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PROGRESS REPORT NO. 4

Improving the Nutritive Value of Cereal Based Foods

Agency for International Development

Contract No. AID/csd - 1586

CONTRACTOR

The Food and Feed Grain Institute
Kansas State University
Manhattan, Kansas 66506

Submitted June 1, 1972, covering period January - December, 1971.

IMPROVING THE NUTRITIVE VALUE OF CEREAL BASED FOODS

Progress Report No. 4

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Improving the Nutritive Value of Cereal Based Foods

AID/csd - 1586

Report Summary

A. 1. Improving the nutritive value of cereal based foods.
AID/csd - 1586

2. Dr. William J. Hoover, Principal Investigator

Contractor: Kansas State University
Food and Feed Grain Institute
Shellenberger Hall
Manhattan, Kansas 66502

3. Contract Period (as amended): June 30, 1967 to June 29, 1973

4. Period covered by Report: January 1, 1971 to January 1, 1972

5. Total A.I.D. funding of contract to date: $615,2[illegible]

6. Total expenditures and obligations through previous contract year -- $136,348

7. Total expenditures and obligations for current year: $170,338

8. Estimated expenditures for next contract year: $186,000

B. Narrative Summary of Accomplishments and Utilization

Development of protein fortified wheat based bread, chapatis, and couscous using soy flour, chickpea flour, and broadbean flour has been accomplished. The products meet the nutritive guidelines established by the project and have proven acceptable to small consumer panels. Field consumer testing evaluations to be carried out in Morocco and Pakistan have been planned. Final marketing potential and operational significance are yet to be determined.

Many other protein resource materials have been evaluated and the results will provide guidance to researchers and industrial concerns worldwide on the use of these materials in the development of various types of protein fortified foods.

A system of developing and evaluating protein fortified foods has been evolved which should prove to be a valuable procedure for future research work in this field.

The inclusion of soy fortified wheat flour products in P.L. 480 Title I and II programs based on products demonstrated in this project is currently under consideration.

Improving the Nutritive Value of Cereal Based Foods

AID/csd - 1586

ANNUAL RESEARCH REPORT

A. General Background

Although research and product development work on nutritionally improved infant foods or gruels or beverages was under way in the mid-1960's, there was a dearth of information regarding the protein improvement of cereal based foods in the form in which they were traditionally consumed. A basic study was initiated to evaluate the physical, chemical, nutritional and functional properties of all protein resource materials available as potential fortifying agents for cereal based foods. While the implications of this research have worldwide application, the project was given the practical parameters of working, as demonstration foods, with the breadstuffs of North Africa and Pakistan, i.e., bread, couscous, and chapatis.

B. Statement of Project Objectives as Stated in the Contract

The general objective of this research project is to improve the nutritional value of cereal based foods in North Africa and Pakistan by supplementation and process modification without decreasing the food acceptability to the general consuming public in those areas.

C. Continued Relevance of Objectives

Information gathered during the survey phase of the project indicated a lesser emphasis on process modification of wheat milling methods for increased use of wheat millfeeds than had

been planned and thus investigations in this area have been limited. The dietary importance of couscous in North Africa was found to be of secondary importance to that of bread. In the latter stages of the research and in the field testing phase, much more emphasis is being given to bread than to couscous.

D. Accomplishments to Date

1. Specific Objectives for 1971

a. Complete arrangements for field testing of fortified bread and couscous in Morocco and of fortified chapatis in Pakistan.

b. Continue basic nutrient requirement and nutrient availability studies.

c. Complete nutritional evaluation of products developed in 1970.

d. Continue product development and evaluation.

e. Initiate studies on the production of protein concentrates from chickpeas and broadbeans.

f. Apply knowledge gained by project to other protein resource materials.

g. Initiate studies on other cereal based foods.

2. Report of Progress in 1971

Field testing of fortified products

Morocco -- Early in 1971, high protein Moroccan bread was successfully prepared in a bakery which provides, under contract, bread for the school lunch program in Morocco. The fortified bread was evaluated by officials of the Ministry of Health, Ministry of Agriculture, and Ministry of Education of the Government of Morocco

and by personnel of the Catholic Relief Service and U. S. A. I. D. A limited amount of soy fortified bread flour was baked into bread and tested on a short term basis by school children. It was enthusiastically accepted by all of these persons.

Tentative plans were made for a month-long acceptability test in several schools in November, 1971. The fortified flour was to be obtained through regular Food for Peace channels. Unfortunately, a specification for this product has not yet been established and the test program has not been accomplished.

Morocco has no governmental or institutional programs involving couscous. Thus, we have dealt with commercial manufacturers as potential test marketers in the retail marketplace. Two companies have expressed interest in evaluating the product. One company has evaluated the fortified couscous and found it acceptable for trial marketing. This same company has processed a small amount of the product and found it adaptable to their production techniques.

The company would be willing to test market the product under its own brand name provided: (1) the high protein flour (soy, chickpea, or broadbean) would be supplied to them; (2) the Government of Morocco would assist in advertising the value of the more nutritious couscous; (3) assistance in evaluating the results of the test marketing program would be provided under the program.

A basic decision was made at the annual project

review in February, 1972 not to proceed with the commercial market testing of fortified couscous.

Pakistan -- In September, 1971 a plan was developed for test marketing protein fortified chapati products in the area of Lyallpur, West Pakistan by cooperating with the West Pakistan Agricultural University on a joint venture. The final plans for a May, 1972 test have been evolved for approval by West Pakistan Agricultural University.

3. Research Design

The basic design of the research project is as appropriate at this time as when the project was initiated. Emphasis has shifted generally only as stated in section C. Research findings and relevant economic and political factors have dictated the emphasis given to the specific objectives in 1972.

E. Dissemination and Utilization of Research Results

1. Interest in the results of this project remain high and efforts have been made to quickly disseminate project findings through traditional technical and trade publications, participation in technical meetings, conferences and workshops, correspondence and material exchange, and a large volume of visitors and trainees. These efforts are detailed in the Appendix I.

2. While the use of dough conditioners to produce high quality protein fortified bread was first developed at KSU under an industrial grant, the expanded application of the findings to different breadstuffs and protein materials has been demonstrated under this contract. This work has lead to much interest and testing in the LDC's. It is known to be under evaluation in

Mexico, Guatemala, Colombia, Peru, Venezuela, Curacao, Taiwan, Philippines, Japan, India, Ceylon, Pakistan, Iran, Turkey, Israel, Morocco, Ethiopia, Kenya, Ghana, Norway, Denmark, and England.

Three soy fortified wheat flour products (bread wheat flour + 12% soy flour + dough conditioner, bread wheat flour + 6% soy flour + dough conditioner, and all purpose wheat flour + 6% soy flour + dough conditioner) have been proposed for P.L. 480 Title I and II programs. Final specifications are in preparation. Requests have been made for inclusion of these items in the voluntary agency school lunch programs based on bread or buns in the Philippines and in India. Highly acceptable products meeting the nutritional criteria and providing a substantial cost savings to existing items have been demonstrated.

3. Current interest indicates a needed flexibility in the contract to work, upon request, to adapt the results of this research to other products in other countries. This is indicated in the work plan for 1972, but could necessitate extension of the existing contract or require a new contract by A. I. D. to assure the maximum application of the research findings in LDC's in future years.

4. The field testing phase of the project will involve LDC personnel and institutions both in Morocco and Pakistan. The Moroccan involvement is reported in Section D and details of the evaluation program in Pakistan is given in Appendix I.

F. Statement of Expenditures and Obligations and Contractor Resources

AID/csd - 1586

	Firm Budget	Actual Exp.	Est. Exp.
	4-1-71 3-31-72	4-1-71 2-29-72	3-1-71 3-31-72
Salaries	$99,720	$99,857	$2,808
Equip. & Books	10,000	8,466	--0--
Supplies	5,500	6,157	341
Travel & Trans.	11,000	5,297	308
Other	2,236	2,690	--0--
Overhead	41,882	43,133	1,255
	$170,338	$165,600	$4,712

Firm Budget 4-1-71 to 3-31-72	$170,338
Actual and Estimated Expenditures 4-1-71 to 3-31-72	$170,312
	$ 26

No significant problems or changes in project management were encountered during the year due to budget restrictions.

G. Work Plan and Budget Forecast for Coming Year

Objectives for 1972

1. Accomplish acceptability testing programs and marketing potential projections on bread in Morocco and chapatis in Pakistan.
2. Initiate economic evaluations or cost-benefit studies for for the use of products in applied nutrition programs.
3. Expand use of high protein bread technology to other LDC's through close cooperation with A. I. D. Project Manager.
4. Expand studies to cookies and other traditional cereal based foods.

5. Evaluate additional protein resource materials, i.e., sunflower flour, triticale, fish protein concentrate, sesame, and rapeseed.
6. Limited studies on processing of protein concentrates from legumes (study economics as soon as possible).
7. Limited studies on nutrient availability (effect of processing and natural vs. synthetic nutrients).

Budget for Period 4-1-72 to 3-31-73

Salaries	$116,005
Equipment and Books	8,000
Supplies	2,773
Travel and Transportation	5,632
Other Direct Costs	1,736
Overhead	51,854
	$186,000

APPENDIX I

APPENDIX I

West Pakistan Fortified Roti and Bread Product Acceptability Tests

Purpose:

To determine the acceptability and commercial potential of roti and bread products from protein fortified atta and wheat flour developed by Kansas State University under Contract AID/csd - 1586.

Products to be tested:

1. Roti products from atta fortified with 10% defatted toasted soyflour.
2. Roti products from atta fortified with chickpea flour (level of chickpea flour -- 10, 15, or 20% to be determined by preliminary testing at WPAU).
3. Breakfast buns from Blend K flour (following the tests with products 1 and 2).

Test Program:

Phase 1: The products will be tested at the WPAU hostel with 1,600 students who come from all economic and geographic backgrounds represented in West Pakistan. The fortified atta roti products will be served during a one week period in May, 1972.

The test will be carried out according to the schedule given in Appendix A. The hostels will be divided into three groups. The products will be fed for two days to each hostel. The acceptability forms (Appendix B) will be completed on the second day of consumption of each product tested. On the Thursday preceeding and the Tuesday following the test week, the students will fill out the acceptability forms for their regular chapatis but will not be informed that the product is their regular ration.

In December, 1971, Dr. Sial, Dean, College of Animal Husbandry was to present a series of lectures on the elements and importance of nutrition to the students.

Phase 2: Assuming success in the hostel tests, a second test will be made using the 3,500 members of the faculty and staff families at WPAU. This population represents all economic strata and has been well documented as to food habits by prior studies by the Department of Sociology at WPAU. The families will be given enough fortified atta for family use for 2 days or 4 meals. The acceptability score sheet will be again used, but in addition the families will be interviewed using the consumer reaction form given in Appendix C.

Phase 3: The reaction to and potential use of the fortified products will be measured in selected villages for which WPAU already has good sociological information. This phase would again check acceptability but be aimed at determining the most effective methods of nutritional education prior to product introduction and determining the means of introducing the fortified product into the marketing patterns in the villages.

A decision on the necessity and desirability of Phase 3 will be made after completion of Phases 1 and 2.

Material requirements (Phases 1 and 2 only):

Materials and supplies required in the testing program will be purchased and shipping costs paid from KSU contract AID/csd - 1586 funds.

A. Materials to be shipped from U. S. A.

1. 1,200 lbs. of defatted toasted soyflour
2. 500 lbs. of Blend K protein fortified flour
3. Vitamin and mineral premix (Standard P.L. 480 flour enrichment) sufficient to enrich all test attas
4. 10 lbs. SSL

B. Materials to be obtained in West Pakistan (WPAU will submit invoice to KSU for payment)

1. 22,000 lbs. of atta from Maxipak Wheat
2. 1,200 lbs. of chickpea flour (Sample to be supplied to KSU for evaluation prior to purchase)
3. Sufficient polyethylene bags, labels, etc. to carry out Phase 1 and 2.

Equipment:

A blender for preparation of the fortified attas must be purchased or constructed. The approximate cost of such a blender if purchased in the U. S. is $1,200.

Shipping:

Shipments from the U. S. will be made to:

USAID Mission to Pakistan
Atten: Administrative Officer for Lyl/WSU
Karachi, Pakistan

Shipment should be via United States flag vessel.

The shipping documents should be sent via air mail to:

USAID Mission to Pakistan
Atten: Chief, Agriculture Division
U. S. Mission Building
18 Sixth Avenue, Ramna 5
Islamabad, Pakistan

The following shipping documents are required:

1. Original Bill of Lading - 2 copies
2. Copy B/L - 2 copies
3. Invoice - 3 copies
4. Packing List - 3 copies

Personnel requirements:

1. Kansas State University

One or two KSU faculty members will be in West Pakistan during the test period in May, 1972.

2. West Pakistan Agricultural University

The extent of faculty and staff time necessary is difficult to estimate at this time. Faculty time will be contributed by WPAU, but unusual staff or labor requirements, subject to prior approval by KSU and A.I.D., may be charged to the project.

Protocol for Product Testing

TEST PERIOD

Hostel Group	Monday-Tuesday	Wednesday-Thursday	Friday-Saturday
I	Regular	Soy Fortified	Chickpea Fortified
II	Soy Fortified	Chickpea Fortified	Regular
III	Chickpea Fortified	Regular	Soy Fortified

Chapati Acceptability Test

Class Rank_____ Date_____ Code x y z

	Poor	Fair	Good	Very Good	Excellent
Appearance					
Texture					
Flavor					
Overall Acceptability					

Consumer Reaction Form

Questions for the cook

1. Is test atta different from regular atta? _____yes _____no
   If so, how? _____color _____particle size _____smell _____other
2. Was the dough normal? _____yes _____no If no, how was it
   different? _____too stiff _____too weak _____hard to form
3. Did chapatis cook normally? _____yes _____no If no, how was
   it different? _____cooked too fast _____cooked too slow
   _____did not puff _____did not smell right
4. Did cook tell family chapatis were different? _____yes _____no

Questions for food purchaser

1. Would you eat this chapati regularly? _____yes _____no
2. Is the test chapati _____better than, _____equal to,
   _____poorer than, your regular chapati?
3. How often does your family eat chapatis? _____three times daily
   _____two times daily _____once a day _____two to five times a week
4. Do you buy wheat and have it ground into atta _____at home, or
   _____at a mill? _____always _____sometimes _____never
5. Do you buy atta? _____always _____sometimes _____never
6. Do you buy chapatis from a baker? _____yes _____no If yes,
   how often? _____daily _____more than once a week _____weekly
   _____less than once a week
7. Do you buy nan from a baker? _____yes _____no If yes, how often?
   _____daily _____more than once a week _____weekly
   _____less than once a week

8. If prepared chapatis were available from a baker or grocer, would you buy them? _____yes _____no If yes, how often? _____daily _____more than once a week _____weekly, less than once a week

9. If you buy wheat, have it milled into atta, how much do 10 chapatis cost? _____

10. If you buy atta, how much do 10 chapatis cost? _____

11. If you buy chapatis, how much do 10 cost? _____

12. If you do not buy chapatis, would you buy them precooked if they were available for _____the same price, _____x paises more, _____y paises more than chapatis from purchased atta.

13. If you do not buy chapatis, would you buy them precooked if they were available for _____the same price, _____x paises more, _____y paises more than chapatis from wheat purchased and milled into atta?

14. Carbohydrates and fats are sources of energy. Check which of the following foods are good energy sources:

___meat ___milk ___ghee ___chapatis ___vegetable oil
___chickpeas ___fruits ___vegetables ___sugar ___tea

15. Proteins build strong bodies. Check which of the following foods are good sources of proteins:

___meat ___milk ___ghee ___chapatis ___vegetable oil
___chickpeas ___fruits ___vegetables ___sugar ___tea

16. Would it be good for chapatis to have more protein? _____yes _____no _____don't know

THE CHAPATIS YOU HAVE TESTED HAVE ADDED PROTEIN.

17. If you have wheat milled into atta, would you have the miller add protein to your atta if the protein fortified atta were _____the same price as regular atta, _____x paises more than regular atta, _____y paises more than regular atta?

18. If you buy atta, would you buy atta with added protein if it were available at _____ the same price as regular atta, _____x paises more than regular chapatis, _____y paises more than regular chapatis.

APPENDIX II

Abstracts of Publications Resulting from AID/csd-1586, or Related Work Under the Sponsorship of the Kansas Agricultural Experiment Station, or Industrial Grants with Kansas State University.

Chaudhry, M.S., MacMasters, M.M., Farrell, E.P., and Hoover, W.J.
Experimental Production of Atta

An experimental method was developed for making atta, the coarse flour from which unleavened bread (chapatis) is made in Pakistan and India. Attas of 80% and 95% extraction were prepared from Hard Red Winter, Hard Red Spring, Durum, White Club, Soft Red Winter and Pakistani wheats. Particle size distribution of experimental attas were in the range of that of typical Pakistani attas. Proximate composition and dough characteristics of the experimental attas were determined. A standard method was developed and used to produce chapatis from the experimental attas. The chapatis were evaluated organoleptically by a panel using a scoring system devised for the purpose. All attas except those from Durum wheat yielded satisfactory chapatis. Color apparently is a major factor in determining acceptability; the White Club and Pakistani wheat products were found to be significantly more acceptable than those from any red wheat.

Chaudhry, M.S.,.MacMasters, M.M., and Hoover, W.J.
Nutritional Value of Chapatis with and without Added Lysine.

Rats were fed ground whole wheat, attas of 80% and 95% extraction and chapatis made from them with and without supplementation with vitamins and minerals and with lysine at two levels of supplementation but without supplementary vitamins and minerals. Growth rates and protein efficiency ratios (PER) were evaluated weekly over an eight week period. The PER values were higher for chapatis than for attas from which they were prepared. Supplementation with vitamins and minerals resulted in an increase in PER during the 9 week feeding trial. A similar improved PER resulted during the first four weeks on diets with added lysine but without added vitamins and minerals, but an adverse effect on PER during the second four week period was found using this diet. Livers of rats fed lysine-supplemented diets had lower moisture content and higher protein content than those of the rats on other diets. Fortification of cereal products with lysine in the absence of adequate concurrent fortification with vitamins and minerals may not be of value when the products form essentially the only article of diet as is often true in developing countries.

Chung, H.Y., MacMasters, M.M., and Hoover, W.J.
A Note on the Relative Importance of Vitamins and Minerals as Dietary Supplements.

Feeding experiments with weanling male rats indicate that adequate supplementation of chapatis with vitamins and minerals is as necessary for optimal growth as is supplementation with lysine. Supplementation of flour or atta with lysine for nutritional improvement in protein-poor countries may be of questionable value unless adequate vitamins and minerals are also supplied.

Kirleis, A.W., Robinson, R.J., and Hoover, W.J.
Some Effects of Soy-Protein Concentrate on Dough and Bread Characteristics.
Presented at 56th Annual Meeting, AACC, October 10-14, 1971, Dallas.

To increase the scope of information on use of a commercial 70% soy-protein in breadmaking, the effects of three grinds (fine, medium, and coarse) of soy concentrate on physical dough properties were studied by the farinograph and extensigraph. Bread-baking potentialities were surveyed by a straight-dough method and no-time dough method, and extended to include the continuous-dough process. Inclusion of soy concentrate in farinograph doughs at levels of 7.5 and 15.0% imparted to the control curve the characteristics of the curve of a strong flour, the effects increasing with concentration level. Addition of salt affected mixing time and absorption of both soy and non-soy farinograph doughs. Doughs containing soy concentrate were significantly less extensible and more resistant to extension than those of the control, these effects generally increasing with soy concentrate level and with increasing particle size. In baking studies, specific volumes of loaves of all the soy concentrate-wheat flour formulae, the difference being greater at the higher level of addition. However, the same soy concentrate-wheat flour blends produced loaves with varied quality when made by different methods. Bread made by the continuous-dough method was least affected by adding soy concentrate; it produced bread that had better crumb grain and color and larger loaf-specific volume than did the straight or no-time dough methods. Of the last two methods, the no-time dough method produced better quality bread than the straight-dough method.

Pomeranz, Y., Shogren, M.D., and Finney, K. F.
Improving Breadmaking Properties with Glycolipids. I. Improving Soy Products with Sucroesters.
Cereal Chemistry, September 1969, Vol. 46, No. 5.

Adding 0.5 g. sucroglycerides per 100 g. flour increased water absorption and maximum hot-paste viscosity; it had no significant effects on mixing time, mixing tolerance, or extensibility characteristics. The sucroesters conteracted the deleterious effects of up to 16% soy products on loaf volume. The improving effect of 0.5% sucroglycerides was equal to, or better than, the effect of 3.0% commercial vegetable shortening. The effect of sucroesters increased with increase in hydrophilic lipophilic balance (i.e.,with decrease in number and chain lengths of fatty acids attached to the sucrose molecule). In addition to increasing loaf volume, sucroesters substantially improved crumb grain and softness. Largest improvement was obtained by adding 0.5% free polar flour lipids, rich in glycolipids. Improvement of free polar flour lipids was observed both in the control and in soy-containing breads; the sucroesters rendered soy proteins functional in breadmaking.

Pomeranz, Y., Shogren, M.D., and Finney, K.F.
Improving Breadmaking Properties with Glycolipids. II. Improving Various Protein-Enriched Products.
Cereal Chemistry, September 1969, Vol. 46, No. 5.

Bread was baked with 8 or 16 g. soy flour, and 8 g. (per 100 g. wheat flour) defatted cottonseed flour, fish protein concentrate, nonfat dry milk, expeller-extracted sesame seed flour, wheat gluten, defatted wheat germ, air-fractionated protein-rich wheat flour, or food-grade Torula yeast. All protein-rich additives substantially lowered loaf volume and impaired crumb grain. Adding 3 g. shortening counteracted partly the deleterious effects of 16 g. soy flour, higher levels had no additional improving effect. Loaf volumes were increased and crumb grain was improved by adding 1.0 to 6.0 g. sucrose tallowate. The loaf volume of bread containing 3.0 to 6.0 g. sucrose tallowate was substantially above that of the control containing no added soy flour. Highest levels of tallowate increased mixing time and impaired rheological properties. Small amounts (0.5 to 1.0 g.) synthetic glycolipids and free lipids (rich in glycolipids) from wheat flour and *Briza spicata* improved volume and crumb grain of nutritionally improved bread as much as or more than 3 g. shortening. Synthetic glycolipids, but not shortening, rendered commercial wheat gluten functional in breadmaking.

Robinson, R. J., Phillips, D. E., and Kirleis, A. W.
Effect of Sucroesters and Soy Protein Concentrate in Continuous Process Bread.

Research conducted by Kirleis and Robinson studied the effect of the particle size of 70% protein soy concentrate, oxidant level, and type of baking process when substituting the soy for 7.5 and 15% of the flour on the farinograph, extensograph and baking properties of bread. Specific loaf volumes for all the soy concentrate-wheat flour blends made by straight, no-time, and continuous-dough methods were significantly lower than the average specific volume of the basic wheat flour formula. For each method, the 7.5% level of soy concentrates had a less deleterious effect on bread quality than did the 15% level. Bread made with the coarse granulation concentrate had better color and crumb softness than the medium or fine grinds. Bread made by the continuous-dough method was least affected by adding soy concentrate; it produced bread that had better crumb grain and color and larger loaf specific volume than did the straight or no-time dough methods. This confirms the results reported by the Institute at Wagenin and by the Arkady bakeries in England that the best results are obtained with "composite flours" if high speed mixing is used.

Robinson, R. J., Farrell, E. P., Deyoe, C. W., and Hoover, W. J.
Observations on the Use of Corn Flour as an Extender in White Bread Production

This study dealt with the use of high lysine corn flour at two protein levels. Four different types of corn samples were used: two yellow dent corns with floury-2 genes; one with opaque-2 genes; and one normal yellow dent corn.[1] Two protein levels of wheat flour 10.2 and 13.2% were used as carriers. It was found that the rheological properties decreased as the content of each corn flour was increased in the formula. However, the nutritive value appeared to be improved with respect to some amino acids and minerals. The percentage range of the corn-flour in the blends was 0, 5, 10, 15 and 20%. Acceptable white bread was baked, but as the percentage of corn flour increased in the formula, the crumb became tighter and firmer. With respect to total score, the breads prepared from blends of (13.2 protein) flour were scored highest.

[1] Samples were furnished by Dr. D. E. Alexander, University of Illinois

Farrell, E. P.
Corn Milling at Kansas State University
A Progress Report, presented to the Technical Research Committee, American Corn Millers Federation, 1969.

The cumulative fat for the products in the increasing order of size from the smallest to the largest was calculated and graphed. The yield of prime products varies from 61 percent for the corn milled, January 29, 1968, using Flow A to 73 percent for the corn milled January 17, 1969, using Flow B, and 71.26 percent with Flow C. These three flow sheets for experimental milling of corn are adapted to the milling of high-lysine corn but none is considered to be more than preliminary steps in our process of learning to mill corn in a "dry" state.

Fryer, B. A., Vesecky, S. A., Deyoe, C. W., and Hoover, W. J.
Effect of Supplementation of High Extraction Wheat Flour with Various Amino Acids, Vitamins and Minerals on Growth and PER of Rats.

Various combinations of limiting amino acids, minerals, and vitamins were tested as possible supplements to a high extraction wheat flour. Gain in weight and protein efficiency ratio (PER) were used as criteria for evaluation of nutritional quality of diets in a rat-feeding study. There was no significant difference in weight gain between the diets supplemented with lysine alone and lysine plus three other amino acids (threonine, methionine and valine). However, PER for the diet with lysine alone was significantly higher than for the diet with all four amino acids. Omission of the calcium, phosphorus, or vitamin B_{12} supplements resulted in significantly lower weight gains and PERs. Omission of the iodine supplement had no significant effect.

Vesecky, S. A., Fryer, B. A., Deyoe, C. W., and Hoover, W. J.
Effect of Cooking on Protein Quality of Chapatis Supplemented with Amino Acids or Broad Beans.

Protein supplementation of high extraction wheat flour used for chapati preparation was studied. Supplements used included lysine, lysine and three other amino acids, lysine with decreased calcium, and ground broad beans.

The relatively high weight gains and PER for all diets fed to male albino rats indicate that all diets contained a good quality of protein. Baked chapatis produced PER as high as raw flour did. At the end of two weeks, there were no differences in PER. Broad beans produced PERs somewhat lower than the other supplements at four and six weeks. At the end of six weeks, lysine-supplemented flour produced higher PER than lysine-supplemented chapatis, but this difference was no longer apparent when methionine, threonine, and valine were added to the lysine-supplemented materials.

Vesecky, S. A., Fryer, B. A., Deyoe, C. W., Robinson, R. J., and Hoover, W. J.
Effect on Protein Quality of Supplementation of Chapatis, Parathas and Nan with Soy and Chick Pea Flours.

Chapatis, parathas, and nan were supplemented with 5% soy, 10% soy, 10% chickpeas, and 20% chickpeas. Chapatis were also supplemented with 0.15% lysine. The results of rat feeding experiments showed that weight gain was improved by most supplements. None of the bread products produced PER as high as casein, but none of the PERs were unacceptably low. Protein quality in chapatis was improved by all supplements. Protein quality in parathas and nan was improved by all supplements except 10% chickpeas.

Bass, Janet L., and Caul, Jean F.
Lab Evaluation of Three Protein Sources for Use in Chapati Flours
Journal of Food Science, Volume 37, 1972.

This study was designed to evaluate the laboratory performance of nine protein-supplemented flours for chapati preparation. The term performance has been used to indicate an assessment of those properties that might affect product acceptability. In that persons examining the products in the laboratory were not native consumers, only the potential acceptability of the flour blends could be predicted.

Shamsuddin, M., Deyoe, C.W., Parrish, D.B., Hoover, W.J., and Tsen, C.C.
Nutritional Evaluation of Breads Containing Soybean Protein and SSL.

Three studies using Charles River strain rats were conducted to determine the nutritive value of breads containing 12% soybean flour, non-fat dry milk solids, Blend A flour and with additions of 0.5% and 2.5% sodium-stearoyl-2 lactylate (SSL) or sucrose tallowate.

Rats consuming 12% soybean flour bread in Experiment 1 gained significantly more and utilized protein and food better than rats consuming diets based on regular bread (no soy protein added) or bread made with Blend A flour. Additions of SSL did not significantly effect protein utilization. Gains were best on the diet with 12% soybean flour. Breads with added sucrose tallowate, Experiment 2, had significantly better gains and protein utilization ($P<0.01$) than control bread. Soybean flour added to bread containing only commercial enrichment levels of thiamin, riboflavin, niacin and iron resulted in significant ($P<0.01$) improvements in weight gain, feed consumption and protein utilization. Data on lysine and available lysine in the breads suggest rat performance similar to that observed.

Deyoe, C.W., Shoup, F.K., Miller, G.D., Bathurst, J., Liang, D., Sanford, P.E., and Murphy, L.S.
Amino Acid Composition and Energy Value of Immature Sorghum Grain.
Cereal Chemistry, Vol. 27, No. 4, 1970.

Proximate and amino acid composition of mature and immature samples of sorghum grain were determined. The data indicate marked differences in amino acid content, immature sorghum grain having higher levels of lysine, aspartic acid, and glycine. Lower values for immature grain were observed for glutamic acid, proline, and leucine. Crude protein content of immature and mature sorghum grain was similar. Feeding studies indicate less available energy from immature than mature sorghum grain.

Shoup, F.K., Deyoe, C.W., Skoch, L., Shamsuddin, M., Bathurst, J., Miller, G.D., Murphy, L.S., and Parrish, D.B.
Amino Acid Composition and Nutritional Value of Milled Fractions of Sorghum Grain.
Cereal Science Today, May 1970, Vol. 15, No. 5.

Two sorghum-grain hybrids of equal protein content were milled with conventional dry-milling equipment. Protein content of the endosperm fractions ranged from 6.82 to 15.96%. The fat, fiber and ash contents of all fractions were approximately 1.0, 1.0, and 0.5%, respectively. Amino acid composition of the fractions varied. On the basis of essential amino acid contents, the nutritional quality of low-protein fractions was superior to that of high-protein fractions. Nutritive value of milled products of low- and high-protein content from each hybrid was compared on the basis of growth and protein efficiency ratios (PER's) of rats, with casein control diets used. Each fraction was fed with and without lysine and methionine supplementation. When diets were not supplemented with lysine and methionine the low-protein endosperm fraction was superior to the high-protein endosperm fraction. However, when the low- and high-protein fractions were supplemented with amino acids to meet calculated requirements, differences were not found, indicating that protein was utilized similarly when deficient amino acids were supplied. Amino acid supplementation of diets caused a marked increase in weight gain of rats, and PER's were similar to those obtained with casein. Differences in PER's relating to hybrids were nonsignificant, irrespective of amino acid supplementation.

Skoch, L.V., Deyoe, C.W., Shoup, F.K., Bathurst, J., and Liang, D.
Protein Fractionation of Sorghum Grain
Cereal Chemistry, July 1970, Vol. 47, No. 4.

Protein solubility of five samples of sorghum grain of both low- and high-protein type were compared to that of high-lysine (opaque-2) corn. A modified Mendel-Osborne technique was used. Results indicate that twice the amount of protein is extracted from opaque-2 corn when compared to that of sorghum grain. The glutelin fraction represented the major soluble-protein fraction of sorghum grain and opaque-2 corn. Amino acids were determined by ion-exchange chromatography. Comparisons of amino acid distributions were made between fractionated proteins, with the assumption that those proteins extracted were characteristic of their class. The percentages of proline and leucine increased and decreased, respectively, in the albumin protein as the protein content of whole sorghum grain increased. Concentrations of lysine and glycine in the nonsolubilized protein of sorghum grain decreased as protein content of the grain increased. Concentrations of lysine, arginine, and glycine in both the albumin and globulin fractions of sorghum grain were nearly double that in protein of whole sorghum grain. The glutelin fraction had an amino acid composition midway between that of the globulin and prolamine. Concentrations of lysine, histidine, arginine, threonine, serine, and glycine were higher in glutelin than in the prolamine fraction.

Gainor, V.J., Robinson, R.J., Deyoe, C.W., Vesecky, S.A., Fryer, B.E., and Hoover, W.J.
Influence of Processing and Protein Supplementation (Horse Bean Flour) on Nutritional Qualities of Cous-Cous.
Presented at 56th Annual Meeting, AACC, October 10-14, 1971, Dallas.

Male albino weanling rats were used to determine the ability of cous-cous to support growth, and to compare nutritional qualities of cous-cous processed in various ways and supplemented with three different levels of protein. Nine blended diets at a 10% protein level were used in Study I. These diets consisted of semolina and 85% extraction flours and cous-cous prepared from these flours. The above ingredients were also supplemented at the 10% level with horse bean (Vicia faba) flour. The diets contained starch, oil, vitamins, and minerals. Study II used 14 diets, 7 at 10% protein level and 7 at 18% protein level. Semolina, semolina cous-cous, and autoclaved cous-cous were supplemented at 5, 10, and 15% levels with horse bean flour. Two cous-cous diets were supplemented with lysine at a level equivalent to that of 10% horse bean flour. From the studies, which continued 28 days, average weekly weight gain, average weekly feed consumption, feed efficiency, and protein efficiency ratios were calculated. The 10% protein series of Study II were extended to 42 days. All diets supported growth and development with significant differences between some. Diets supplemented with horse bean flour gave higher nutritional values than unsupplemented diets.

Sanchez, C., Khan, M., Tsen, C.C., and Robinson, R.J.
Effect of Protein Supplementation (Horse Bean Flour) on Nutritional Qualities of Cous-Cous.
Presented at 56th Annual Meeting, AACC, October 10-14, 1971, Dallas, under the title: "High-Protein Moroccan Bread."

A study on high-protein Moroccan bread using a Moroccan bread formula and procedure was undertaken. Chickpea (19% protein) and horsebeans (29% protein) indigenous to Morocco were ground to a flour. Soy flour (50% protein) was used for comparative purposes. A base flour available to Morocco with 11% protein was used. Moroccan bread was baked using 0 to 32% high-protein flour with 0 to 1.00% sucrose tallowate (ST) or sodium stearoyl-2 lactylate (SSL). Moroccan bread was found to carry higher levels of protein-rich foodstuff (PRF), without objectionable effect, than American-type bread. Upwards of 24% soy and horsebean flour levels and as much as 32% chickpea flour, using either ST or SSL, were reached. This is significant since approximately 20% horsebean and 32% chickpea flours are needed to compare with 12% soy flour. Maximum bread scores were obtained at the 0.75% level ST. Specific loaf volume and crumb grain score increased linearly with SSL and curvilinearly with ST under all levels of PRF. Both improvers showed similar effects at 0 to 0.5% levels.

Robinson, R. J., Sanchez, C., Khan, M., and Hoover, W. J.
Effect of Protein Supplementation (Cottonseed Flour) on American and India-Pakistani Bread.
Presented at 56th Annual Meeting, AACC, October 10-14, 1971, Dallas.

Cottonseed flour was blended at eight levels, from 0 to 30%, with two wheat flours, low and high in protein content, to give flours of increased protein content. Farinograph data indicated strengthening only when cottonseed flour constituted up to 8% of a mixture with high-protein flour. Absorption consistently increased as content of cottonseed flour increased. Extensigraph data paralleled those of the farinograph. Baking by the standard pup-loaf method showed that above the 15% level cottonseed flour depressed loaf volume and imparted undesirable flavor. Nan and chapattis (Indian-Pakistani breads) baked from blends containing 8% cottonseed flour resulted in good products.

Robinson, R. J., Ward, A. B., Sanchez, C., Khan, M., and Hoover, W. J.
Some Observations of the Milling and Baking Quality of Moroccan Wheat.

Seven wheat samples were obtained from various locations in Morocco. These samples were Norteno, Penjamo, Inia, Siete Cerros, Tobari, BT 908 and BD 2777. Tobari gave exceptional milling yield. No milling problems were encountered except with BD 2777 which was exceptionally hard and required additional reduction to give reasonable flour yield.

Tobari, Siete Cerros and Inia were found suitable for production of white pan bread. Norteno, Inia, Siete Cerros, Tobari and BT 908 were suitable for blending. Penjamo and BD 2777 were found suitable for cous-cous production with BD 2777 having the greater suitability.

Farrell, E. P.
Milling High Lysine Corn.
Presented at AOM Technical Conference, Buffalo, New York, May 25, 1971.

The millings were evaluated for low fat content in the grits and flour, the yield of these prime products and the appearance of these to the eyes. The Two-pass Entoleter degerminator flow with a first and second temper gave the lowest fat flour and grits at 67% yield. The Two-pass Entoleter degerminator flow with one temper and the One-pass Entoleter degerminator with a first and second temper were nearly equal in producing low-fat products when compared with each other at 70% yield. The all roller mill system produces good looking grits that are the highest in crude fat in the smaller size flour and grit fraction but nearly equal in the mixture of all prime products into a straight grade. The yield was 66%. The use of a second temper proved to be beneficial when compared to similar systems using only one long time (12-20 hours) temper. All four systems produce prime products lower in fat and better looking than much of the commercial family meals produced and sold in the areas of the U. S. where corn meal is an important part of the daily diet. A higher yield of higher crude fat products could be made easily with any of these systems. None of these systems produce the rge grits used to make corn flakes because the corn is too soft.

Gainor, V. J., Robinson, R. J., Ward, A. B., and Hoover, W. J.
Effect of Protein Supplementation (Horse Bean Flour) in Cous-Cous.
Presented at I.F.T. Annual Meeting, New York, New York, May, 1971.

Cous-cous is a cereal based food common in developing countries of North Africa. This study investigated effects on physical characteristics of processing methods and of supplementing cous-cous with horse bean (Vicia faba) flour. Cous-cous were made from 70% extra extraction flour, semolina, or 85% extraction flour of durum wheat. The flour was agglomerated with water in 3000 g. batches. Agglomerated particles were sieved, separated and sized, then dried, steamed 7 min. or autoclaved for 4 min. and dried at 50° C. for 20 hours. Horse bean flour was blended at 3 levels, from 5 to 15%, with three durum flours, to increase protein content of the flours.

Water Absorption Index (WAI) values were greater for the steamed or autoclaved cous-cous than for agglomerated cous-cous. Horse bean flour supplementation decreased the WAI values of steamed cous-cous and increased the WAI values of autoclaved cous-cous. Water Solubility Index (WSI) values were higher for agglomerated cous-cous than for the steamed or autoclaved samples. (WSI values in general increased as horse bean flour supplementation increased.)

The steamed cous-cous had higher amylograph values than did agglomerated or autoclaved cous-cous. Supplementing with horse bean flour tended to decrease the amylograph values.

Tsen, C.C., Hoover, W.J., and Phillips, D.
High Protein Breads: Use of Sodium Stearoyl-2 Lactylate and Calcium Stearoyl-2 Lactylate in Their Production.
Bakers Digest 45 (2): 20-23, 26, 74, April 1971.

The novel use of two dough conditioners, SSL and CSL, to produce acceptable high-protein breads was demonstrated. Different factors and processing conditions were evaluated, using up to 16 per cent soy flour. By adding SSL or CSL, high levels of various protein-rich foodstuffs can be used to enhance the nutritional value of finished bread. Though either SSL or CSL can improve the baking performance of wheat flour fortified with soy flour or other protein-rich foodstuffs, SSL is more effective than CSL. The significance of the findings is increased by the fact that both SSL and CSL are already being used commercially in the baking industry and have been approved by the Food and Drug Administration as safe food additives, so that commercial production of high-protein breads or other baked products can start immediately.

Tsen, C.C., and Hoover, W. J.
The Shortening-Sparing Effect of Sodium Stearoyl-2 Lactylate and Calcium Stearoyl-2 Lactylate in Bread Baking.
Bakers Digest, Vol. 45, No. 5, pp. 38-40, 42, June 1971.

SSL and CSL, added to a sponge formula at 0.25 to 0.50 percent, can spare or replace shortening (texturated lard) normally required in white (plain) bread or bread containing 12 per cent soy flour. SSL was more effective than CSL in sparing shortening. In producing high-protein bread, 0.50 per cent SSL replaced all shortening and gave an acceptable loaf superior to that with 3 per cent shortening in volume and loaf score. With SSL or CSL limited to 0.25 per cent and shortening to 1 or 2 per cent, a complementary action appeared between SSL or CSL and shortening, reflected by better volume than with SSL, CSL, or shortening alone. The complementary action clearly indicates that SSL or CSL can spare the shortening requirement for both white and high-protein breads. White breads stored at 25°C up to 5 days are slightly softer when SSL rather than shortening is used.

Hoover, W. J.
Blend K Bread.
Soybean Digest, November 1971.

The increasing acceptance of bread in the developing world of Latin America and Asia, in addition to the traditional role of wheat as the staple of diets elsewhere, makes bread the most likely vehicle for nutritional improvement of diets. Protein-calorie malnutrition is and will become increasingly the most serious nutrition problem in the developing world. Soy flour is the only protein-rich foodstuff that is available in large quantities at a reasonable price. The technological barriers to the use of substantial levels of soy flour in baked foods have been largely overcome.

Thus, it appears that the era of the use of soy-flour-fortified wheat flour for making high-protein breadstuffs is at hand.

Tsen, C. C., and Tang, R. T.
K-State Process for Making High-Protein Breads. I. Soy Flour Breads.
Bakers Digest. Vol. 45, No. 5, pp. 26-27, 30-32, 1971.

Various straight dough processing factors such as fermentation period, floor time, yeast level, and treatment level of oxidant or reducing agent were evaluated in relation to the volume and grain of bread made from wheat flour fortified with 12% soy flour. Based on such evaluations, K-State Process has been developed to produce marketable high-protein bread without bulk fermentation.

Pushpamma, S., Parrish, D.B., and Deyoe, C.W.
Improving Protein Quality of Millet, Sorghum and Maize Diets by Supplementation.
Nutrition Reports International, Vol. 5, No. 2, February 1972.

Nutritive value of the protein of millets (Bajra and Ragi), sorghum, and maize was studied by amino acid analyses, by growth of rats and calculations of PER using diets containing the grains, unsupplemented or supplemented with lysine, tryptophan, or four protein concentrates. Ragi protein was highest in essential amino acids (EAA) except leucine, and compared to the FAO reference pattern, no amino acid in Ragi was limiting except lysine was marginal. Bajra protein was deficient in lysine; sorghum and maize were deficient in three or more amino acids. On several protein-quality scores, Ragi ranked first and Bajra second; both ranked considerably higher than sorghum or maize. Among unsupplemented diets, Bajra caused greatest weight gain in rats and had the highest PER. Supplementing Bajra and Ragi diets with lysine increased both gains and PER. Lysine improved sorghum and tryptophan improved maize diets; together lysine and tryptophan markedly improved both diets. Fish protein concentrate was the most effective supplement with sorghum and Ragi, dried milk with maize, and isolated soybean protein with Bajra.

Parrish, D.B.
"A Fresh Look at Millets: Nutritive Value of Ragi and Bajra Proteins."
L.I.F.E. Newsletter, November 1971.

(A popular version of Improving Protein Quality of Millet, Sorghum and Maize Diets by Supplementation.)

Tsen, C.C.
Concepts for Use of Soy Flour in Baking: Preparation of High-Protein Bread. (Chapter) in SOY: THE WONDER BEAN (1971). American Association of Cereal Chemists, St. Paul, Minnesota.

Of all protein-rich foodstuffs available today, soy flour is the most attractive in price, quality, and quantity for making high-protein breads. Recent advances in soy flour processings, including heat and chemical treatments or cook-extrusion, make soy flour more suitable for baking uses.

Conditions for making soy breads have been well studied in conjunction to absorption, mixing, oxidation, and fermentation requirements. Various agents such as lecithin (47), glyceryl monostearate, natural and synthetic glycolipids, and lactylates (CSL and SSL) have been used to improve the baking performance of soy dough. A no-time dough process has been developed to make acceptable soy bread with SSL added. The simplified process with a great time-saving advantage could become an asset in expanding production of soy breads in poverty areas of the United States and other countries where such breads are needed most.

Tsen, C. C., and Hoover, W. J.
High-Protein Bread Made from Wheat Flour Fortified with Full-Fat Soy Flour
Presented at 56th Annual Meeting, AACC, October 10-14, 1971, Dallas.

Fortification of wheat flour with a full-fat soy flour in making bread can not only raise the bread protein content and balance its essential amino acids but also provide extra caloric value. Such fortification may offer an effective way to combat protein-malnutrition and caloric deficiency in poverty areas of the U. S. and of other countries. In the present study, processing conditions for making bread containing full-fat soy flour were evaluated. Various levels of soy flour, bromate, and dough conditioners such as sodium stearoyl-2 lactylate all could greatly affect the quality and volume of the finished bread. Under a modified breadmaking process, acceptable bread could be produced from wheat flour fortified with full-fat soy flour as high as 24%.

Tsen, C. C., and Hoover, W. J.
Emulsifiers for the Improvement of Protein Fortified Bread (Chapter)
PAG Bulletin (UN) in press, 1972.

Bread is an ideal food to fortify with protein because it is a staple food in many countries. However, the fortifiers, such as soy flour, can induce adverse effects on dough properties and bread quality. To alleviate these effects, three food emulsifiers, sodium stearoyl-2 lactylate (SSL), calcium stearoyl-2 lactylate (CSL), and ethoxylated monoglycerides (EM), have been found to be effective in improving the baking performance of wheat flour fortified with soy flour or other protein-rich additives in the present study. Accordingly, acceptable high-protein bread containing a high level of soy flour or other protein-rich additives such as cottonseed flour and fish protein concentrate can be made with the addition of one of the three food emulsifiers.

Shamsuddin, M., Deyoe, C. W., Parrish, D. B., Hoover, W. J.,
and Tsen, C. C.
Nutritional Evaluation of Breads Containing Soybean Flour, Blend A Flour, with and without Additives SSL and ST.

Three studies were conducted to compare the nutritive value of breads containing 12% soy flour, Blend A flour, with and without additions of sodium stearoyl-2 lactylate (SSL) or sucrose tallowate (ST), with those made of white flours.

Rats fed diets made with 12% soy flour bread gained significantly more and utilized protein and total food significantly better than rats fed diets based on regular white bread (control) or bread made with Blend A flour. Additions of 0.5 or 2.5% SSL and ST did not significantly affect gains or protein utilization. Soybean flour added to an enriched bread formula resulted in significant ($P = 0.01$) improvement in weight gain and protein utilization when compared to regular enriched (thiamin, riboflavin, niacin and iron) bread and enriched bread containing 3% non-fat dry milk solids. Feed consumption increased when bread supplemented with soy flour was fed. Growth was as might be expected based on lysine and available lysine values of the breads.

Technical Meetings at Which Papers Have Been Presented

C. E. C. T. A. L., Rio de Janiero, Brazil	1969
Institute of Food Technologists	1969
	1970
	1971
American Association of Cereal Chemists	1970
	1971
S O S - 70	1970
American Chemical Society	1971
International Bread Congress, Dresden, E. Germany	1970
International Association of Cereal Chemists Working Group on Composite Flours Vienna, Austria	1971
FAO Industrial Liaison Meeting	1970
Western Hemisphere Nutrition Congress III	1971
American Society of Bakery Engineers, Regional Meeting	1971
Baking Industry Research Advisory Committee to U.S.D.A., Albany, California	1971
Protein Resource Meeting, U.S.D.A., Peoria, Illinois	1971
Soybean Symposium, A.A.C.C.	1971
Wheat Utilization Conference	1969
	1971

Participated in Workshops

Breeding and Fortification Conference, Annapolis, Maryland	1970
Assaying Improved High Protein Crop Cultivars, Washington, D. C.	1971
Senator Frank Carlson Symposium on World Food Problems	1969
	1970
	1971
Foods Fortified with Soy Products, Mexico City	1971

Correspondence and Material Exchange

A large volume of correspondence with workers in the field from all areas of the world has been established and continues. Samples of products have been furnished upon request and samples of high protein materials have been tested when submitted to Kansas State University.

Visitors

Many workers from overseas have visited our laboratories and reviewed and discussed results. Longer periods of training (1 week to 3 months) have been given to visiting technologists from India, Colombia, and Guatemala.