was assumed that one-third of the RDA for lysine should be supplied, and that lysine would have to be imported, with charges for duties, taxes and other handling charges; amounting to 50% of materials costs. These costs were estimated to be U.S. $10 per ton. The required lysine level was estimated to be about 0.2%. Again the costs would vary depending on the lysine level and the amount of duties and taxes paid. The range of lysine costs was thus estimated to be from U.S. $5-15 per ton of wheat.

Costs of Protein Fortification. If instead of lysine fortification, protein in the form of soy flour (52% protein) were used, and if one-third of the RDA were supplied, the cost for soy flour would be U.S. $43. per ton. This level of fortification represents a 12% substitution for wheat, and therefore a credit of U.S. $23 was estimated for savings on wheat and the cost of the fortificant reduced to only U.S. $23 per ton. Savings resulting from this kind of substitution depend very much on the relative costs of the product to be fortified and of the fortificant. When the two materials cost the same (as has been the case with wheat flour and soy flour in Brazil before 1973) fortification direct costs can be zero.

NUTRIENT COSTS

	Unit cost 1/	Annual requirement 100% RDA (kg.)			Annual cost 100% RDA (U.S. $)		
	(US $/kg)	Infant	Male	Female	Infant	Male	Female
Energy (3300/kg.).....	0.20	100	311	222	20	62	44
Protein (52% as soybean flour).....	0.40	11.2	45.6	38.6	4.48	18.2	15.4
Lysine.....	3.00	0.34	0.31	0.26	1.02	0.93	0.78
Vitamin A (250 M IU)..	12.50	.0022	.0073	.0073	0.028	0.091	0.091
Niacin.....	4.50	0.0039	0.0066	.0047	0.012	0.030	0.021
Riboflavin.....	30.00	.00022	.00062	.00055	0.007	0.019	0.017
Thiamin.....	20.00	.00018	.00051	.00037	0.004	0.010	0.007
Iron (reduced).....	0.75	.0055	.0037	.0066	0.004	0.003	0.005

1/ Approximate Costs August 1973.

RECOMMENDED DIETARY ALLOWANCES (RDA) 1/

Daily Nutrient	Infant (½-1 yr.)	Adult Male (22-35 Yrs.)	Adult Female (22-35 yrs.)
Energy (keal)	900	2800	2000
Protein (g.)	16	65	55
Lysine (mg.) 2/	930	840	700
Vitamin A(IU)	1500	5000	5000
Niacin (mg.)	8	18	13
Riboflavin (mg.)	0.6	1.7	1.5
Thiamin (mg.)	0.5	1.4	1.0
Iron (mg.)	15	10	18

1/ Except as noted, figures are from Recommended Dietary Allowances, National Academy of Sciences Publication 1694, Washington, D.C. 1968--Based on body weights of 70, 58, and 9 kg. for adult males, adult females, and infants respectively.

2/ Energy and Protein Requirements, FAO, Rome 1973.

Equipment Costs. (Mr. Robert Wooden, Pillsbury Company, provided the following note on costs of fortification equipment).

One feeder is required for each type of final product and each feeder produces a maximum of three tons per hour. The cost for the type of machinery used in Tunisian mills for adding lysine and nutrients is $1,000 per feeder plus spare parts estimate on each of $200.

B. Examples of Costs of Fortification with Soy

by Dr. William Hoover, Director
Grain Science Institute
Kansas State University

Following are the costs of raw flours and the dough condition sodium stearoly-2 lactylate (SSL) (cost of delivered goods in Kansas City):

	Normal	Now
Wheat flour per hundredwt.	$5.85	$11
Soy flour per hundredwt.	7.33	17
SSL per lb*	.56	.49

* .5% used.

When these flours are baked as breads, biscuits, cookies, etc., there are important offsetting aspects in costs which occur when soya flour is used with wheat flour in 12 to 88 blended ratio. The ingredients of most breads include: 100 parts flour; 6 sugar; 3 shortening; 2 salt; 1½ yeast; 3 NFDM. When 12% soy flour is used, there is a 6-7% increase in water absorption and therefore in bread yield. With SSL, the shortening can be omitted. With these two offsetting factors, fortified bread can be made at the same, or at a lower, price than normal bread.

Most cookie recipes call for 28% shortening. Soy-fortified cookies require only 22% or less of shortening. The offsetting costs more than pay for the fortification costs. And even with breads where savings on reduced shortening cannot be assumed, the savings on wet dough yield can cover the difference.

The Nutrabun program in the Philippines, by using soy-fortified flour, saved $.01 per child per day. In the U.S. the school lunch program feeding 25

million children in the past has required that 2 oz. (56 grams) of meat be included in the meal. Now that use of an alternate protein has been approved, it is possible, with soy fortified bread to use two pieces of bread and only 46 grams of meat, and save $.01 per child per day.

There are several countries marketing soy fortified flour, including Taiwan and Venezuela. Soy seeds can be imported, and processing plants established.

C. Other Costs and Who Pays

by Dr. Lyle Schertz, Deputy Administrator, Economic Research Service, U.S. Dept. of Agriculture

Other Costs

The direct costs of fortification programs have already been identified -- the costs for ingredients and machines for adding the ingredients. There are other costs which must be anticipated and among them are:

Quality Control: The real cost of quality control associated with a fortification program in any specific country will vary. We could estimate the cost of buildings, equipment, and technicians. But, such cost estimates would likely be irrelevant to specific country situations. We all have varying amounts of laboratories, equipment and technicians. In some cases quality control of a fortification program could be easily absorbed by present facilities. In other cases, additional laboratories, equipment, and technicians would be needed.

Administration and Management: Some of the same considerations apply to this area. In many countries government officials and private industry already have responsibilities for this type of activity and no additional government or private resources would be needed for administration and management. In other cases, this would not be the case.

Surveys and Evaluation: Surveys and evaluations are important as a basis for deciding on levels of fortification, selecting target groups, structuring of programs, monitoring operations of the programs and appraising the effects of the program. While not costly, especially in relation to the influence they can have on the efficiency of program activities and in terms of enhancing support for the programs, they are often overlooked.

Education and Publicity: This activity may often be overlooked when planning a program. It should not be. Education of recipients, the public, industry and government officials is important. The cost, of course, will vary with facilities, size of program and the like.

Distribution: In an optimal situation, there would not be any additional costs for distribution of fortified materials. The products would be handled in the same manner as unfortified products and the market system, private or government, would find the same incentives for distributing it to the target groups as they do unfortified products. But, this may not be the case, especially if plans call for the fortified product to reach a very specific small group. Monitoring and steps for identification would be required to insure that it reached the target groups rather than other groups.

Policy and Programs: Most people would not add this item to the list. I include it simply to remind all of us that fortification programs, as most all programs designed to improve nutrition, have required a great deal of effort by many people in order to obtain favorable decisions by political bodies and to obtain sound decisions regarding program implementation. It is not an easy task and we should not forget the resource requirement to give rise to related policies and programs.

I want to introduce one other concept of costs. It is related to benefits and in a sense is very much related to other nutrition programs, as well as fortification programs. It is, "what is the cost of not implementing the programs?" And of course, you specify these in terms such as:

- Less physical and mental growth
- Disease
- Medical
- Nutrients not utilized
- Less productivity

Measurement of these is the purpose of projects such as ANTAR. Their estimation is important especially for international financing and obtaining political program and policy decisions to support nutrition improvement.

Who Pays

If there are to be fortification programs, someone must pay -- individual consumers, governments, and international assistance.

The willingness of an individual to pay for fortified products depends on whether he thinks he is getting his money's worth. Unfortunately, history supports the idea that man places major emphasis on palatability rather than nutrition.

One of the great virtues of fortification is that traditional foods are not changed in appearance or taste. Inability to distinguish fortified flour from unfortified flour has merit in terms of fitting existing consumption patterns, for example. But, this virtue can also be a disadvantage in getting the consumer to pay a somewhat higher price for a fortified product which is indistinguishable from an available unfortified product. This difficulty is further compounded if the regulations of markets are such that consumers cannot be certain that a product represented as being fortified is, in fact, fortified.

In some circumstances it may be possible to pre-empt the choice of the consumer. The effect of this course depends on the degree of central direction given by the government and the portion of consumption that enters into marketing channels

in significant volume. Government rules can naturally affect how large mills are operated. But, they can have little effect on small mills in small villages. In a limited number of cases, private companies may find it advantageous to either make fortified foods available to their workers with the workers paying for the improved nutrition, or pay for the improved nutrition directly with the expectation that the costs are more than offset by the increased productivity. Governments may, of course, pay for fortification materials and provide it to processors for inclusion in products. They might also distribute fortification materials to consumers at zero or low costs. The effect on individuals would depend on the tax structure of the country and related fiscal programs of the government.

I am intrigued by a possible approach whereby the rich would pay for fortified products purchased by the poor in the market. One way of course, is through the government funds covering the costs of fortification with progressive income and wealth taxes. But might an alternative be utilized which is akin to a practice in the United States whereby similar or identical products are priced differently by selling firms because the nature of the demand by groups of consumers differ? The classic example is the price of children's tickets for movies -- they are less than the price of adult tickets to the same movies.

Thus, I ask--Is there some way to arrange for mills to grind a high extraction flour (white flour) and a low extraction flour (atta)? The atta flour is considered an economically lower quality product and is usually priced below white flour. Therefore, why not fortify it, but price it below the white flour price and in fact, price the white flour sufficiently high to cover the cost of fortifying the atta. The viability of this approach or any other, for that matter, depends greatly on economic relationships and political considerations of the particular markets and countries.

International assistance is now carrying the costs of fortification in selected food programs. It is important to recognize that the receiving countries have an extremely important role in deciding if to request fortified products. In practice, the costs of the inclusion of fortified products in an international program will involve a "sharing" of the costs of the fortification. Limits on food availabilities will likely result in the programs including smaller quantities of food if products are fortified than if they are unfortified simply because their total cost in the donor countries will be higher. It is important for the receiving countries to consider this quality/quantity trade-off when deciding on the specifications of commodities to be received.

V. ALTERNATE TECHNIQUES FOR IMPROVING THE NUTRITIONAL QUALITY OF WHEAT

A. Genetic Improvement of Protein in Wheat Varieties

by Professor Paul Mattern
Food Science and Technology
University of Nebraska

There follows a description of the characteristics and status of the work in wheat breeding research which was initiated in 1954 at the University of Nebraska in cooperation with the U.S. Department of Agriculture.

(1) Background

One genetic source for high protein was available in 1954. By 1962 lines containing 20-25% more protein were available with normal yield potential. In 1966 with USAID support the University of Nebraska undertook the examination of 20,000 wheat varieties to identify additional sources of high protein and/or high lysine. As lines with improved protein were identified, they were incorporated into a breeding effort by hybridization with suitable agronomic types.

(2) Conclusions and Status of Research

a) Protein increases need not be associated with decreased yields.

b) A gene with the large effect of the opaque-2 gene in maize has not been found in hexaploid or tetraploid wheats. However, genetic differences in lysine that are believed to be sufficiently large to be useful in wheat breeding programs have been detected.

c) Combinations of genes for high protein and/or lysine have produced additive effects resulting in recovery of lines with very high protein and/or lysine. Efforts to combine additional gene sources continues.

d) Lines and populations that possess excellent nutritional potential combined with desirable agronomic traits are available from the Nebraska program.

e) Nebraska is developing a high protein variety with good baking quality and high yield potential for possible release in 1974.

B. Soy-Fortified Flour (SFF)

by Dr. William Hoover, Director
Food and Feed Grains Institute
Kansas State University

Background.

First it was demonstrated that bread made with SFF (12% soy-fortified wheat flour plus vitamins and minerals) when fed to rats instead of normal bread, had a very favorable effect on growth rate.

But the soy-fortified bread did not look like normal bread. (Except for shortening, any added ingredient to bread changes its character.) Finally it was discovered, thus far for unexplained reasons, that the addition of .5% sodium stearoyl-2-lactylate (SSL) to soy-wheat flour mix produced a bread with the same appearance and characteristics of those of normal bread. Incidentally soy was used for the protein source in the fortified bread because it was the only available choice.

The fortificants are added by means of a mechanical feeder to the mill stream during the milling operation.

Uses of SFF.

All types of national breads, leavened and unleavened, can be made with the fortified mix. Cookies, which will take more soy flour than bread without losing desirable characteristics, become nutritious foods. Noodles and other pasta products with 12% soy are now being marketed in Taiwan. The mixed flours are also being used for sauce and gravy bases. 200 million pounds of SFF are to be distributed this year. India and the Philippines, notably, are using the mix in programs. There is interest in having a pre-mix which could be added at the mills in the different countries and brought into commercial channels.

Positive Characteristics of Breads made with SFF.

There is a 6-7% increase in bread yield caused by an increased level of water absorption which is easily recognized as the one where the dough "feels right". Mixing time is less (the usual 5.5 minutes may be reduced to 3 minutes) and in a large bakery, this will mean increased productivity; in the home, it leaves little likelihood of undermixing. Shelf life is essentially the same as that of normal flour breads. And depending on the type, because of the emulsifying system and the extra water, the soy itself adds better keeping qualities. This could be especially useful in distributions that must be made in the country far from bakeries.

Discussion.

Flours of higher extraction rate have been used, such as atta.

Peanut flour is not an alternative protein source for adding to wheat flour because it is poor in lysine. There is, however, a variety of cottonseed protein concentrate, free of gossypol, which is now being produced and looks like a very promising source.

There is no toxicity risk in the use of SSL.

C. Other Fortification Programs.

Fortification field trials under way in Thailand (rice with lysine and threonine) in Guatemala (corn with lysine and soy flour as tryptophane source) and in Brazil (cassava with methionine addition to improve beans as diet staple) differ from the Tunisian program in that they do not rely on central milling. Every village has at lease one rice or corn or cassava mill, which may serve as the intervention point for adding fortificants. Such an intervention point exists somewhere between the producer and the consumer in most parts of the world.

There are also options of scope -- whether all cereals will be fortified or only a portion of the supply to meet special needs, such as school lunch and institutional programs.

Some examples of fortification programs in countries represented at this meeting are the following:

Pakistan — Namet Ilahi, Nasin Jafri

The results of a nutrition survey completed in 1970 revealed caloric deficiencies to be most serious problem - 1806 per capita compared with the recommended 2350. The poorer groups and particularly the 6-24 months old group were most deficient, the latter receiving less than 65% of needs. Protein was generally adequate: 58 grams for the urban population, 68 for rural areas. And there were Vitamin A and iron deficiencies. Attempts were made to identify commodities to fortify in the urban area--tea with Vitamin A, atta with Vitamins A&B, riboflavin, iron and iodine. The project is channelled through the 147 mills in cities where conditions are most severe. The fortification

tests of tea with Vitamin A are encouraging. A nutrition working group of all the related disciplines operates from within the Planning Commission.

Brazil — Alceu De Castro Romeu

A small fortification project to add lysine to wheat was attempted but costs for the fortified product were 12.8% above costs for the unfortified product. It is not known at this time which people need protein and indicators are needed for determining the need for lysine fortification. At the moment, it is felt that all of the wheat supply would have to be fortified to reach the needy and that the costs would be too high.

Colombia — Maria Aguirre Garcia
Teresa Salazar de Buckle

Assisted by the Dutch Government. Colombia undertook a 1½ year bread project. After considering various cereals, including corn, yucca and sorghum, rice was chosen as the cereal to be fortified. Production of rice has doubled, while there has been little change in other cereal yields. A French-type bread was made for distribution through bakeries, using 27 parts of rice flour, 3 of soya, 5.1 of CSM and wheat flour. It was found to be highly acceptable, but economically not too hopeful. However, wheat prices were excessive; at $80 a ton, it would be economically feasible. Technical problems include training millers to make the rice flour.

Discussion. Risks and guesses often have to be taken. Needs of lower income groups can be estimated and this could be more meaningful than determination of means. There are differences in lysine requirements, between growing children and adults. Perhaps one half of population would need lysine.

It is important to consider the least expensive answers that do not take from land resources and which improve the protein that is being eaten.

VI. WORKSHOP RECOMMENDATIONS

I. How Should Fortification Costs Be Met?

A. Discussion

1. Capital costs for most fortification projects are low enough to be ignored for the purposes of this group. They can be worked out on a project-by-project basis.

2. International agencies and donor countries should fortify all wheat products which they export to LDCs.

3. There is no one solution to this question, but rather a combination of several.

B. Recommendations.

1. Developing country governments must be very firmly committed to improved nutrition via fortification. This point cannot be overemphasized.

a. Governments must follow the commitment by decree and regulations that all flour be fortified.

b. Governments can decree by regulation that certain flour for controlled distribution, i.e., school lunch programs, prison meals, Food for Work payments, etc. be fortified.

2. Many developing country governments currently subsidize part of the cost of flour as a method of price control. This subsidy could be extended to cover fortification costs.

3. Consumers might agree to pay more for the nutritionally-improved product but the odds are strongly against this solution, particularly if a choice of quality and price of flour is available.

4. Governments must be willing to sacrifice, perhaps, part of the funds for some other program (e.g., roadbuilding or housing construction) in order to pay for fortification.

5. Governments can eliminate or at least lower import duties on nutrients and make up for it by raising them on non-nutritious food items or luxury items.

6. At least at the stage of getting a program started and moving it well along, it is most important to have help from international agencies. This is especially important in countries which must import the fortificants because of balance of payment and hard currency problems. Much of the cost of planning and background research costs can be or have been borne by international agencies.

7. Millers must be willing to cooperate with this program, at least insofar as accepting the added inconvenience and problems in their mills.

C. Summary.

In the final analysis, people are going to pay for fortification--people who are taxpayers of the LDC government, people who are taxpayers supporting international agencies, and people perhaps who buy the fortified wheat products. This payment will be made only, however, under the financial management of: 1) LDC governments; 2) international agencies; and 3) LDC food industry working as a closely knit team toward the common goal of target group nutrition improvement via fortification.

II. Required Actions for Introducing a Fortification Program

A. Discussion.

1. Fortification is one of the possible ways to help reduce specific nutritional deficiencies and, in any case, fortification should be part of an overall food and nutrition plan.

2. Where lacking, nutritional planning bodies should be established above Ministerial level, and where existing and when necessary, be empowered, to formulate and assist in implementing nutritional policies for the government, deciding on alternatives, including fortification. Where a food and nutrition policy exists, all programs should be within that framework.

3. The eventual publicity needed to ensure and encourage the consumption of fortified food should be based upon correct and broad health education, including nutrition education, and be supervised by authorized bodies.

4. Constant attention should be given to the prime objective of reaching the normally recognized target recipient group of any food and nutrition program.

B. Recommendations.

1. The nation's food and nutrition problem must first be assessed, using all available data, and preferably using nutrition systems analysis methodology. Such assessments must be repeated on a regular basis in order to make the necessary evaluation.

2. Complementary ways to fulfill nutritional needs must then be determined, including the route of fortification when it is desirable and feasible.

3. Next, food standards must be established and necessary modifications of food regulations made to make possible the implementation of a fortification program.

4. Field trials must then be carried out as necessary, depending on the status of worldwide and country knowledge and experience with fortification work.

5. Simultaneous with field trials, intensified efforts must be undertaken to obtain and increase maximum and meaningful support from the government and private sector for mounting larger scale fortification programs (if justified by field trial experience) and the necessary nutrition education for ensuring success of the program.

6. Full-scale programs should then be undertaken, through the education of malnourished economically well-off people and the subsidized distribution of fortified foods to low-income target groups through either institutional distribution or government-controlled marketing channels.

III. Role of the Private Sector and the Government in Promoting Fortification

A. Government

1. Discussion of Major Functions

a. Determine the state of nutritional health of the population for vulnerable segments, the cause of malnutrition, and the need of those segments for supplementary nutrients.

b. Determine which of the nutritional needs have higher priority.

c. Examine alternative means of attacking these problems to determine which ones are preferred.

2. Recommendations
(Where fortification is selected as preferred intervention means)

a. Demonstrate that fortification would have a significant impact, for example, by:

1. implementing a small-scale or pilot project;
2. evaluating the small-scale project to demonstrate that it has functioned properly

b. Implement fortification on a full scale, by:

1. setting standards and providing laws and regulations for foods to be fortified and levels of fortification.

2. monitoring, controlling, and enforcing fortification.

3. educating consumers, doctors, nutritionists and others concerning the benefits of fortification.
4. coordinating the activities of government and industry.
5. determining the preferred means of financing fortification, and if government subsidies or other funding is selected, arrange for such financing.

c. Evaluating the effectiveness of the whole program

B. <u>Private Sector</u>

Recommendations.

a. Manufacture and distribute fortified foods. (In certain cases, governments might take this manufacturing role.)

b. Cooperate with government by:

1. Advising on research, technology, and administrative matters.

2. Undertaking educational or promotional activities complementary to those of government (e.g., by appropriate educational statement in package labelling.)

IV. Establishing, Monitoring and Enforcing Fortification Standards

A. Discussion.

1. Staple foods consumed by the masses are the logical ones to fortify, e.g., wheat in Chile, Morocco, Tunisia, Turkey, rice in Indonesia, etc.

2. Lysine should be added to cereal staple foods to improve the quality of their proteins, providing the results of Project Antar so demonstrate. Riboflavin should be added as it would need to be supplemented when milk is not consumed in adequate quantities, which would be the case in most of the developing countries. Furthermore, it is not expensive. Vitamins A and D are expensive, therefore, they should only be added when rickets and xerophthalmia are observed. Both Indonesia and Bangladesh would need supplementation of A rather than D.

B. Recommendations.

1. Producing nutrient premixes and establishing standard methods of characterization of added nutrients:

a. The production of nutrient premixes should be carried out locally to ensure their availability and to avoid duties and possible delay involved in importation.

b. Any existing laboratory--governmental, industrial, or even a university laboratory--could be modified to produce these premixes.

c. The search for an analytical standard method for characterizing different nutrients should develop methods that are reliable, selective, sensitive, rapid, simple, and which do not require expensive or unusual equipment.

d. From the available procedures, perhaps the best method for determining the available lysine is the Carpenter and Hegsted method (developed at the Harvard University School of Public Health).

e. When an accurately prepared premix includes more than one nutrient, the simplest analysis for any nutrient of the premix would constitute the desirable test, e.g. the slick test of riboflavin.

2. Quality Control.

a. Production control is achieved by adjusting the feeding rate of premixes hourly according to the mill capacity.

b. When mills do not have individual laboratories, there should be a regional laboratory for a group of mills to assure the accurate addition of the desired levels of nutrients. Checks should be made daily.

c. Governmental control should be assured by nonregular unannounced checks to ensure that mills are producing at the desired levels of fortification. Inspections should be made at least twice monthly at each mill.

3. The enforcement of standards might be voluntary or government-controlled. While voluntary enforcement works in advance societies such as the U.S., it might not be effective in some of the developing countries, at least not in the near future. Thus, the governmental type of control is essential, at least in the beginning, and it might well become voluntary after the public and the millers have become aware of the importance and necessity of fortification.

There should be free distribution of premixes by governmental agencies to each mill, based on its capacity, so that the miller is not tempted to make a profit by adding smaller concentrations of premixes.

Publicity should be given to the best and worst mills. Boycotting the worst temporarily and rewarding the best would advance the desirable adoption of voluntary enforcement of standards.

VII. CONCLUSIONS AND CLOSE OF WORKSHOP

A. Summary of Workshop Conclusions.

Even if fortification is not imminent in a country, its general consideration should be within proper perspective:

- Fortification should be part of an overall food and nutrition plan;
- Implementing bodies should exist to determine status of nutrition requirements and the alternative courses for meeting them, including the improvement of the wheat supply of a population.

And if fortification is to be seriously considered:

- Responsibilities should be distributed between industry and government as follows:

Government	Private Industry
Learn nature, extent and cause of problem. Establish priorities.	Manufacture and distribute fortified foods. Cooperate with government, particularly on advertising, research and administration
Select alternative means of solution. Demonstrate that selected alternatives work. Take responsibility for coordinating government and industry roles. Educate specific community as well as general community Make evaluations. Establish and enforce standards.	Undertake educational activities to complement government activities - e.g. labelling.

- Costs will have to be met:

Initial costs are small and not much of an issue (2-10% of total costs).

While consumers pay the final bill, the consumer who is expected to buy the fortified food will have to pay more for it, and it would be government's role to provide incentives for such purchases.

- A series of steps have to be taken, which can be viewed in retrospect:

Increased interest and technological breakthroughs brought about serious consideration of the use of amino acids. (Fortification had been in existence for a long time, but fortification with amino acids was new.);

The use of amino acids was seen to correct protein deficiencies;

Animal studies were carried out and when nutritional impact on animals was confirmed, tests were done on human subjects;

Small-scale fortification projects were then undertaken, to test larger scale applicability. During this stage, it has been noted that the technological problems are relatively easy to work out. The modification of mills, e.g. is fairly simple, cheap, and much of the trial work is transferable. The Antar project does not give clear results yet, but even after one year of fortified feeding, there are slight trends of improvement which could continue to increase (or not). We should be at a point for consideration of policy decisions now.

B. Where to Now.

Perhaps other tests need to be undertaken. Some might look at commercial aspects of feasibility, and there is a variety of other levels that would benefit from field trials. These will probably require some form of international assistance.

Programs that might merit loan or grant assistance from international and other bodies -- e.g. grants for fortificants or loans for equipment and

local production of fortificants can be developed. A.I.D. would assist in advising on solution of problems.

Perhaps after two years, a group similar to the present one should meet to compare progress.

The Tunisian Institute of Nutrition is committed to completing a project in Tunisia and hopes it will be useful in other countries later.

APPENDIX A

AGENDA - WHEAT FORTIFICATION WORKSHOP - TUNIS

September 10-14, 1973

Monday, September 10

Morning	Chairman, Professor Agrege Dr. Zouhair Kallal Director, Tunisian National Institute of Nutrition and Food Technology
8:00-9:00	Registration
9:00	(1) Welcome speech: Mr. Hedi Khefacha Minister of Public Health (Acting) (2) Welcome speech: Talcott W. Seelye U.S. Ambassador to Tunisia
10:00	Keynote speech by Dr. Kallal "Rationale for Wheat Fortification"
10:30	Dr. Martin J. Forman, Director, Office of Nutrition, U.S. Agency for International Development Workshop Purpose
11:00	Tour of new building of the Tunisian National Institute of Nutrition and Food Technology
Afternoon 3:00	Tour of Fortification Flour Mill (S.T.IM. Megrine-Coteaux) and the Laboratory of the Lysine Fortification Project.

Tuesday, September 11

8:30	Chairman: Dr. Habib Rejeb Tunisian National Institute of Nutrition and Food Technology Co-Chairman: Dr. Aaron Altschul, Professor (Nutrition) Department of Community Medicine and International Health Georgetown University School of Medicine, Washington,D.C.

A. Health improvement via fortification.
B. An overview of Project Antar.
C. Mechanics of Fortification.

a. What can be fortified?
b. Potential fortificants.
c. Intervention points.
d. Techniques.
e. Monitoring.

D. Target groups, extent of coverage and special opportunities

Wednesday, September 12

Morning

Chairman: Mr. Tahar Jaouadi
Tunisian National Institute of Nutrition and Food Technology

Co-Chairman: Dr. Lyle Schertz, Deputy Administrator Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

A. Costs of Fortification

1. Direct Costs
2. Indirect Costs
3. Who pays

B. Alternate techniques for improving wheat quality

C. Other fortification projects.

Afternoon

2:30

Work Groups Meet

Work group assignments will be made at the beginning of the workshop. All participants will be members of a group assigned a given topic. Topics to be addressed include the following:

1. How should cost of fortification be met?
Chairman: Mr. Tahar Jaouadi, Tunisian National Institute of Nutrition
Secretary: Mr. Robert Wooden, Pillsbury Milling Company

2. What are the required actions for introducing a fortification program?
Chairman: Dr. Habib Rejeb, Tunisian National Institute of Nutrition
Secretary: Mrs. Joyce King, U.S. Agency for International Development.

3. What is the role of the private sector and the government in promoting fortification?
Chairman: Dr. A. Dziri, Tunisian Institute of Nutrition
Secretary: Mr. Rod Corwley, U.S. Department of Agriculture.

4. How can fortification standards be established, monitored and enforced?
Chairman: Dr. Fred Stare, Harvard University
Secretary: Dr. M.T. El Ghamry, Harvard Univ.

The work groups will meet at their convenience. The Wednesday afternoon session will supplement the planary sessions and provide an opportunity to consolidate thinking.

A draft summary will be prepared by each group on their own time on Wednesday and/or Thursday.

Thursday, September 13

6:00 a.m.	Depart from Tunis Hilton hotel. All day visit to Kebili. This will afford opportunity to observe villages, field operations, and obtain in-depth description of Project Antar.

Friday, September 14

9:00-11:00	A. Present "Work Group" conclusions at planary session
	B. Wrap-up session - Dr. M. J. Forman
	1. Where do we go from here? 2. Follow-up plans.
11:30	Return to Tunis

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