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9. ABSTRACT
Contains the twenty-two appendices of the Harvard study entitled Global Malnutrition and Cereal Fortification. The study presents a methodology for assessing the feasibility of fortification intervention in any developing country, and it presents case studies of Guatemala, Tunisia, and Thailand. The appendices include: (1) an annotated bibliography, (2) chemical structures of commercially produced vitamins; (3) chemical structures of commercially produced amino acids; (4) a process for the industrial production of L-Lysine.HCL; (5) industrial processes for the production of soy proteins; (6) a process for production of fish protein concentrate; (7) a diagram of flour milling and premix addition in centralized mills; (8) a Tunisian village wheat mill (drawing and specifications); (9) the manual procedure for fortifying semolina and flour at a village mill; (10) a description of the infusion production of amino acid and vitamin enriched rice kernels; (11) an outline of the simulated kernel process; (12) cost estimates of the extrusion cooking system; (13) a description of the Maillard Browning Reaction; (14) the Strecker degradation; (15) reactions leading to vitamin degradation; (16) the moisture content of cereals at different humidities and temperatures; (17) the social costing and shadow pricing of foreign exchange; (18) the regions of Guatemala; (19) basic elements in fortification feasibility analysis; (20) size estimates of the non-controlled grain purchase system; (21) groups participating in the controlled system of grain purchases; (22) and the first estimate of number of mills and grinders in Tunisia.

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APPENDIX A

ANNOTATED BIBLIOGRAPHY

I. Studies - Adult Human

Clark, Helen, Malzer, J., Underka, H., Howe, J., and Moon, W.H. Nitrogen Balances of Adult Human Subjects Fed Combinations of Wheat, Beans, Corn, Milk and Rice. Am. J. Clin. Nutr. 26:702, July 1973.

The experiment, using healthy adults ages 23 to 30 years of age, tested the ability of six combinations of navy beans, corn, milk, rice and wheat supplying 7.0 g of nitrogen to maintain nitrogen-balance. The trial period lasted 60 days; white wheat flour supplied 50% of the 7.0 g of Nitrogen, two other sources supplied 25% each of the total nitrogen. Total protein intake averaged 41.3 to 43.8 g per day. Total energy intake was determined by age and sex and ranged from 2,150 to 3,620 kcal/day. Two groups were selected based on sex and weight. Results showed that Group 1, Men, had a Mean Daily Nitrogen Balance of 0.72 ± 0.58 g and Group 2, Women, had an average of 0.38 ± 0.57 g. The data indicates that the nitrogen balance did not differ as a result of the various treatments.

Scrimshaw, K.S., Taylor, Y., and Young, V.R. Lysine supplementation of Wheat Gluten at Adequate and Restricted Energy Intakes in Young Men. Am. J. Clin. Nutr. 26:965, September 1973.

Sixteen, healthy male students were studied in two metabolic balance studies to determine the effect of lysine supplementation and dietary energy restriction on the utilization of wheat gluten. Two levels of wheat gluten were tested; 0.27 g protein/kg of body weight/day and 0.73 g of protein/kg of body weight/day. Phase 1 of the study tested the two levels of protein intake under conditions of adequate energy intake; adequate caloric intake was determined by maintenance of body weight. During Phase 2, the total caloric intake was decreased by 20%.

The results of the study indicate that for subjects receiving an adequate caloric intake and fed a diet low in wheat protein (0.27 g protein/kg of body weight/day), nitrogen utilization can be improved through supplementation with the limiting amino acid lysine.

Howe, J., Clark, H., Jewell, J., and Senchak, M.M. Nitrogen Retention of Adults Fed 6.0 Grams of Nitrogen From Combinations of Rice, Milk and Wheat. Am. J. Clin. Nutr. 25:559, June 1972.

The study was designed to compare the effectiveness for seven adult human subjects ages 22 to 25, of a daily intake of 6.0 g of nitrogen from two generally available cereals; rice and wheat, with and without milk. The nitrogen was limited to 6.0 g/day which maintained equilibrium in all subjects when rice was fed with chicken, but not when rice was fed alone. Rice was included in the diet in amounts of 25, 50 or 75% of total nitrogen; enriched white flour provided 0, 25, 50 or 75% and milk provided 0, 25 or 50% of the nitrogen. The foods were supplied in 6 combinations.

The results showed that a daily intake of 6.0 g of nitrogen from six combinations of rice, milk, and wheat must be considered borderline as none of the food combinations maintained equilibrium in all subjects. All of the diets permitted nitrogen equilibrium in some and five of the six diets tested allowed a group mean positive nitrogen balance.

el Lozy, M., Hegsted, D.M., Kerr, G.R., Boutourline, E., Tesi, G., Ghamry, M.T., Stare, F.J., Kallal, Z., Turki, M., and Hemaidan, N. Amino Acid Composition of The Diet in a Region of Southern Tunisia. Am. J. Clin. Nutr. 28:1183, October 1975.

A survey conducted on the dietary habits in Tunisia revealed the average diet provided 1,670 kcal, 42.0 g of protein and 1,280 mg of lysine/person/day. Therefore, the overall diet supplied only mg lysine/g of protein or only 56% of the FAO recommendation addition of lysine to the diet at a concentration of 0.2% would raise dietary lysine of wheat products to a final concentration of 45 mg/g of protein or 82% of the FAO recommendation.

Butler, L.C., Dawson, V.T., and Adams, Y.L. Utilization by Young Women of Peanut Flour Equilized to The FAO pattern. Am. J. Clin. Nutr. 23:1169, September, 1970.

The study was designed to determine the nutritive value of peanut flour compared with a 5:1 casein lactalbumin mixture when the peanut protein were supplemented with pure, crystalline essential amino acids to equal the FAO provisional patterns. The study subjects ranged in age from 17 to 20. The diet provided 0.4 g protein/kg of body weight and adequate calories based on body weight. After a seven-day preliminary period, the subjects were placed on two ten-day trials, one using the protein and the second utilizing the casein-lactalbumin control diet. Results showed a significantly lower nitrogen retention when the subjects were on the peanut flour diet.

Clark, H., Howe, J.M., Lee, C.J. Nitrogen Retention Of Adult Human Subjects Fed A High-Protein Rice. Am. J. Clin. Nutr. 24:324, March, 1971.

A high protein rice was compared in seven adult subjects ages 21 to 24 to an equal weight of commercially available rice. The high protein rice contained 1.8 times more protein than the standard rice. A total of 480 g of rice was supplied; adequate calories based on individual needs was supplied.

Results indicated that the high protein rice caused significantly higher ($P < 0.01$) nitrogen retention than the commercial rice. The perspective positive mean nitrogen balances were 1.41 ± 0.89 g and 0.24 ± 0.31 g.

Edwards, C.H., Booker, L.K., Rumph, C.H., Wright, W.G., and Ganapathy, S.N. Utilization Of Wheat by Adult Man: Nitrogen Metabolism, Plasma Amino Acid And Lipids. Am. J. Clin. Nutr. 24:181, February, 1971.

The study was to determine whether the nutritive value of a diet consisting primarily of wheat and containing common foods such as potatoes, turnip greens and fruit could be improved by other sources of plant protein such as pinto beans, rice, and peanut butter. Twelve males ages 23 to 30 years old participated in the 74 day trial. The control diet consisted of 46 g of protein with 35 g from wheat and 11 g from other sources; approximately 3,000 calories were provided. The three experimental diets replaced 20% of the nitrogen supplied by wheat with equal amounts of either pinto beans, rice or peanut butter.

The authors concluded that a diet containing 46 g protein/day of which 76% of the nitrogen was supplied as wheat and the remainder potatoes. Vegetable and fruit was adequate to maintain nitrogen equilibrium. Replacement of 20% of the wheat did not improve nitrogen utilization.

Lee, C-J., Howe, J., Carlson, K., and Clark, H. Nitrogen Retention Of Young Men Fed Rice With Or Without Supplemented Chicken. Am. J. Clin. Nutr. 24:318, March, 1971.

The study was designed to determine the effect on nitrogen retention of young men of two quantities of rice when this grain was the principal source of protein and when rice was partially replaced by animal protein. Six male students participated in the 59 day experiment. Two levels of nitrogen from rice were tested: 6.0 and 8.0g. At both levels, three treatments were tested:

1) 100% nitrogen from rice.
2) 85% nitrogen from rice plus 15% chicken.
3) 70% nitrogen from rice plus 30% chicken.

Caloric intake in all trials was based on individual need and varied from 3,050 to 3,700 calories.

Results showed that all subjects were in positive nitrogen balance when they consumed only 8.0 g of nitrogen from 595 g of rice alone, but only half were in nitrogen balance when 6.0 g of nitrogen from 446 g of rice were supplied mean daily nitrogen balances were 1.07, 0.89, 1.04 g when rice supplied 100, 85 and 70% of 8.0 g of nitrogen and 0.18, 0.39, and 0.030 g when 100, 85, and 70% of 6.0 g nitrogen were consumed.

Clark, E.A., Meyers, P.E., Tuckett, S.E., and Yamamura, Y. Nitrogen Balance Of Adults Consuming Opaque Maize Protein. Am. J. Clin. Nutr. 20:825, August, 1967.

Opaque 2 maize is a strain of corn higher in lysine and tryptophan and has a better balance between leucine and isoleucine than other hybrid strains of corn. Four levels of opaque-2, 350, 250, 200, and 150 g, were administered to healthy adults. The requirement of corn to maintain nitrogen-balance was found to relate to body size. Five of the six subjects were in nitrogen balance on 300 g; most subjects were in balance on 250 g, but one man needed 350 g.

Astur, S.S., Clark, H., Moon, W.H., and Malzer, J. Nitrogen Retention Of Adult Human Subjects Who Consumed Wheat And Rice Supplemented With Cheapen Sesame, Milk And Whey. Am. J. Clin. Nutr. 26:1195, November, 1973.

Five experimental diets that supplied 8.0 g of nitrogen were administered to healthy adults ages 24 to 28 years for a period of 51 days. In two diets, cereals (white wheat flour, bulgur and rice) furnished 80% of the nitrogen and either non-fat milk or whey supplied the other 20%. In the three other diets, the cereals provided 60%, chickpea 20% and either milk, whey or sesame flour 20%. Mean nitrogen balances ranged from 0.79 ± 0.29 g to 1.10 ± 0.47 g, but did not differ significantly from one another.

II. Studies - Children

Knapp, J., Barness, L., Hill, L.L., Kaye, R., Blattner, R., and Sloan, J. Growth and Nitrogen Balance in Infants Fed Cereal Proteins. Am. J. Clin. Nutr. 26:586, June, 1973.

The study was designed to investigate the effectiveness of various protein sources in maintaining positive nitrogen balance and supporting growth in infants. Undernourished, male infants hospitalized for acute diarrhea were admitted to the study two to three weeks following recovery. Diets provided 2.0 g/kg/day of protein provided from one of nine sources: dry skim milk, soybean, rice, cottonseed, peanut, cottonseed and rice, cottonseed and peanut, rice and soybean or soybean and peanut. All formulas were isocaloric providing 100 kcal/kg of body weight/day. The trial period lasted three months; gain in weight, gain in body length and nitrogen balance were measured. Results indicated no significant differences in all the proteins tested except peanut protein which was significantly inferior.

In the short term balance studies, nitrogen retention in infants fed isocaloric diets containing 2.0 g protein/kg body weight could be maintained when protein was cow's milk, cottonseed and rice, soybean, rice, soybean and peanut, soybean and rice, cottonseed and peanut or cottonseed.

Graham, G.G., Baertl, J.M., Placko, R.P., and Cordano, A. Dietary Protein Quality In Infants And Children VII. Wheat or Oat-Soy Mixture. Am. J. Clin. Nutr. 25:875, September, 1972.

The present study is a report of the evolution of wheat-soy blend (WSB) and oat-soy in the diet convalescent, malnourished and normal infants and children. Diets provided between 100 and 150 kcal/kg and body weight/day. Comparisons were made in the same children between casein and the test mixture as the only source of isocaloric, isonitrogenous diets. Protein supplied 8% of the calories in all but one case where it was 6.7%.

The digestibility of the protein in WSB was similar to other cereals, but inferior to white wheat flour. This resulted in a nitrogen-retention which was inferior to that of white flour enriched with lysine or fish protein concentrate

despite similar biological values. Prolonged feeding with both mixtures at high enough protein/calorie ratios, at least 8% and preferably 9-10% of calories, can provide the dietary protein for healthy infants and children, but does not appear adequate for malnourished or sick children.

The data from the study strongly imply that wheat concentrates or whole wheat feeding because of their inferior digestibility do not, increase protein utilization to the same extent that might be expected. However, the biological value of the oat flour-soy flour mixture was so high that it almost compensated for its inferior digestibility when compared with milk protein.

Albernathy, R.P., Ritchey, S.J., and Gorman, J.C. Lack of Response To Amino Acid Supplements By Preadolescent Girls. Am. J. Clin. Nutr. 25:980, October, 1972.

The study was designed to evaluate the effect of supplementation of the basal menus with the amino acids most limiting with respect to egg protein. The diet supplied 4.0 g of nitrogen and 2,000 kcal/day. Two replicite 20 day trials were conducted with 32 preadolescent girls ages 7 to 9 years old. The subjects were fed a diet formulated to simulate one typical of low-income Southern families. Although the protein in the diet was supplied primarily by legumes and cereals supplementation with lysine, threonine and methionine, the amino acids calculated to be most limiting, failed to improve nitrogen utilization.

Pereira, S.M. Begum, A., Jesidian, G., and Sundarara, R. Lysine Supplemented Wheat And Growth Of Preschool Children. Am. J. Clin. Nutr. 22:606, May, 1969.

The study was undertaken to assess the effect of lysine supplementation of wheat on the growth of 52 healthy preschool children ages 2 to 5 residing in an orphanage. The diets provided 2.0 g vegetable protein and 100 kcal/kg of body weight/day. The children were divided into one of two groups based on height, weight, age, sex, and rate of growth during the previous three months. The control group received 0.68 g lysine daily, the experimental groups received an additional 0.37 g/day or a total of 1.05 g of lysine.

The results indicated there was a statistically significant increase in the height of the lysine supplemented children.

Begum, A., Radhakaishnan, A.N., and Pereira, S.M. Effects Of Amino Acid Composition Of Cereal-Based Diets On The Growth Of Preschool Children. Am. J. Clin. Nutr. 23:1175, September, 1970.

Surveys conducted in Southern India have shown that cereals supply 70 to 80% of the dietary protein of preschool children. The present study was designed to test the adequacy of a wheat-based and a rice-based diet in healthy children ages two to five years old. Both the wheat and rice diet were designed to provide 100 kcal and 2.0 g vegetable protein/kg of body weight/day. The two groups were matched-paired based on age, sex, height, and weight. Twenty-two children were assigned to the wheat-based diet and 24 to the rice-based diet.

Results showed that increases in height of the children on the rice-based diet were significantly greater than increases in height of the children on the wheat based diet and were comparable to rates of growth of North American children at the 50 percentile. The differences in gain in weight and nitrogen retention were not significant; children maintained positive nitrogen balances on both diets.

V. Reddy. Lysine Supplementation of Wheat And Nitrogen Retention In Children. Am. J. Clin. Nutr. 24:1246, October, 1971.

The study investigated the effect of lysine supplementation on exclusively wheat based diets on nitrogen retention in six hospitalized children ages two to five who were moderately undernourished. The diet provided 2.0 g protein and 100 kcal/kg of body weight/day. The unfortified wheat contained 56 mg lysine/kg of body weight and the fortified wheat had 72 mg lysine/kg of body weight. Balance studies were carried out on each child at three different periods:

Phase 1: Unfortified wheat given
Phase 2: Fortified wheat at 0.1% level
Phase 3: Unfortified wheat

Data indicates no significant differences in nitrogen retention during any of the three periods.

Graham, G., Morales, E., Cordano, A., and Placko, R. Lysine Enrichment Of Wheat Flour: Prolonged Feeding Of Infants. Am. J. Clin. Nutr. 24:200, February, 1971.

Six convalescent infants ages three to six months were provided with white wheat flour enriched with lysine as the sole source of protein. Protein provided 8% of total calories and the equivalent of 0.1, 0.2 and 0.4% lysine enrichment were tested during trials of 92 to 182 days duration. Calorically adequate diets were supplied.

The diet showed that the three levels of lysine enrichment were equally effective in supporting normal linear growth, weight gain, nitrogen retention, serum proteins and plasma amino acids.

Graham, G., Morales, E., Acevedo, G., Placko, R., and Cordano, A. Dietary Protein Quality In Infants And Children IV. A Corn-Soy Milk Blend. Am. J. Clin. Nutr. 24:416, April, 1971.

A comparison of milk protein with cornmeal. Soy milk (CSM) mixture at 6.4 to 7.3% of total calories, was carried out in nine convalescent infants. For six of the children studied, nitrogen retention from CSM was 65, 98, 64, 80, 62 and 50% of that from milk. The fact that the studies were carried out at levels of protein intake that were on the borderline of adequacy suggests that these figures are a fairly accurate representation of relative biological value. The average rate of apparent nitrogen absorption from the milk protein was 83% of intake compared to 70% for the CSM.

King, K.W., Sebrell, W.H., Severinghans, E.L., and Storvick, W.O. Lysine Fortification Of Wheat Bread Fed To Haitian School Children.

The study was to evaluate the nutritional value of lysine-supplemented wheat flour in chronically undernourished school age children. Three rural villages in Haiti comprising approximately 600 children participated in the study; data on 464 children was included in the final analysis.

The response of rural Haitian school children to lysine supplementation of enriched white flour was studied over a complete school year. A general trend toward increased stature, weight gain, mean corpuscular hemoglobin concentration and skinfold thickness was evident. In comparing the children receiving the lysine supplementation with both the control group and the unsupplemental lysine group, the authors found that of the eight sex-age groups, the children in one group (Females, 9-12 years) showed a statistically significant increase in height after two months and in two groups (Males, 9-12 and Females 13-14) after four months.

Significant weight responses were found in children in six groups after two months and in one group after four months.

Reddy, V., Gopta, C.P. Treatment Of Kwashiorkor With Opaque-2 Maize. Am. J. Clin. Nutr. 27:122, 1974.

Children with Kwashiorkar were tested with a diet providing 4 g protein/kg of body weight and 200 kcal/kg of body weight/day; 22 children were investigated. They were grossly underweight and with varying levels of edema and hypoalbuminemia. Children were divided into two groups, 10 children received a diet based on opaque-2 maize and 12 other children received a skim milk diet both for a period of four to five weeks.

The clinical and biochemical responses observed in children who consumed to those obtained with skim milk. The criteria employed in the assessment of responses were:

1) Time taken from the disappearance of edema.
2) Gain in weight after minimum body weight was reached.
3) Serum albumin regeneration.

The results of the study indicate opaque-2 is effective in the treatment of Kwastiorkor.

III. General

Hegsted, D.M. Amino Acid Fortification And The Protein Problem. Am. J. Clin. Nutr. 21:688, June, 1968.

General review of the topic of amino acid fortification and the problems inherent in the design and implementation of projects. The author points out that many researchers have the impression that the addition of small amounts of lysine or lysine and threonine added to cereals will produce products with high quality proteins comparable to meat and milk. This is generally not true.

Also discussed are problems with current methodology Protein Efficiency Ratio (PER). A widely used method will generally indicate differences in protein quality, but does necessarily measure the quantitative differences between proteins since PER is often not proportional to nutritional quality.

Hegsted, D.M., and Juliano, B.O. Difficulties In Assessing The Nutritive Qualities Of Rice Proteins.

The difficulties in the biological assessment of the protein quality of rice with relatively little protein is discussed.

Bressani, R., Elias, L.G., and Gomez-Brenes, R.A. Protein Quality Of Opaque-2 Corn; Evolution In Rats. J. Nutr. 97:173, February, 1969.

The present study was designed to test the protein quality of opaque-2 corn in rats. The results of the chemical analysis of the corn indicates that opaque-2 corn has a higher protein quality than that of common corn. In addition, the analysis shows that opaque-2 corn has higher niacin levels then common corn and the niacin is more available in opaque-2.

Clarke, H., Howe, J.M., Magee, J.L., and Malzer, J.L. Nitrogen Balances Of Adult Human Subjects Who Consumed Four Levels Of Nitrogen From A Combination Of Rice, Milk and Wheat. J. Nutr. 102:1647, December, 1972.

Nitrogen balance studies were conducted on human subjects consuming diets supplying 8.0, 7.0, 6.0, and 5.0 g of nitrogen per day from rice, milk and wheat flour. Rice supplied 50% of the nitrogen, 25% was from milk and 25% of the nitrogen was from wheat flour. Mean nitrogen balances decreased from + 0.85 to + 0.12 as total nitrogen supplied from the diet decreased. Mean daily nitrogen balances were positive at all levels of dietary nitrogen; however, only the combination of rice, milk and wheat at the 8.0 and 7.0 g nitrogen level maintained positive nitrogen balances in all subjects. The 6.0 g of dietary nitrogen approximated the minimal requirement of the group.

Forsum, E. Use Of A Whey Protein Concentrate As A Supplement To Maize Rice And Potatoes: A Chemical And Biological Evaluation Using Growing Rats. J. Nutr. 105:147, February, 1975.

The study was designed to test the efficacy of use of whey protein concentrates to improve the protein quality of grain. Maize, protein is known to be low in tryptophan and lysine, whereas rice protein is relatively low in lysine and threonine. The Whey Protein Concentrate (WPC) used in this study contains high levels of these amino acids. The supplementary effect of the WPC on rice and maize protein was compared to the corresponding effect of dried skim milk. Biological tests performed on both raw and boiled protein mixtures showed WPC to be superior to skim milk in supplementing maize and rice proteins. The data also indicated that a potato-WPC mixture may possess high protein quality comparable to potato-lactalbumin and potato-egg mixtures.

Young, V.R., Fajardo, L., Murray, E., Rand, W. and Scrimshaw, N. The Protein Requirements of Man: Comparative Nitrogen - Balance Response Within The Submaintenance to Maintenance Range of Intake of Wheat and Beef Proteins. J. Nutr. 105:534, May, 1975.

The nitrogen balance response of young men given beef or wheat protein over the submaintenance-to-maintenance range of protein intake was determined as the basis for estimating the relative capacities of these proteins to meet the minimum protein needs for young adult males. Sixteen healthy students participated in one of two studies. All diets provided adequate energy as determined by food intake history. Equal meals were provided four times per day. The levels of protein intake tested were 0.2, 0.3, 0.4 and 0.5 g/kg body weight/day in the beef study and 0.3, 0.4, 0.5 and 0.65 g/kg of body weight/day in the wheat study. The regression of the estimated "true" nitrogen balance (Y) on nitrogen intake (X) was Y = +0.51 for beef and Y = + 0.27 for whole wheat protein. The amounts of beef and wheat estimated to be needed to support nitrogen balance in 97.5% of the population supplied 96 and 178 mg nitrogen/kg/day, respectively. The relative protein value of beef and wheat protein in comparison with egg protein was 78 ± 12 and 41 ± 10, respectively. The authors suggest that protein quality should be taken into account in assessing the protein adequacy of diets for individual and population groups.

Clark, H.E., Moon, W.H., Malzer, J.L., Birt, D.F. and Pang, R.L. Nitrogen Retention of Adult Human Subjects Fed Varying Quantities of Tryptophan. J. Nutr. 104:1121, September, 1974.

Young adult human subjects consumed 750, 625, 500, 375 and 250 mg of L-tryptophan in conjunction with quantities of other essential amino acids. Essential amino acids were provided in part by cereal and in part by mixtures of L-isomers of crystalline amino acids. Mean nitrogen balances were between + 0.20 ± 0.38 and + 0.57 ± 0.15 g per day, and did not differ significantly as a result of modifying the tryptophan over a three-fold range.

Bolourchi, S., Friedemann, C. and Mickelsen, O. Wheat Flour As A Source of Protein For Adult Human Subjects. Am. J. Clin. Nutr. 21:827, August, 1968.

A study was undertaken to determine the effect produced by feeding young men a diet which 90-95% of the protein came from wheat flour with the remainder from other plant sources. The study consisted of a 20 day control phase followed by a 50 day experimental phase. The control diet provided an average of 72 g of protein per day with 45% from animal protein; the experimental diet provided 11.0 g of nitrogen per day with 90-95% from commercial wheat flour. Adequate calories were provided; results indicated that nitrogen equilibrium could be maintained on a diet in which most of the protein was supplied by wheat.

Kies, C. and J. Mertz-Fox. Effect Of The Level Of Total Nitrogen Intake On The Second Limiting Amino Acid In Corn For Humans. J. Nutr. 100:1275:1070.

The objective of the study was to determine the second limiting amino acid in corn protein for maintenance and nitrogen equilibrium in human adults under conditions of a high total nitrogen intake and in a second study under intakes of both high and low total nitrogen intake. Study 1: the 70 day study consisted of two parts: Part A: a 7 day preliminary period and Part B: five experimental periods of five days each. In this first study, various proportions of lysine-supplemented corn meal to diammonium citrate-glycine nitrogen with a total dietary nitrogen kept constant at 13.0/nitrogen/day were fed to ten adult men in order to determine the minimum lysine supplemented corn requirement. Results indicated that under conditions of high total nitrogen intake, methionine is the second limiting amino acid.

In second study lysine-supplemented corn was again fed to subjects, but to supply a low nitrogen intake. When total dietary nitrogen was maintained at 4.0 g nitrogen/day, tryptophan additions resulted in increased nitrogen retention and methionine additions had no effect. The authors conclude that the level of total dietary nitrogen can influence the order in which amino acids become more limiting in the dietary protein source.

Bressani, R., Elias, L.G., and Gomez-Brenes, R.A. Protein Quality of Opaque-2 Corn Evaluation In Rats. J. Nutr. 97 :73, February, 1969.

The present study was designed to test the protein quality of opaque-2 corn in rats. The results indicate that opaque-2 has a higher protein quality than that of common corn. In addition, the analyses show that opaque-2 has higher niacin than common corn and the niacin is more available in opaque-2.

Babcock, M.I. and Markley, R.A. Utilization of Amino Acid From Protein By Weaning Pigs. J. Nutr. 93:368, November, 1967.

The study presents responses of weaning pigs to equal amounts of essential amino acids and nitrogen derived from three sources: milk protein, a 5:1 mixture of casein and lactalbumin, wheat gluten and pure amino acids. Two pigs each were fed either the amino acid, casein, lactalbumin or wheat gluten diet for 14 days. Results indicate that the mean body weight gain was lowest with wheat gluten and highest with the amino acid diet. Nitrogen balances were also lowest with the wheat gluten.

Kies, C., Mertz-Fox, H. and Williams, Eleanor R. Effect of Non-Specific Nitrogen-Supplements On Minimum Corn Protein-Requirements and First Limiting Amino Acid For Adult Men. J. Nutr. 92:377, 1962.

The minimum amount of corn protein and first limiting amino acid in corn protein for maintenance of nitrogen-equilibrium of human adults were investigated at a high constant level of total nitrogen intake. When a slightly inadequate amount of corn protein, as individually determined for each subject, was fed under a total-nitrogen intake of 12.45 g/day, only the inclusion of a lysine supplement resulted in re-establishment of nitrogen retention. Lysine, thus was the first limiting amino acid.

Chi-Shya, Chen Shirley, Mertz-Fox, H. and Kies, C. Nitrogenous Factors Affecting The Adequacy of Rice to Meet The Protein Requirement of Human Adults. J. Nutr. 92:429, August, 1967.

The study was designed to determine the first limiting nitrogenous component in rice protein for nitrogen retention in human adults. Six subjects were fed diets providing 6 g of nitrogen from rice or 6 g of nitrogen from rice supplemented with either 2 g of amino acid nitrogen provided in the pattern of rice protein or 2 g of non-specific amino acid nitrogen. Nitrogen retentions were significantly higher in response to the lysine containing supplements than to those containing threonine alone or methionine-cystine; lysine is the first limiting amino acid for rice protein.

Bolourchi, W., Vaghefi, M. and Mickelsen, O. Lysine Supplementation of Wheat Protein. Am. J. Clin. Nutr. 28:1231, November, 1974.

A review of papers concerned with the ability of protein in wheat and/or white flour to meet essential amino acid requirements of human subjects. Pertinent animal and human studies are discussed. The conclusions drawn from the review are:

(1) The protein in whole wheat flour is adequate to maintain nitrogen equilibrium in adults. A corollary to this is that lysine fortification of white flour produces no improvement in adults who receive an adequate caloric intake.
(2) The provision of an adequate caloric intake is needed before a valid evaluation of lysine fortification trials can be made.
(3) No conclusive answers exist as to whether lysine fortification will produce long-term improvements in the growth of children.

Gershoff, S., McGandy, R., Suttapreyasri, D., Nondasuta, A., Pisolyabutra, U., and Tantiwongse, P. Amino Acid Fortification of Rice, Studies in Thailand: 1. Background and Baseline Data.

Description of the design and large scale fortification of rice with lysine, threonine, thiamine, riboflavin, vitamin A and iron. The population studied obtains 70 to 80% of its calories from rice. Baseline data was obtained on

29 Test Villages including clinical, biochemical and anthropometric information. All the anthropometric measurements indicated that the Chiang-Mai Village children of this study were severely retarded in growth.

Maruyamn, K., Shands, H.L., Harper, A.E., and Sunde, A.L. An Evaluation of the Nutritive Value of New High Protein Oat Varieties. J. Nutr. 105:1048, August, 1975.

The study was conducted to evaluate the nutritive value of the newely developed oat varieties using chicks and rats. To correct amino acid deficiencies the oats were supplemented with 0.55, 0.60 and 0.65% lysine and 3.2, 5.1 and 6.6% of a mixture of other amino acids. The omission of lysine from the supplement resulted in retarded growth and a decrease in plasma lysine concentration. The protein efficiency ratio of oats increased from 2.2 to 2.4 by lysine-methionine supplementation.

Kies, C. and Mertz-Fox, H. Protein Nutritive Value of Opaque-2 Corn Grain For Human Adults. J. Nutr. 102:757, June, 1972.

Protein nutritive value of opaque-2 corn was studied in human adults under three separate conditions:

1) The first study consisted of a 3-day nitrogen depletion period and three experimental periods of 10 days each. During the experimental period, opaque-2 corn provided 4.0g of nitrogen/subject/day. The corn diets were supplemented with 0, 4.0, and 8.0g of nitrogen per subject per day from urea. The basal diet during the three experimental periods provided a total of 4.8, 8.8 and 12.8g N/subject/day, respectively. The mean N-balance of the subjects fed 4.0g N from ground opaque-2 corn plus 0.0, 4.0, and 8.0g N from urea were -0.36 + 0.27 and + 1.49g N/day. These results suggest that total nitrogen as well as favorable amino acid proportions may be important in determining the apparent nutritive value of this dietary protein source.

2) The 33-day second study was to determine the first limiting amino acid in degermed, ground opaque-2 corn for maintaining nitrogen equilibrium in human adults. The mean N-Balance of subjects maintained on 4.0g N/day from opaque-2 corn plus L-lysine, L-tryptophan, L-methionine, a combination of these amino acids or no essential amino acids was -0.11, -0.84, -0.77, -0.18 and -0.8 g/N/day. Nitrogen retention when L-lysine was added alone or in combination was significantly different than when unsupplemented opaque-2 corn was fed. This indicates that L-lysine is the first limiting amino acid.

3) Study 3 compared two strains of opaque-2 corn to whole ground Nebraska field corn for humans under conditions of equal intake of corn protein and under conditions of equal intake of corn grain. Nitrogen balance data indicate that the two strains of opaque-2 corn were superior to field corn.

Young, V.R., Ozalp, I., Cholakos, B.U. and Scrimshaw, N.S. Protein Value of Colombian Opaque-2 Corn For Young Adult Men. J. Nutr. 101:1475, November, 1971.

This paper reports the results of a study in eight young men of the nutritional quality of proteins of whole and degerminated Colombian corn containing the opaque-2 gene, compared with that of hen's egg as a reference protein. The test protein (whole corn, degerminated corn and whole dried hen's egg) provided essentially all the dietary nitrogen and were incorporated to supply 0.27 g protein/Kg/day. This level of protein was calculated to furnish about 10% less than the total nitrogen necessary to meet the average obligatory urinary and metabolic fecal nitrogen losses. The experimental results indicate that at relatively low levels of protein intake the nutritive value of whole and degerminated opaque-2 corn is about 80% of the value of whole hen's eggs. These data underscore the high quality of opaque-2 corn protein for humans.

Rice, H.L., Shamon, A.C., Matthias, R.H. and Flodin, N.W. Nitrogen Balance Responses of Young Men to Lysine Supplementation of Bread. J. Nutr. 100:847, July, 1970.

The study was planned to determine whether significant nitrogen-balance responses to lysine-supplementation could be observed in healthy young adults receiving diets in which the protein came mostly from white wheat flour in the form of bread. The subjects were 22 male students. Diets were fed at two protein levels, 0.75 g/kg and 1.1 g/kg/body weight. After standardization of subjects by feeding bread diets without lysine for nine days, nitrogen balance responses were measured in the succeeding 12-day period. Experimental groups received diets containing L-lysine. HCL baked into bread at 0.15, 0.25 and 0.45% based on flour weight. Control groups received isonitrogenous amounts of glycine baked into bread. Group responses to the lysine supplements were positive and statistically significant as compared to control subject.

Romo, G.S. and Linkswiler, H. Effect of Level and Pattern of Essential Amino Acids on Nitrogen Retention of Adult Men. J. Nutr. 97:147, January, 1969.

The studies reported were made to determine whether increasing the dietary intake of essential amino acids patterned as in the poorly balanced protein of corn would have a beneficial or an adverse effect on nitrogen retention in adult human subjects. The results indicate that at the level of 6.0 g total nitrogen intake, each increase in the intake of essential and semi-essential amino acid was accompanied by an increase in nitrogen retention. In a second study, nitrogen balance responses were compared when equivalent amounts of nitrogen were supplied by the essential plus semi-essential amino acid of egg protein and corn protein. The data indicated that when essential nitrogen provided 3.30 or 5.50 g, more positive nitrogen balances were obtained when subjects were fed the egg pattern than when they were fed the corn pattern of amino acids.

Drews, J.E., Moody, N.W., Hoys, V.W., Speer, V.C. and Ewan, R.C. Nutritional Value of Opaque-2 Corn For Young Chicks and Pigs. J. Nutr. 97:537, April, 1969.

One day old chicks and 25 day old pigs were used to study the effect of replacing normal hybrid corn with opaque-2 corn in diets containing varying levels of supplemented soybean meal. At suboptimal protein levels, both chicks and pigs gained significantly more weight with lower feed/grain ratios when opaque-2 corn replaced an equal amount of normal corn in the diet. There was a significant increase in body weight gain and decrease in feed required per unit of gain by chicks and pigs fed increased levels of soybean meal. Because of the higher protein and lysine content of opaque-2 corn as compared with normal hybrid corn approximately 5% less soybean meal was required in diets containing opaque-2 corn to result in maximum performance of chicks and pigs.

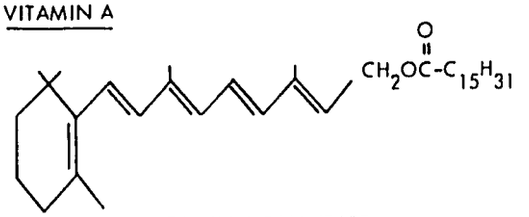
Graham, G.G., Placko, R.P., Acevedo, G., Morales, E. and Cordano, A. Lysine Enrichment of Wheat Flour, Evaluation in Infants. Am. J. Clin. Nutr.

The effect of lysine fortification was studied in six previously malnourished infants. The equivalent of 0.12% lysine enrichment of white wheat flour resulted in significant enhancement of its protein value for the rapidly growing human infant as demonstrated by increased rates of weight gain and nitrogen retention, stability of serum albumin. Isonitrogenous and isocaloric casein diets were used as controls. The authors suggest that enrichment of white wheat flour with lysine to the 0.12% and possibly the 0.2% level be considered in those areas of the world where cereal serves as the major source of protein particularly for infants and children.

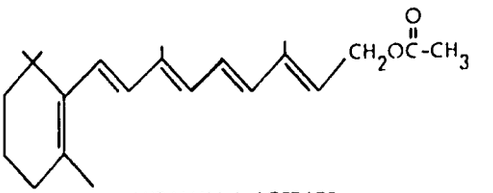
APPENDIX B

CHEMICAL STRUCTURES OF COMMERCIALLY PRODUCED VITAMINS

VITAMIN A

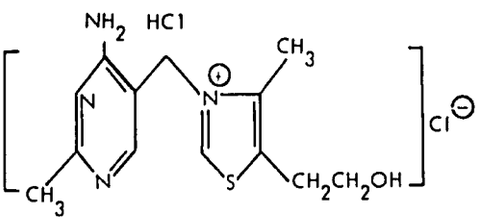


VITAMIN A PALMITATE

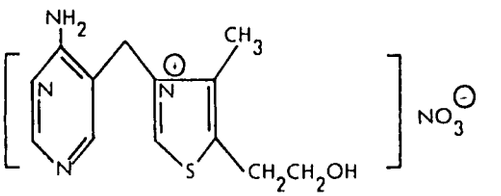


VITAMIN A ACETATE

THIAMINE

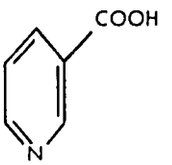


THIAMINE HYDROCHLORIDE

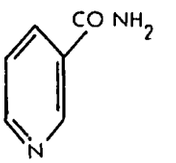


THIAMINE MONONITRATE

NIACIN

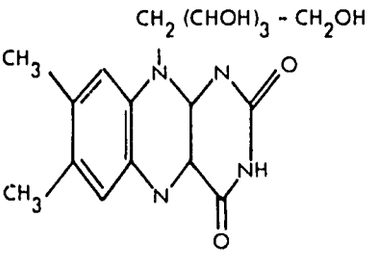


NICOTIVE ACID



NICOTINAMIDE

RIBOFLAVIN

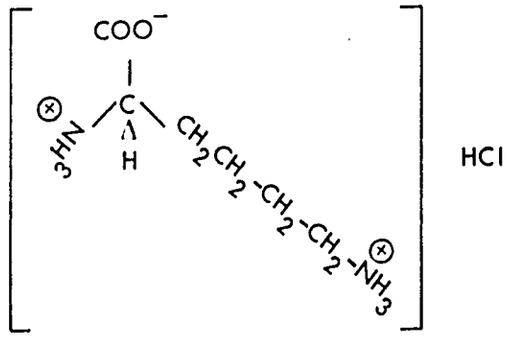


RIBOFLAVIN

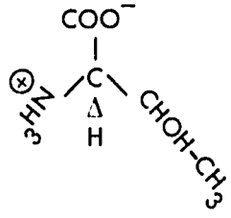
APPENDIX C

CHEMICAL STRUCTURES OF COMMERCIALLY PRODUCED AMINO ACIDS

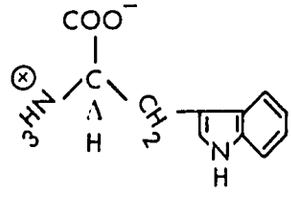
LYSINE HYDROCHLORIDE



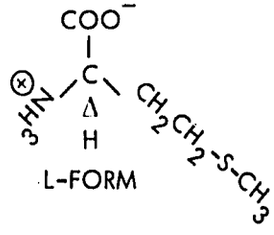
THIOMINE



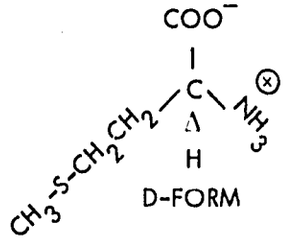
TRYPOTOPHAN



METHIONINE



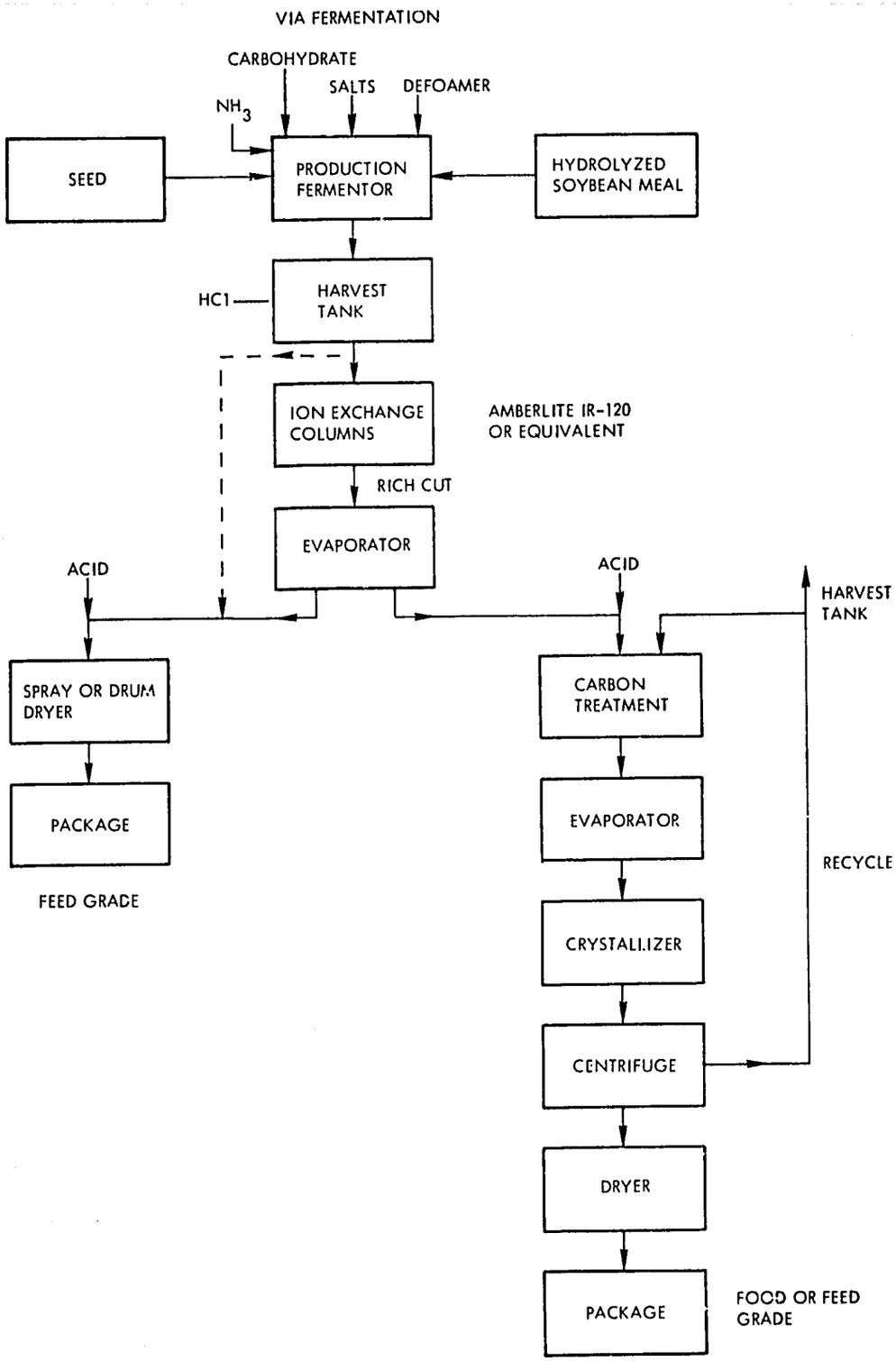
L-FORM

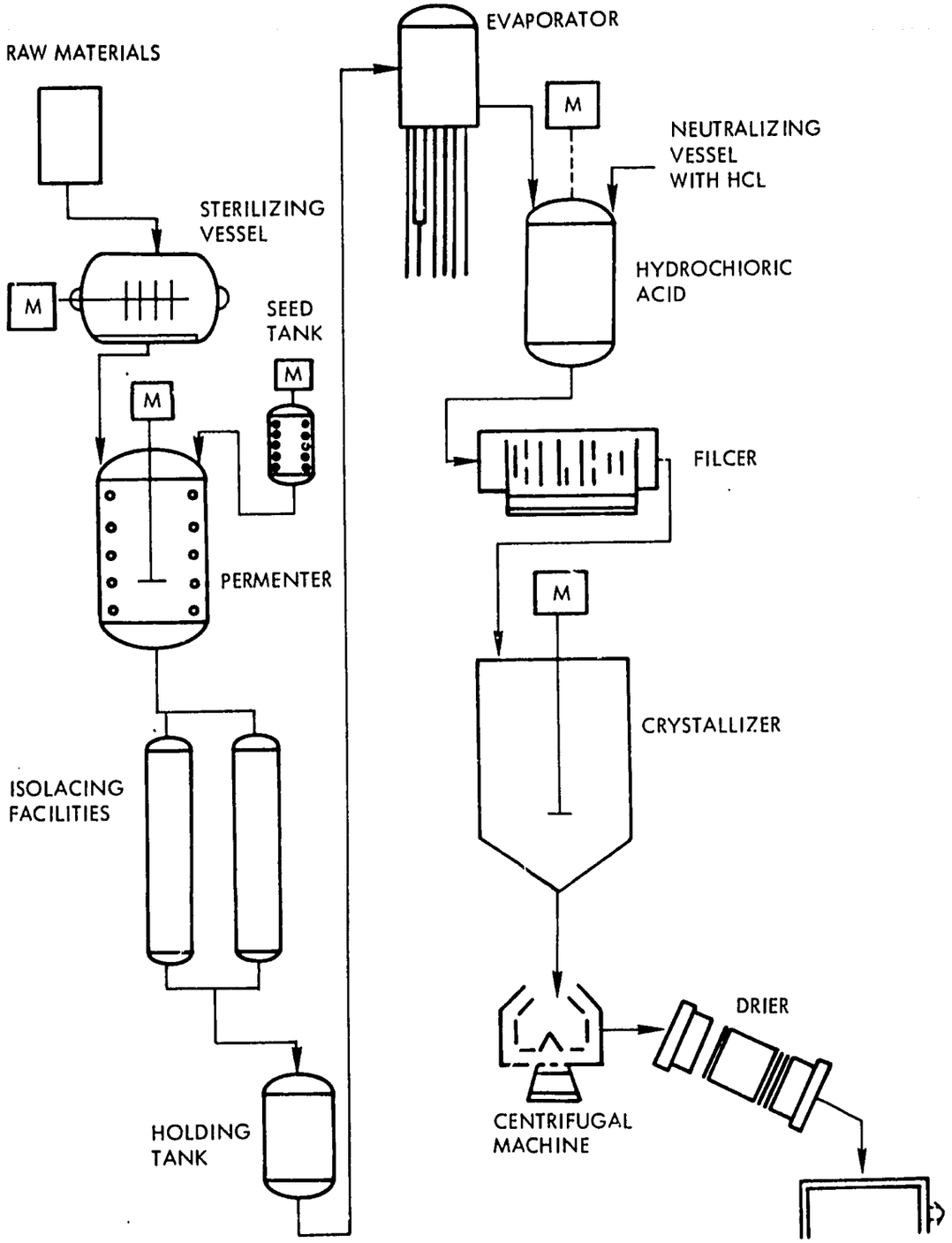


D-FORM

APPENDIX D

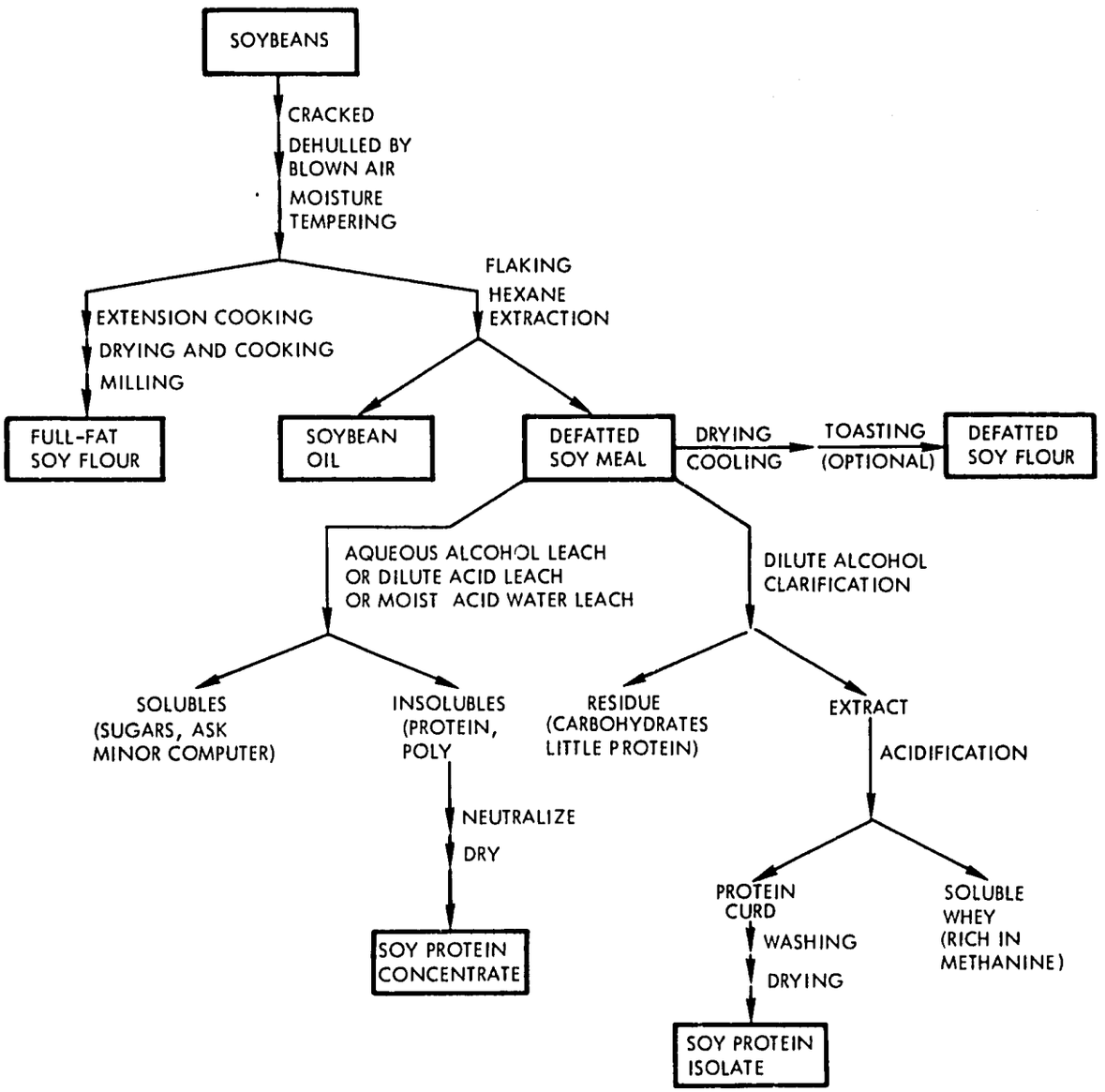
~~PROGRESS~~ PROCESS FOR THE INDUSTRIAL PRODUCTION OF L-LYSINE . HCL

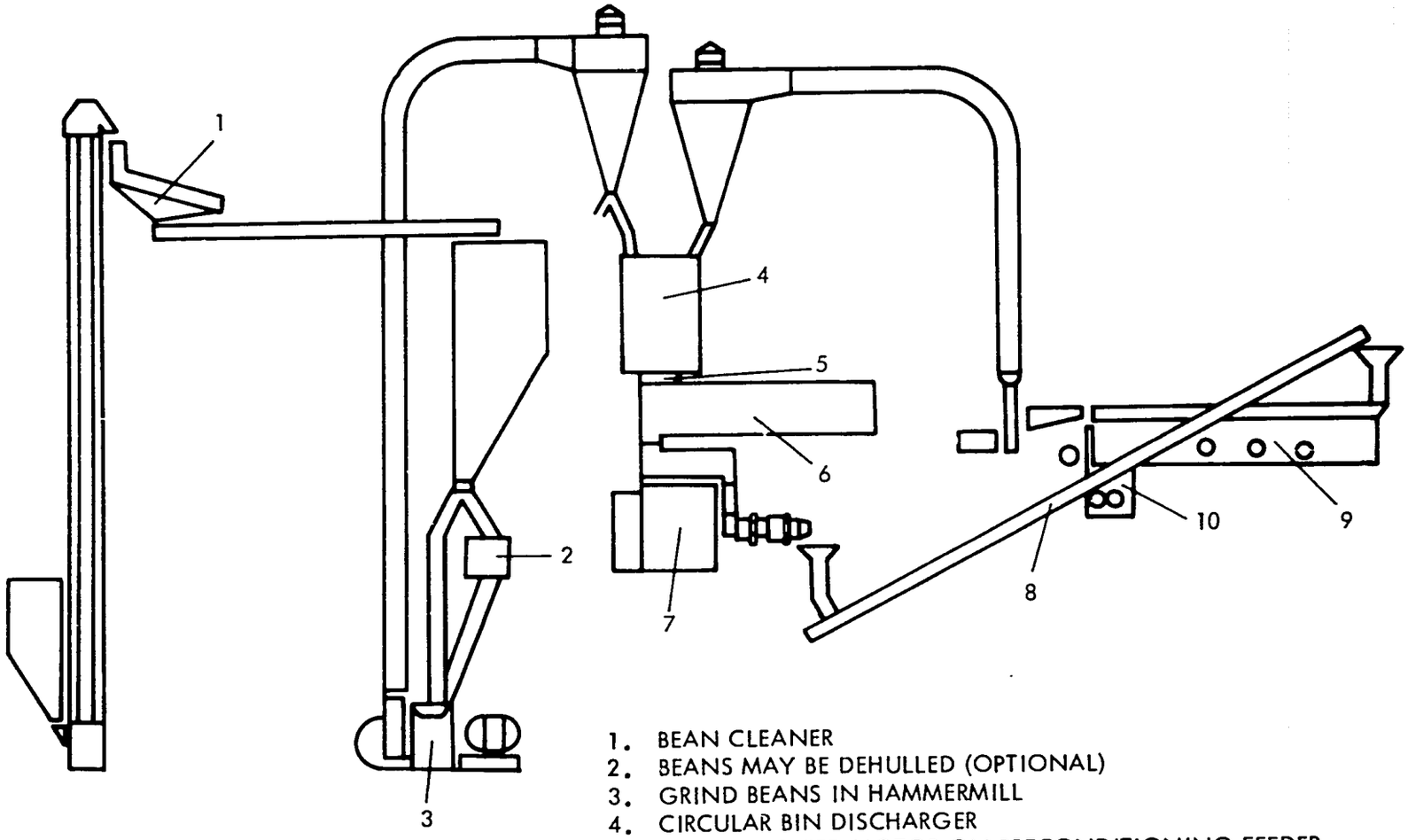

VIA FERMENTATION
CARBOHYDRATE
SALTS
DEFOAMER
NH_3
SEED
PRODUCTION FERMENTOR
HYDROLYZED SOYBEAN MEAL
HC1
HARVEST TANK
ION EXCHANGE COLUMNS
AMBERLITE IR-120 OR EQUIVALENT
RICH CUT
EVAPORATOR
ACID
ACID
HARVEST TANK
SPRAY OR DRUM DRYER
CARBON TREATMENT
PACKAGE
EVAPORATOR
RECYCLE
FEED GRADE
CRYSTALLIZER
CENTRIFUGE
DRYER
PACKAGE
FOOD OR FEED GRADE


RAW MATERIALS
STERILIZING VESSEL
M
SEED TANK
M
M
PERMENTER
ISOLACING FACILITIES
HOLDING TANK
EVAPORATOR
M
NEUTRALIZING VESSEL WITH HCL
HYDROCHIORIC ACID
FILCER
M
CRYSTALLIZER
CENTRIFUGAL MACHINE
DRIER

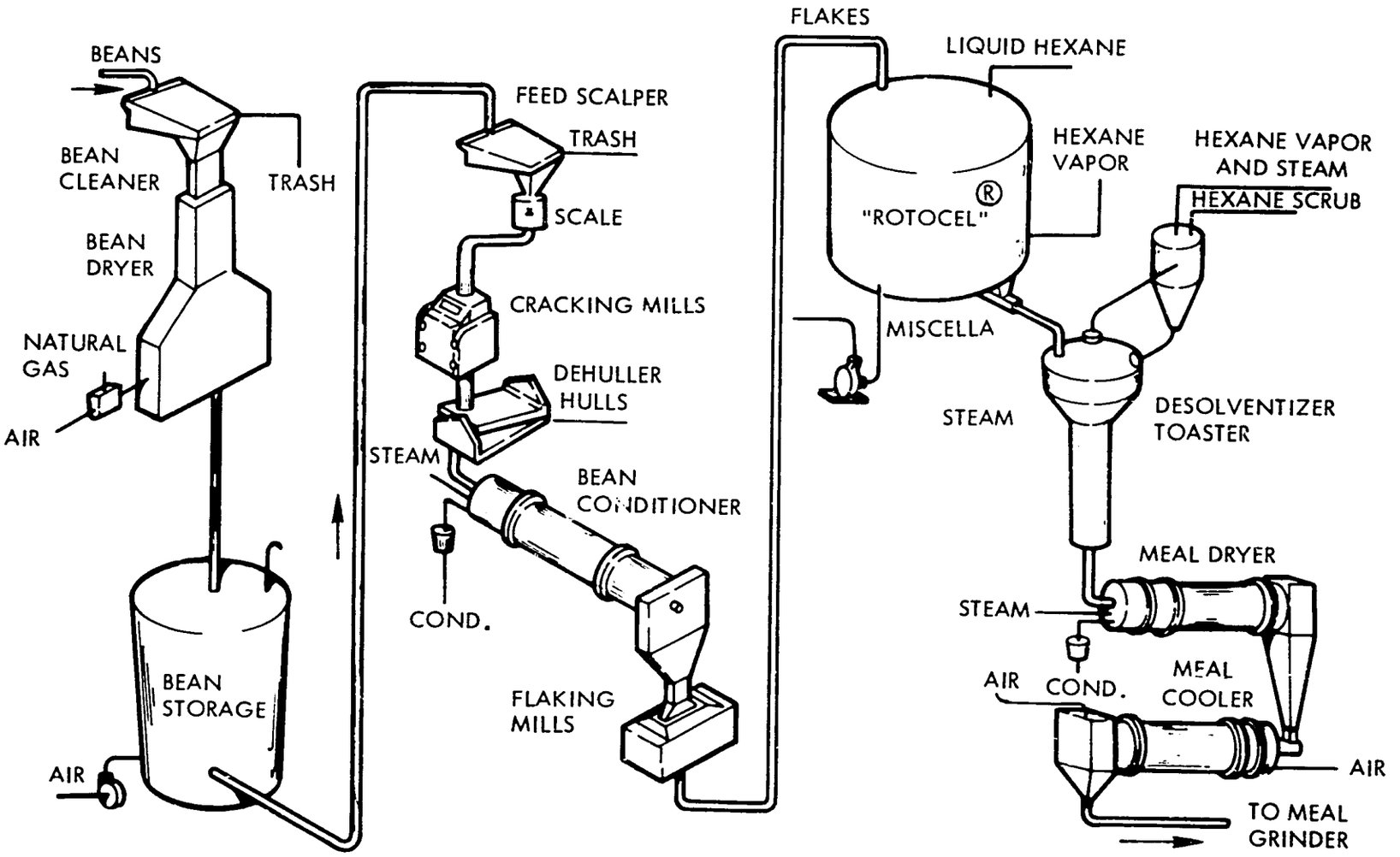
APPENDIX E

OUTLINE OF INDUSTRIAL PROCESSES FOR THE PRODUCTION OF SOY PROTEINS (Wolf and Cowan, 1971)


SOYBEANS
CRACKED
DEHULLED BY BLOWN AIR
MOISTURE TEMPERING
EXTENSION COOKING
DRYING AND COOKING
MILLING
FLAKING
HEXANE EXTRACTION
FULL-FAT SOY FLOUR
SOYBEAN OIL
DEFATTED SOY MEAL
DRYING
COOLING
TOASTING
(OPTIONAL)
DEFATTED SOY FLOUR
AQUEOUS ALCOHOL LEACH
OR DILUTE ACID LEACH
OR MOIST ACID WATER LEACH
DILUTE ALCOHOL CLARIFICATION
SOLUBLES (SUGARS, ASK MINOR COMPUTER)
INSOLUBLES (PROTEIN, POLY
RESIDUE (CARBOHYDRATES LITTLE PROTEIN)
EXTRACT
ACIDIFICATION
NEUTRALIZE
DRY
SOY PROTEIN CONCENTRATE
PROTEIN CURD
WASHING
DRYING
SOLUBLE WHEY (RICH IN METHANINE)
SOY PROTEIN ISOLATE



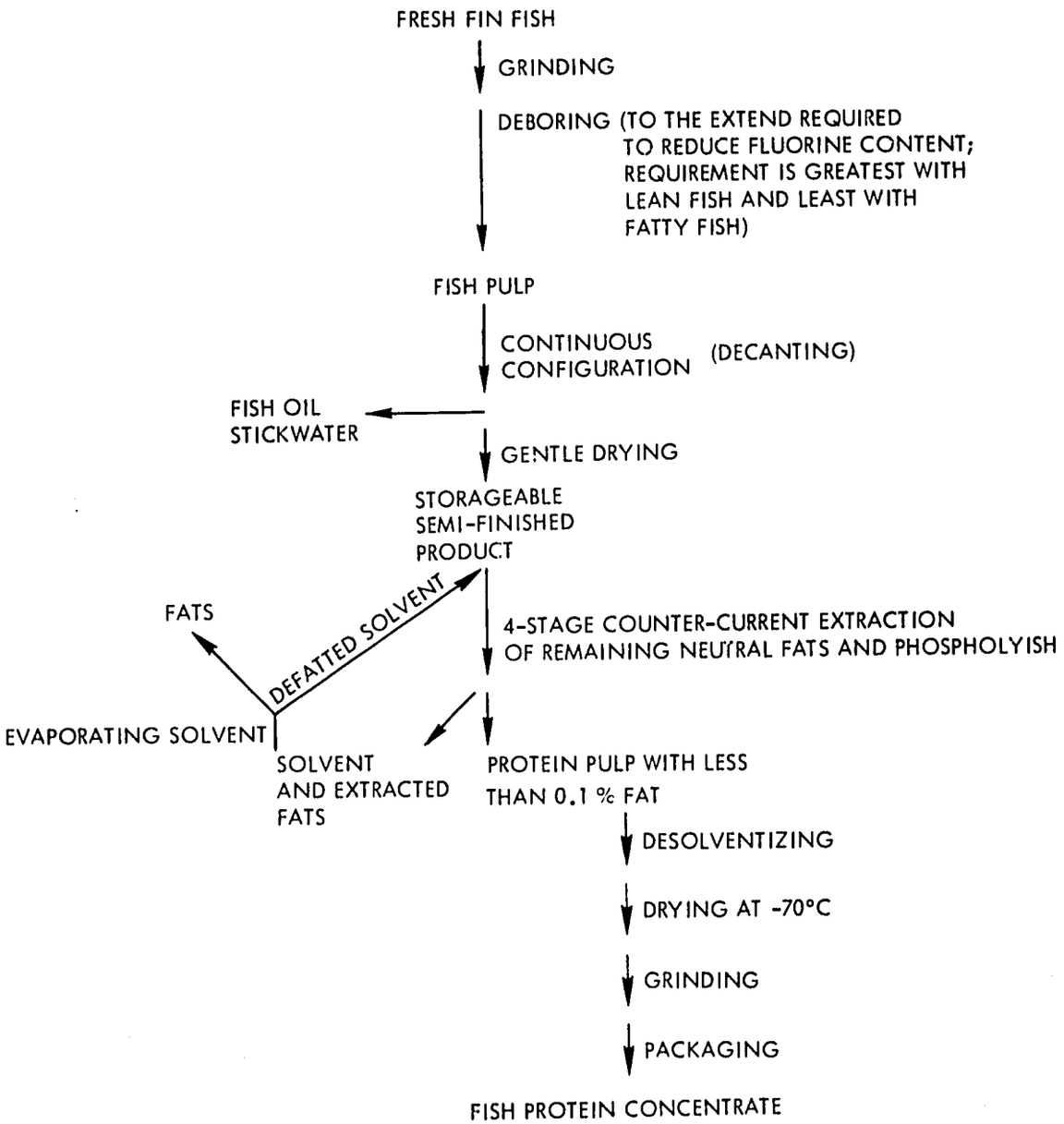
1. BEAN CLEANER
2. BEANS MAY BE DEHULLED (OPTIONAL)
3. GRIND BEANS IN HAMMERMILL
4. CIRCULAR BIN DISCHARGER
5. VARIABLE SPEED MOTOR ON PRECONDITIONING FEEDER
6. PRECONDITIONER
7. SHORT TIME/HIGH TEMPERATURE COOKING EXTRUDER
8. INCLINED BELT
9. HORIZONTAL COOLER
10. CRUMBLIZING ROLLS - BYPASS WHEN DESIRED

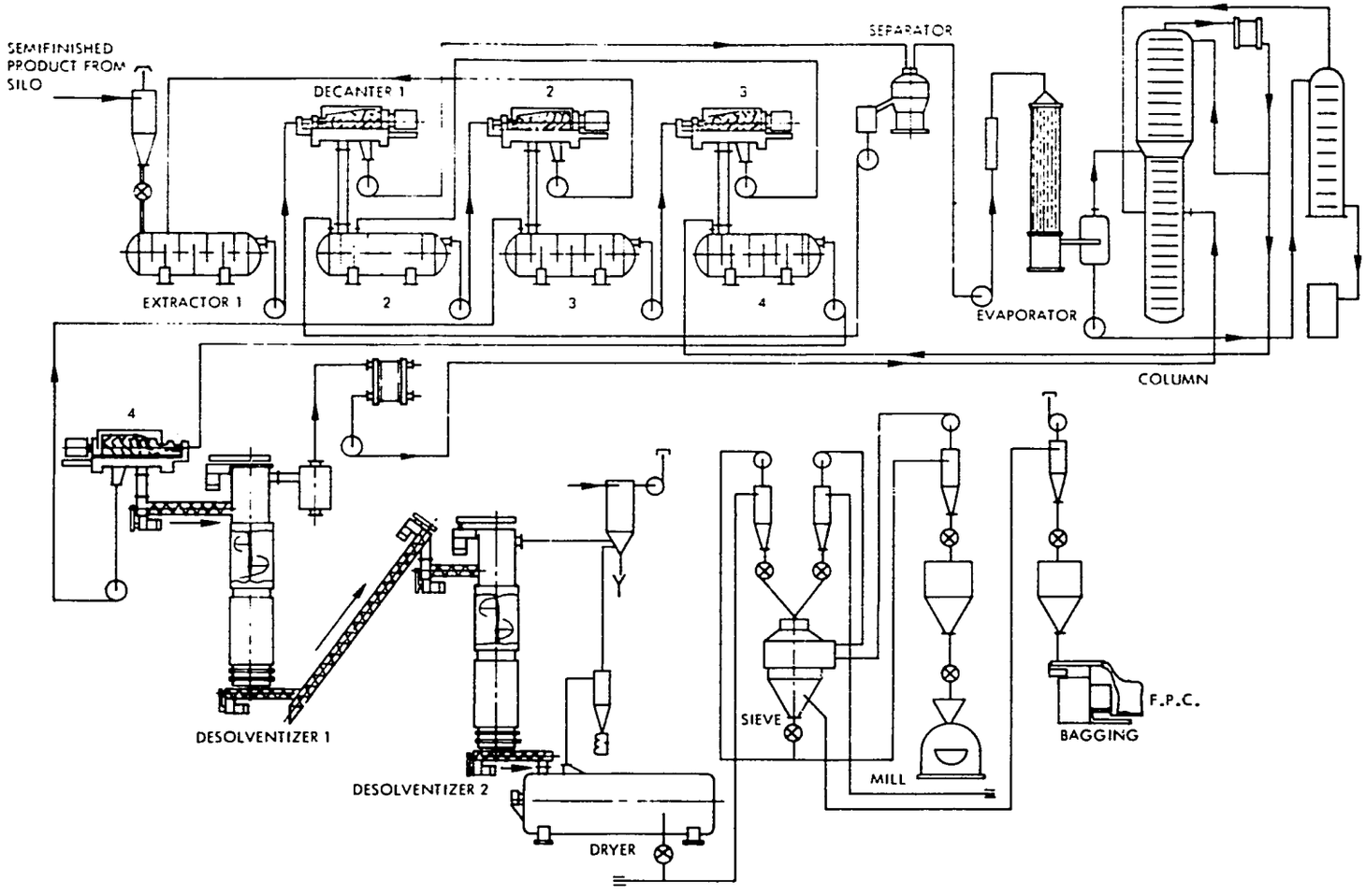

BEANS
BEAN CLEANER
TRASH
BEAN DRYER
NATURAL GAS
AIR
BEAN STORAGE
AIR
FEED SCALPER
TRASH
SCALE
CRACKING MILLS
DEHULLER
HULLS
STEAM
BEAN CONDITIONER
COND.
FLAKING MILLS
FLAKES
LIQUID HEXANE
"ROTOCEL" ®
HEXANE VAPOR
HEXANE VAPOR AND STEAM
HEXANE SCRUB
MISCELLA
STEAM
DESOLVENTIZER TOASTER
MEAL DRYER
STEAM
AIR
COND.
MEAL COOLER
AIR
TO MEAL GRINDER

APPENDIX F

PROCESS FOR PRODUCTION OF FISH PROTEIN CONCENTRATE

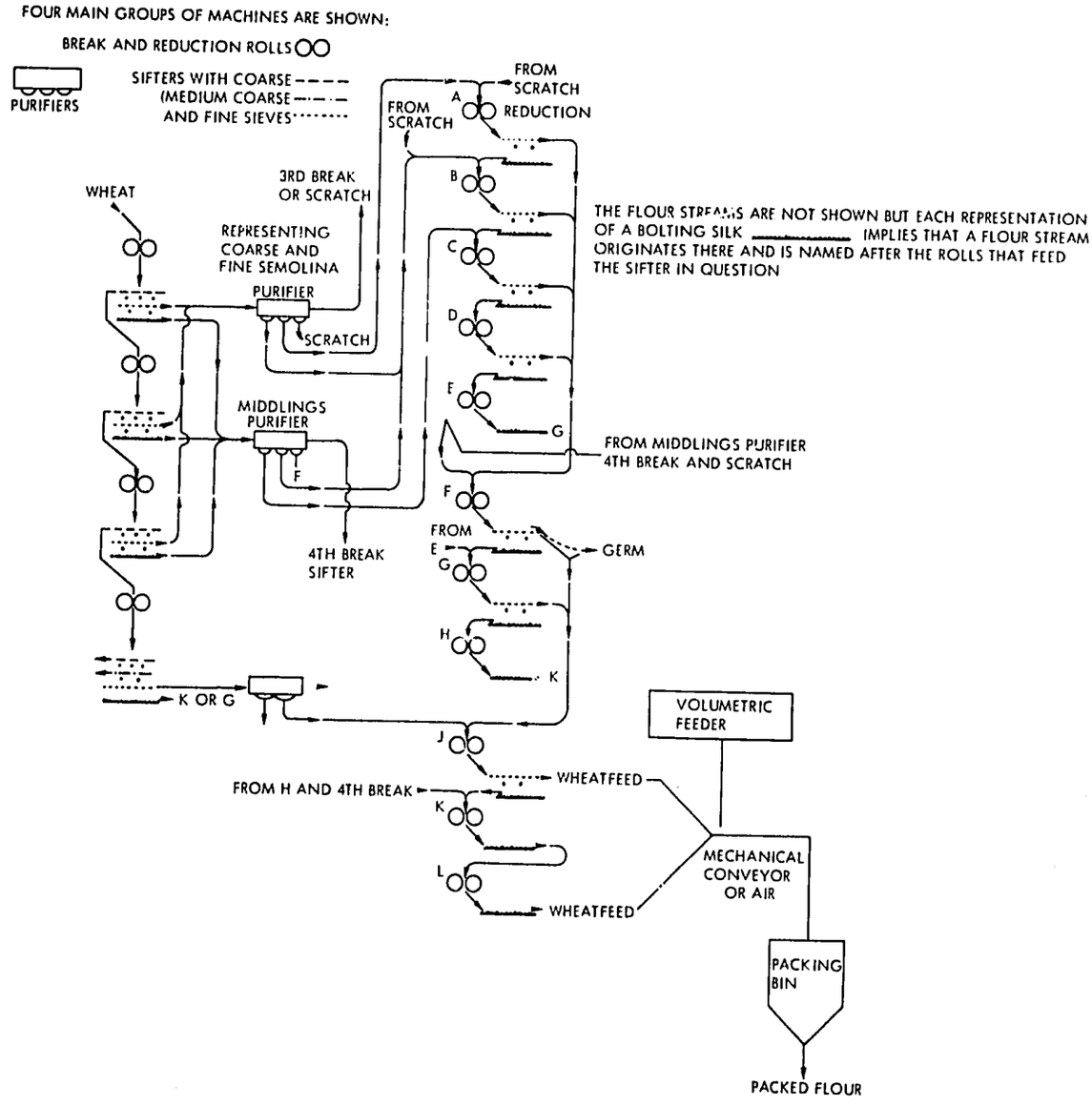
FLOW CHART OF THE ASTRA FPC PROCESS




SEMIFINISHED
PRODUCT FROM
SILO
DECANTER 1
2
3
SEPARATOR
EXTRACTOR 1
2
3
4
EVAPORATOR
COLUMN
4
DESOLVENTIZER 1
DESOLVENTIZER 2
DRYER
SIEVE
MILL
BAGGING
F.P.C.

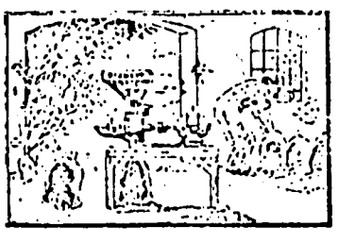
APPENDIX G

DIAGRAMMATIC REPRESENTATION OF FLOUR MILLING (Jones, 1958) AND PREMIX ADDITION IN CENTRALIZED MILLS



THE FLOUR STREAMS ARE NOT SHOWN BUT EACH REPRESENTATION OF A BOLTING SILK ——— IMPLIES THAT A FLOUR STREAM ORIGINATES THERE AND IS NAMED AFTER THE ROLLS THAT FEED THE SIFTER IN QUESTION

APPENDIX H
TUNISIAN VILLAGE WHEAT MILL



Diamant

GRAND PRIX

Rio de Janeiro 1923
Barcelona 1929

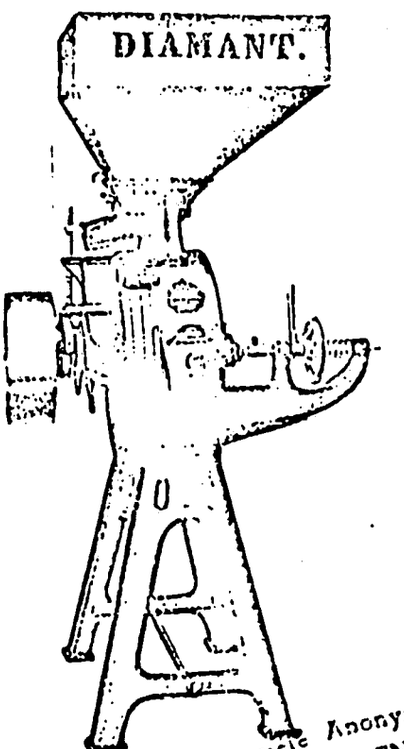
En Danemark, pays plus exigeant que tout autre pays en ce qui concerne les machines agricoles,

le moulin

"DIAMANT"

est

employé dans un nombre beaucoup plus grand que les moulins d'autres fabrications.



GRAND PRIX
HORS CONCOURS

Salonique 1936

Le moulin

"DIAMANT"

est employé par milliers dans toutes les parties du monde.

Les essais officiels et l'expérience pratique ont montré, que le moulin

"DIAMANT"

est le meilleur moulin du monde.

Société Anonyme Turis
ZARAA ENRIQUEZ & C°
S.A.T.Z.E.C.
Carthage-Tunis

Le meilleur moulin

A. B. C. HANSEN COMP. A/S - COPENHAGUE

INDUSTRIBYGNINGEN — ADRESSE TÉLÉGRAPHIQUE: ABCIMPULS - COPENHAGUE — INDUSTRIBYGNINGEN

CODES: A. B. C. 6e ÉDITION ET BENTLEY'S

Le moulin "DIAMANT"

ÉVITEZ LES IMITATIO:

EST SUPÉRIEUR À TOUT AUTRE MOULIN

en ce qui concerne

RENDEMENT — CONSOMMATION DE FORCE MINIME — ARRANGEMENT PRATIQUE — DURABILITÉ ET MANIEMENT FACILE —

1.

Entonnoir en bois de grandeur convenable.

2.

Appareil spécial qui au moyen d'un excentrique sur l'arbre et une bielle produit un mouvement oscillatoire de sorte que le produit à moudre passe de l'entonnoir dans l'intérieur du moulin.

3.

Ressort monté autour de l'arbre et conduisant le produit à moudre jusqu'au centre des meules.

4.

Poulie au moyen de laquelle le moulin peut être tiré par un moteur ou au moyen d'un arbre.

5.

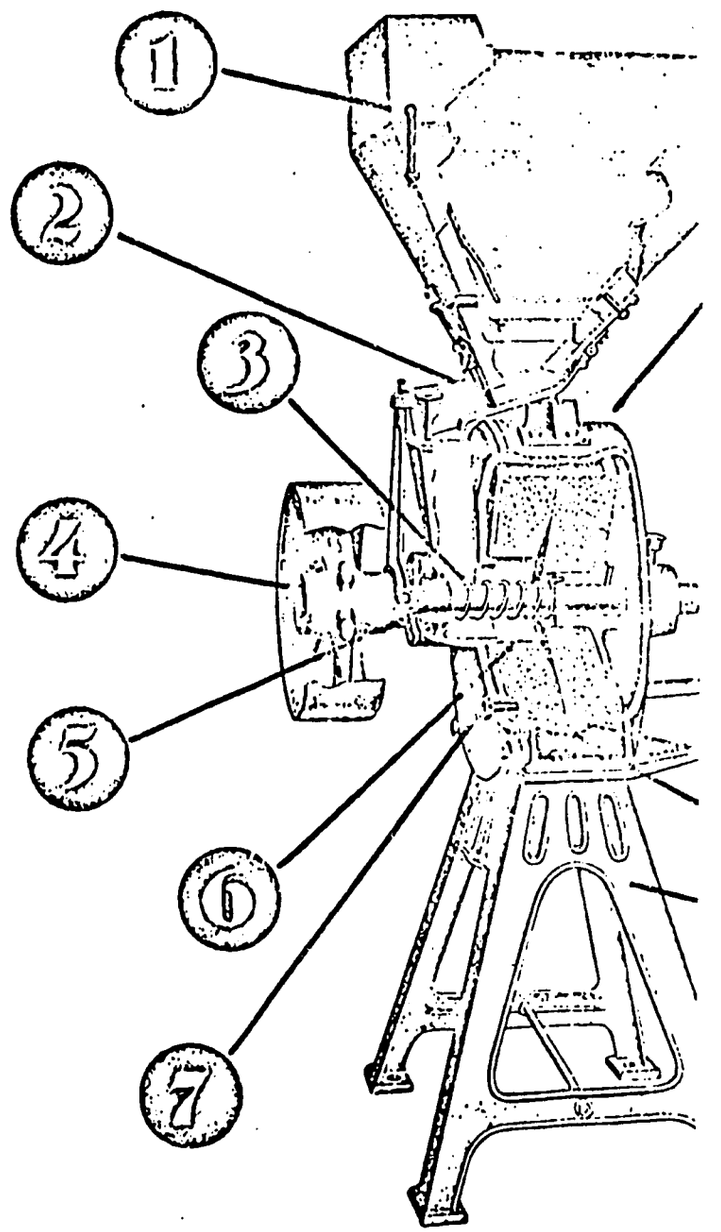
Arbre de moulin tournant aves le moins de friction possible dans des paliers à billes à l'épreuve de la poussière.

6.

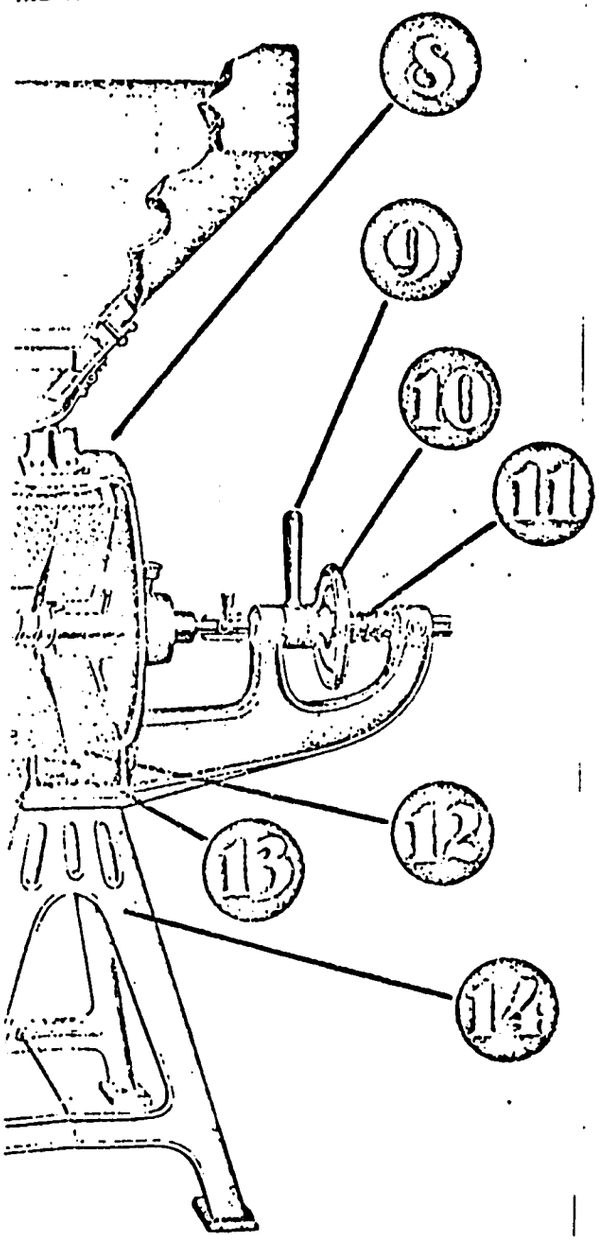
Les meules "DIAMANT" — le coeur du moulin — sont faites d'une composition, qui est le secret de la fabrique. Elle consiste en plusieurs matières mélangées avec des pierres françaises de la meilleure qualité, de sorte que les meules du moulin "DIAMANT" sont aussi poreuses que les meules naturelles, aussi dures que le silex, et elles possèdent une capacité et une durabilité qui dépassent celles de toutes autres meules, qu'elles soient naturelles, artificielles ou faites d'acier.

7.

Couvercle avec palier à billes formant l'un côté de l'enveloppe du moulin, et auquel est fixée l'une des meules, la meule stationnaire.



Le moulin "Di



Le moulin "DIAMANT"

en ce qui concerne son utilité, est

UNE MACHINE UNIVERSELLE,

qui convient à moudre toutes sortes de graine ainsi que les pois, l'avoine, le café, le sucre, les épices, les produits chimiques et d'autres produits secs. Il moud à n'importe quelle finesse désirée.

8.

Enveloppe du moulin fabriquée de fonte et solidement construite.

9.

Mécanisme de débrayage instantané muni d'un manche au moyen duquel les meules peuvent être écartées l'une de l'autre pour faciliter la mise en marche, ou pendant la marche afin d'enlever les objets durs tels que morceaux de fer, pierres, etc, qui se seraient glissés dans le moulin avec les produits à moudre; et cela peut se faire sans toucher à la roue à main modératrice.

10.

Roue à main au moyen de laquelle on peut facilement et d'une façon commode ajuster les meules afin d'obtenir le degré de finesse désiré du produit à moudre.

11.

Ressort de sûreté qui agit au moment même où un objet dur se glisse entre les meules; ainsi les meules sont protégées contre les dégâts qui peuvent être causés par des objets qui souvent se trouvent parmi le produit à moudre.

12.

Deux orifices — un de chaque côté du moulin — avec des portes de sorte que le moulin peut marcher constamment, même lorsqu'on change les sacs.

13.

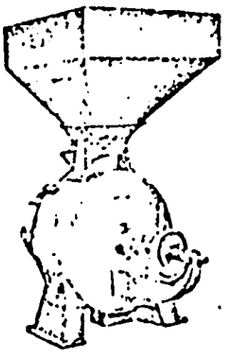
Porteur de sac à chaque orifice constituant un arrangement simple et pratique.

14.

Bâti de fer d'une hauteur convenable et solidement construit.

Diamant"

LE MOULIN
"DIAMANT"

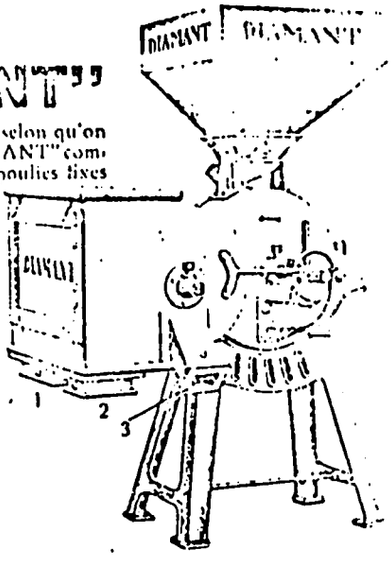


MOULIN "DIAMANT" AVEC SORTIE DE FOND POUR LA MOUTURE DE CAFÉ

peut être livré avec bâti de fer ou sans bâti, selon qu'on le désire. Les accessoires standard du "DIAMANT" comprennent une poulie à courroie, mais des poulies fixes et des poulies folles peuvent être fournies aussi: mais elles ne sont pas nécessaires, vu que le moulin est d'une marche si facile, qu'il se met en mouvement avec n'importe quelle force motrice.

Le moulin "DIAMANT" peut être livré directement couplé à un moteur électrique, ou combiné à un tamis, si le moulin est particulièrement destiné à moudre la farine.

Comme le rendement dépend naturellement de la force motrice disponible, de la nature des produits à moudre, et de la finesse désirée, il est impossible d'indiquer un rendement qui puisse être obtenu dans toutes les circonstances. C'est pourquoi les chiffres du tableau ci-dessous indiquent le rendement du moulin employé dans les fermes danoises, où il est employé par milliers.



MOULIN "DIAMANT" COMBINÉ À UN TAMIS

Les dimensions etc. des moulins "DIAMANT"

Diamètre des meules	24" - 600 mm	20" - 500 mm	16" - 400 mm	12" - 300 mm	10" - 250 mm
poulie normale	500×130 mm 20"×4"	400×105 mm 16"×4"	300×105 mm 12"×4"	250×90 mm 10"×3½"	200×75 mm 8"×3"
puissance en chevaux tours par minute rendement par heure	10 - 15 425 600 - 800 kgs.	7 - 9 525 400 - 550 kgs.	4 - 5 600 250 - 300 kgs.	3 - 4 700 175 - 225 kgs.	2 - 3 800 100 - 150 kgs.
puissance en chevaux tours par minute rendement par heure	15 - 20 450 800 - 1000 kgs.	8 - 10 550 500 - 600 kgs.	5 - 7 650 300 - 450 kgs.	4 - 5 750 250 - 300 kgs.	3 - 4 900 150 - 200 kgs.
puissance en chevaux tours par minute rendement par heure	20 - 25 475 1000 - 1200 kgs.	10 - 15 575 600 - 650 kgs.	7 - 9 700 400 - 550 kgs.	5 - 6 800 275 - 350 kgs.	
prix		276.000	264.000	176.000	

Pour les mots de code, les poids, etc. voir la liste à part

Most sales 4 - adjustable.

En dehors de milliers de références favorables reçues d'acheteurs satisfaits du moulin à moudre „DIAMANT", nous avons devant nous les rapports ci-dessous au sujet d'essais officiels faits en Danemark.

RAPPORT DE LA SOCIÉTÉ AGRICOLE ROYALE DANOISE, 1913.

"DIAMANT" est un moulin de bel aspect et bien construit, et d'une capacité de travail exceptionnellement supérieure comparativement à sa grandeur.

La finesse peut être réglée commodement et surement, de manière à obtenir un produit fin ou gros suivant le désir.

Le rendement est très élevé en comparaison de la force motrice exigée.

Pendant l'essai il n'y a eu aucun dérangement de n'importe quel genre.

En égrugeant de la façon ordinaire, le produit à moudre ne devint pas plus chaud qu'il ne pût être conservé dans les sacs.

D'un essai fait en 1925 le juge rapporte ce qui suit:

"DIAMANT" est un moulin particulièrement solide, et c'est un avantage que les meules peuvent être écartées au moyen du mécanisme de débrayage instantané sans toucher la roue à main modératrice, comme c'est également un avantage que le moulin est muni de deux ouvertures de sortie pour changer les sacs, et que les portes sont arrangées de façon à ce que les deux ouvertures ne peuvent être fermées en même temps. Les porteurs de sacs tiennent bien les sacs et ne les endommagent pas.

Quant à l'économie il résulte de la déclaration du juge, que la consommation de force du moulin "DIAMANT" est de

30 % plus favorable

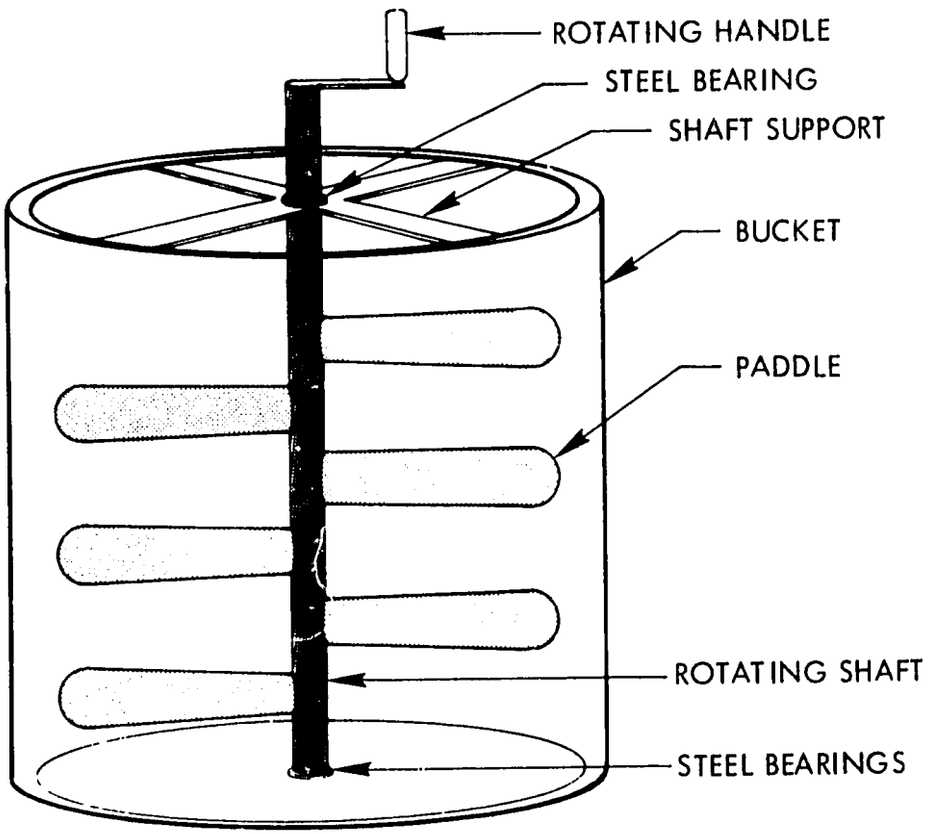
que celle des moulins pareils.

GARANTIE. Nous garantissons le moulin "DIAMANT" — y compris les meules — pour une période de deux ans à partir de la date de la facture, en ce que nous remplaçons gratuitement f.à.b. port danois, toutes pièces qui par suite de mauvais matériaux ou mauvais travail ne conviennent pas à l'usage.

APPENDIX I

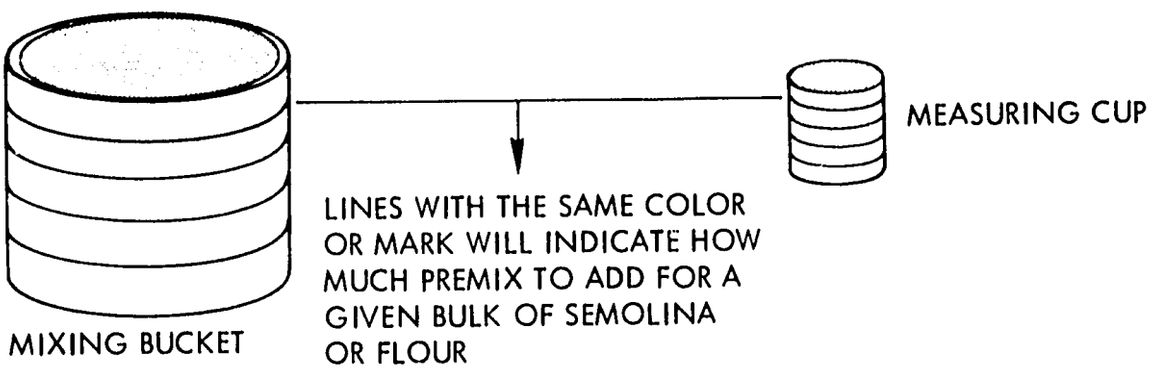
MANUAL PROCEDURE FOR FORTIFYING SEMOLINA AND FLOUR AT THE VILLAGE MILL

DESCRIPTION OF THE MIXING BUCKET



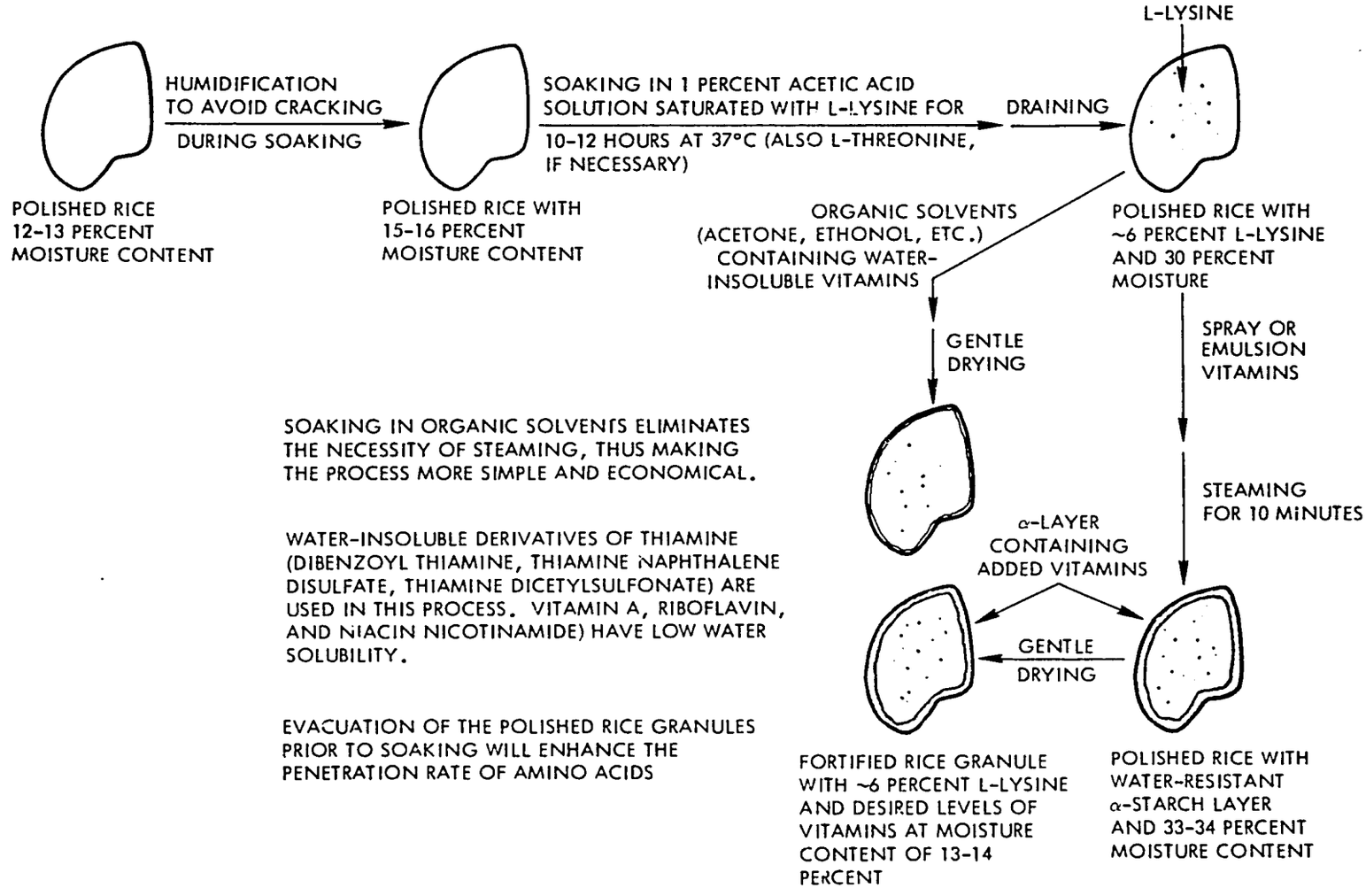
THE MIXING BUCKET CAN BE MADE FROM WOOD OR PLASTIC WHILE THE ROTATING SHAFTS CAN BE MADE OF WOOD EXCEPT FOR THE BEARINGS (STEEL).

STANDARDIZED MIXING BUCKET AND MEASURING CUP



APPENDIX J

PRODUCTION OF AMINO ACID AND VITAMIN ENRICHED RICE KERNELS BY INFUSION (Mitsuda and Yasumoto, 1974)



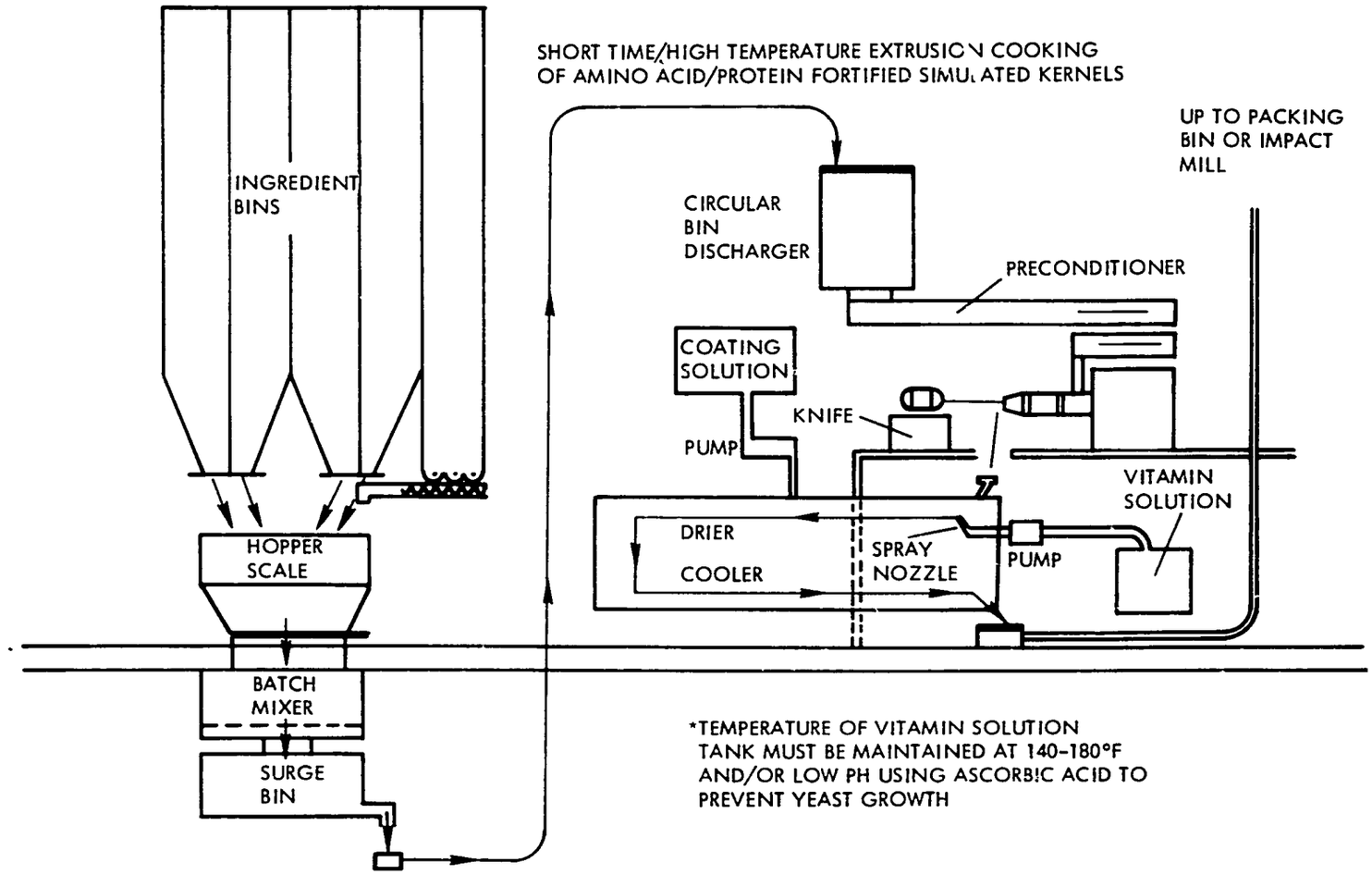
SOAKING IN ORGANIC SOLVENTS ELIMINATES THE NECESSITY OF STEAMING, THUS MAKING THE PROCESS MORE SIMPLE AND ECONOMICAL.

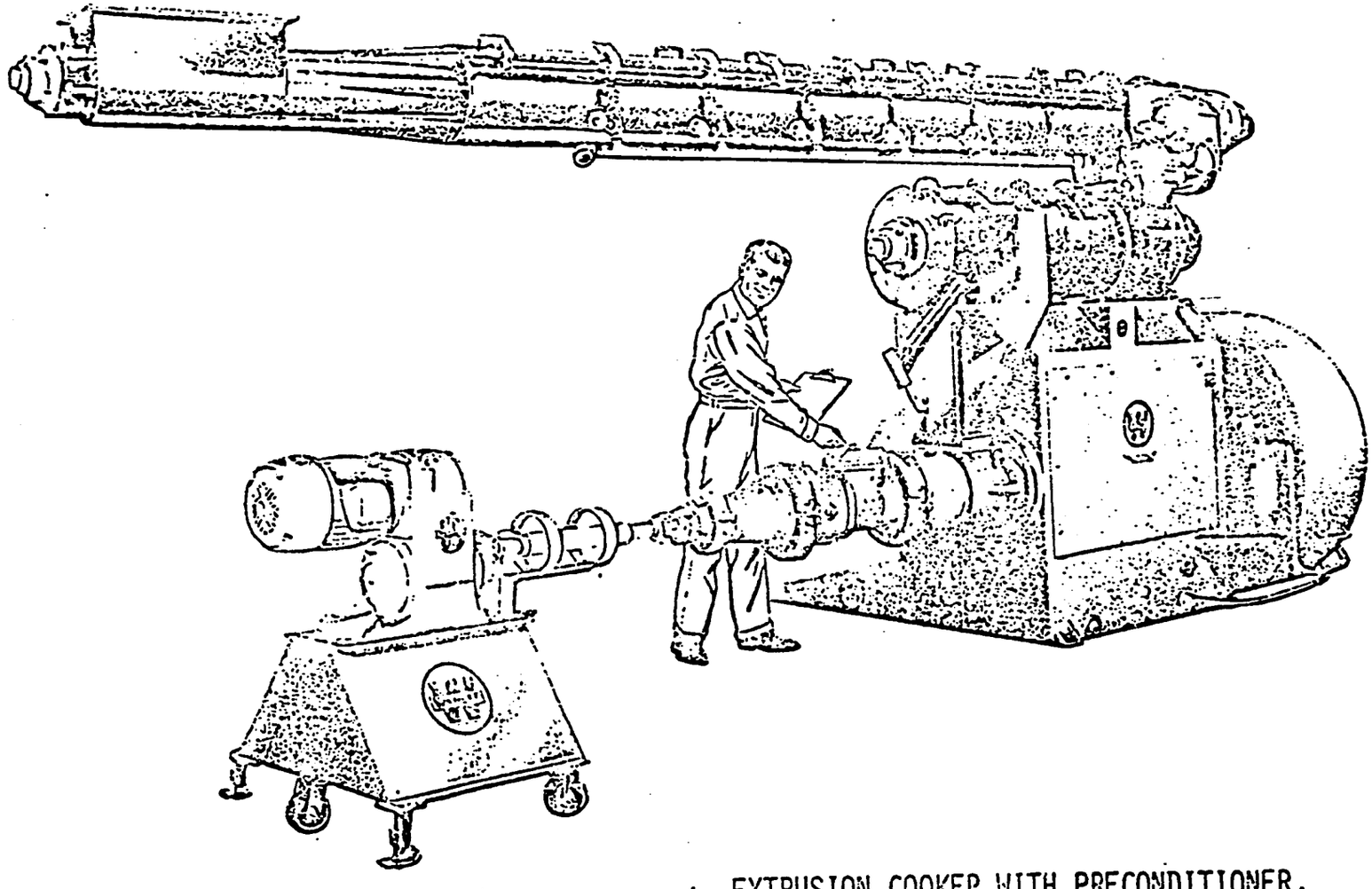
WATER-INSOLUBLE DERIVATIVES OF THIAMINE (DIBENZOYL THIAMINE, THIAMINE NAPHTHALENE DISULFATE, THIAMINE DICETYLSULFONATE) ARE USED IN THIS PROCESS. VITAMIN A, RIBOFLAVIN, AND NIACIN NICOTINAMIDE) HAVE LOW WATER SOLUBILITY.

EVACUATION OF THE POLISHED RICE GRANULES PRIOR TO SOAKING WILL ENHANCE THE PENETRATION RATE OF AMINO ACIDS

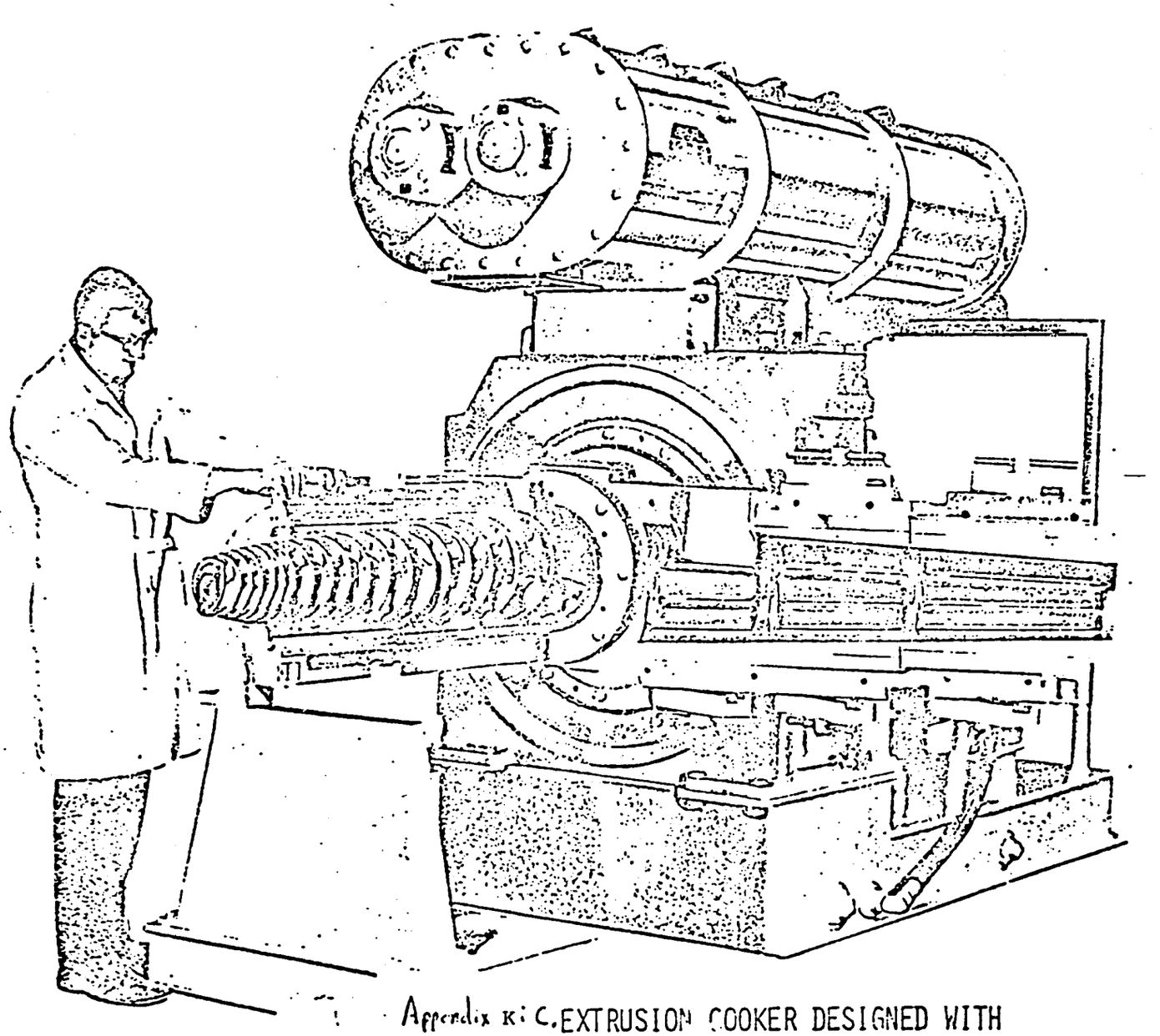
APPENDIX K

A SCHEMATIC OUTLINE OF THE SIMULATED KERNEL PROCESS

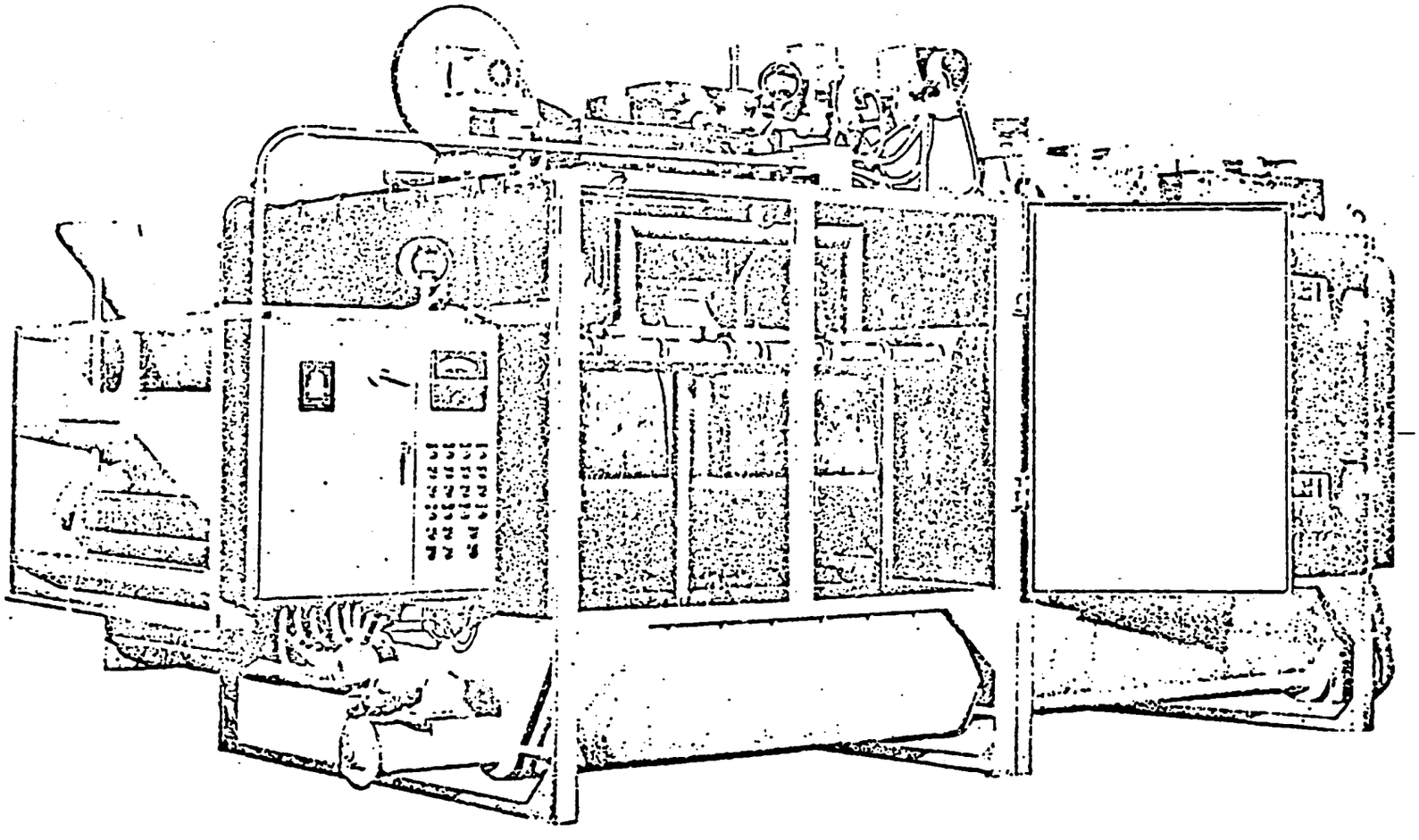

SHORT TIME/HIGH TEMPERATURE EXTRUSION COOKING
OF AMINO ACID/PROTEIN FORTIFIED SIMULATED KERNELS
UP TO PACKING
BIN OR IMPACT
MILL
INGREDIENT
BINS
CIRCULAR
BIN
DISCHARGER
PRECONDITIONER
COATING
SOLUTION
KNIFE
PUMP
VITAMIN
SOLUTION
DRIER
COOLER
SPRAY
NOZZLE
PUMP
HOPPER
SCALE
BATCH
MIXER
SURGE
BIN
*TEMPERATURE OF VITAMIN SOLUTION
TANK MUST BE MAINTAINED AT 140-180°F
AND/OR LOW PH USING ASCORBIC ACID TO
PREVENT YEAST GROWTH



Appendix K: b. EXTRUSION COOKER WITH PRECONDITIONER, VARIABLE SPEED KNIFE



Appendix K: C. EXTRUSION COOKER DESIGNED WITH ACCESSIBLE EXTRUSION ASSEMBLY



APPENDIX K: J. DRIER/COOLER DESIGNED FOR EXTRUSION COOKED PRODUCTS

APPENDIX L

APPENDIX L: a. ESTIMATES[1] OF CAPITAL AND OPERATING COSTS OF THE EXTRUSION COOKING SYSTEM USED TO MAKE SIMULATED KERNELS

	Capital cost (million $)	Operating cost ($/hr)
basic extrusion cooking system[2]	.26	17.8
building and related facilities	.44	9 (includes management)
miscellaneous (running-in, etc)	.20	2.5
quality control laboratory	.10	2.5
Total	1.0	29.3

[1]All the capital and operating cost estimates are based on a unit producing 4000 lbs of extruded goods per hour.

[2]For both capital cost and operating cost, 10 percent has been added to the 1976 estimates provided by Wenger Manufacturing.

APPENDIX L: b. ESTIMATES OF THE COST OF PRODUCING DIFFERENT QUANTITIES OF SIMULATED KERNELS (million $)

tons/yr.	Production hours	Capital cost	Operating cost[1]	L-lysine[2]	Binding starch	Vitamin	Cost of simulated kernels ($/kg)	L-threonine[2]	Cost ($/kg) with L-threonine
10900	6000	1	.1758	12.208	1.199	1.09	1.44	21.8	3.44
8000	4400	1	.1289	8.96	.88	.80	1.47	16.0	3.47
6000	3300	1	.097	6.720	.660	.60	1.51	12.0	3.51
4000	2200	1	.0645	4.480	.44	.40	1.60	8.0	3.60
2000	1100	1	.0322	2.240	.22	.20	1.85	4.0	3.85

APPENDIX L: b. (continued)

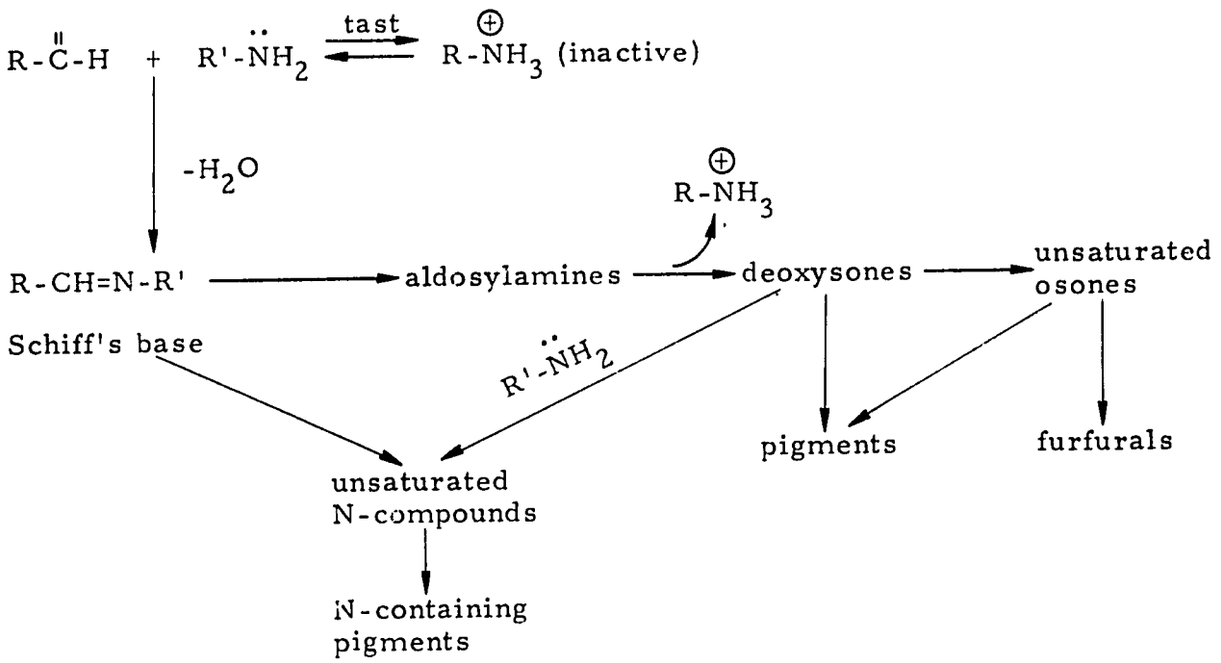
[1]Total operating cost = operating cost per hour (29.3) X production hours. No adjustment has been made for administrative, depreciation, etc. costs since these are very minor components of the final simulated kernel cost.

[2]Simulated kernels are assumed to contain 20 percent L-lysine, 10 percent L-threonine, 50 percent starch, and small quantities (~5 percent) of vitamins. L-lysine price is estimated $1.12/kg simulated kernel (Table 8). L-threonine price is estimated at $2/kg simulated kernel. $20/kg L-threonine is used rather than the current price ($57.70/kg) which is quoted for pharmaceutical grade L-threonine. Starch is estimated at $.11/kg simulated kernel by adding 20 percent to the data provided by Wooden (1974). Vitamin price per kg simulated kernel is estimated at $.1/kg simulated kernel which is approximately 10 percent the cost of L-lysine per kg simulated kernel.

APPENDIX M
MAILLARD BROWNING REACTION

MAILLARD BROWNING REACTION

Maillard Reaction involves condensations of carbonyl groups from reducing sugars[1] or lipid oxidation products[2] with alpha-amino groups of free amino acids, ϵ-amino group of lysine, and, to a less extent, imino groups of histidine and tryptophan. A general mechanism of Maillard Reaction is given below:



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[1]Reducing sugars are capable of reacting with Fehling's solution to give Cu(I)OH↓ which is red in color. Some examples of reducing sugars are glucose, fructose, galactose, mannose, ribose, xylose, maltose, and lactose. Sucrose, starch, and cellulose are non-reducing, but, upon warming for a short time with 5 percent HCl, these sugars are hydrolyzed to reducing sugars. Hydrolysis can also be effected by invertase (sucrose ⟶ glucose + fructose), amylase (starch ⟶ glucose, maltose), etc.

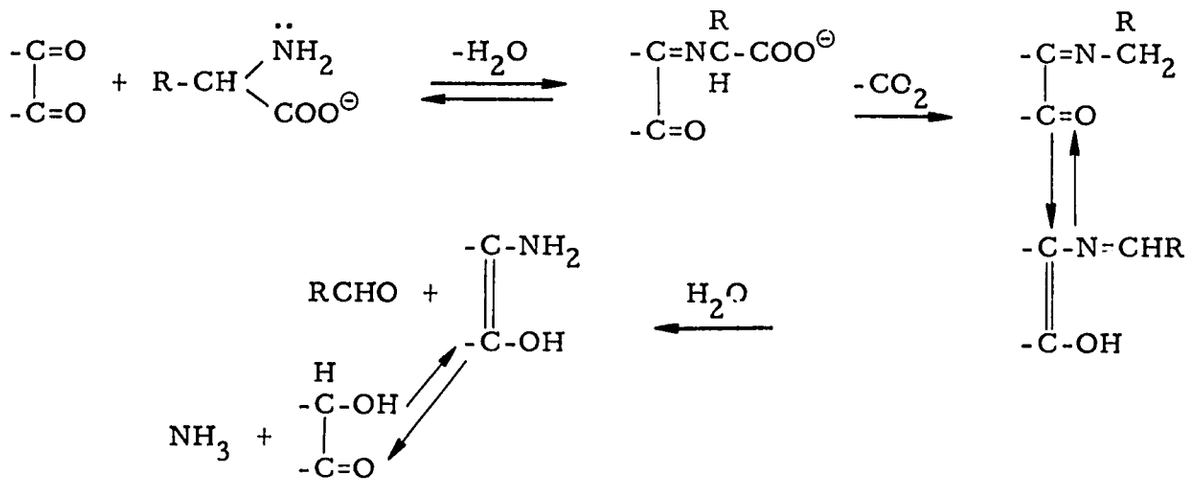
[2]Upon storage, polyunsaturated fatty acids (e.g. linoleic, linolenic, arachidonic acids) are rapidly oxidized to lipid hydroperoxides, particularly in the presence of pre-oxidants, such as lipoxidases, heme-proteins, transition metal ions, light, etc. Lipid hydroperoxides subsequently breakdown into carbonyls (alkanals, alkenals, alkadienals, ketones, etc.), hydrocarbons, and alcohols through free-radical autocatalytic processes. In addition to their roles in Maillard Reaction, carbonyls from lipid oxidation are often the sources of off-flavors and limit the storage life of food containing unsaturated lipids (e.g. spray-dried milk).

During the processing or storage of food, rates of browning and loss of free amino groups due to Maillard Reaction generally increase with temperature and pH. These rates increase with rising water activity to a maximum at .6-.8 (which correspond to 10-20 percent moisture content in many food systems) and then decrease with further rise in water activity. Recent findings indicate that trace metals (e.g. 30 ppm Fe^{++}, Mn^{++}) accelerate Maillard Reaction (Hashiba, 1976).

APPENDIX N
STRECKER DEGRADATION

STRECKER DEGRADATION

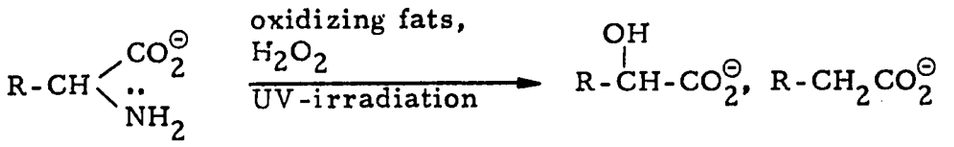
Strecker Degradation of alpha-amino acids by carbonyls are complicated processes which yield CO_2, aldehydes, and amino compounds as end products. In addition to alpha-amino acids, this reaction requires relatively high temperatures (e.g. 100 °C) and carbonyls with the structure $-C-[-\overset{|}{C}=\overset{|}{C}-]_n-C-$ where n = 0 or an integer. Thus, glucose does not degrade a alpha-amino acids via Strecker Degradation when the reaction is carried out in the absence of oxygen even at 100 °C. In the presence of oxygen, glucose is oxidized to a substance containing the active $-C-[-\overset{|}{C}=\overset{|}{C}-]_n-C-$ group which subsequently reacts with alpha-amino acids. A general mechanisms of Strecker Degradation is given below:



N.B. No ammonia is evolved because equilibrium favors the combined form with carbonyl.

DESTRUCTION OF AMINO ACIDS UNDER OXIDIZING CONDITIONS

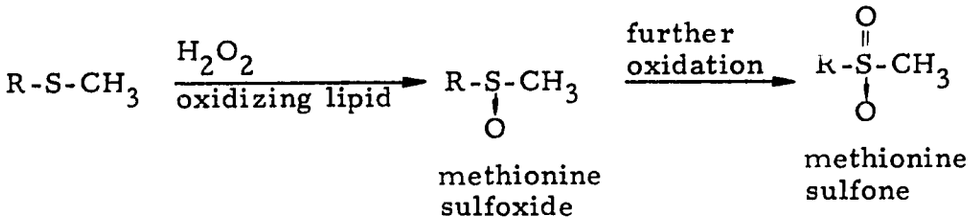
free alpha-amino acids



(Yong and Karel, 1976)

both free and "bound" (as in proteins) amino acids

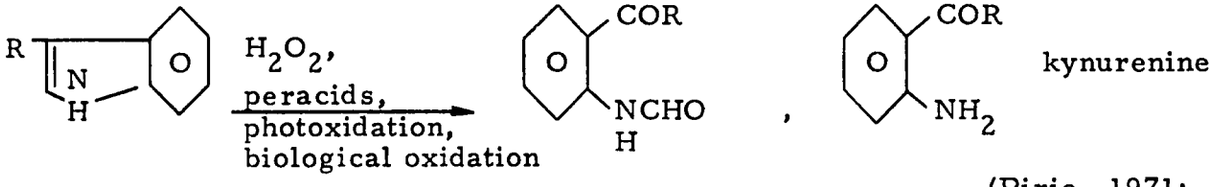
1. Methionine



(Tannenbaum et al., 1969; Cuq et al., 1973)

Methionine sulfone is usually not observed in food systems since its formation requires strenuous oxidizing conditions (e.g. peracids). Methionine sulfoxide, but not methionine sulfone, retains some nutritional value, depending on the age of the animal (Miller et al., 1970).

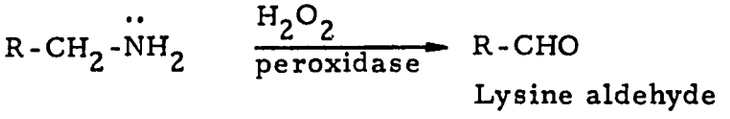
2. Tryptophan



N-formylkynurenine

(Pirie, 1971; Dalgliesh et al., 1951; Savige, 1975)

3. Lysine



(Stahman, 1976)

STRECKER DEGRADATION

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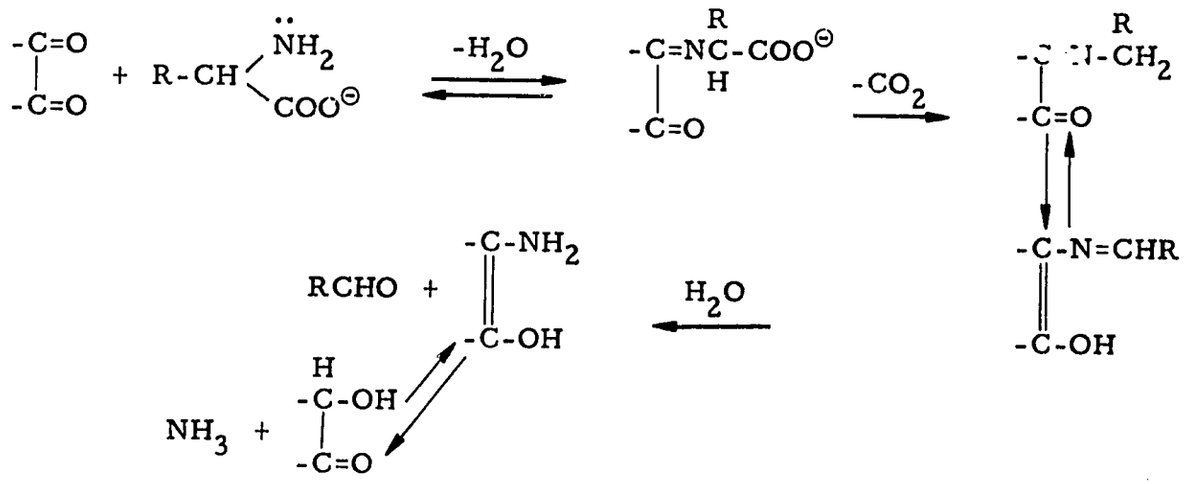
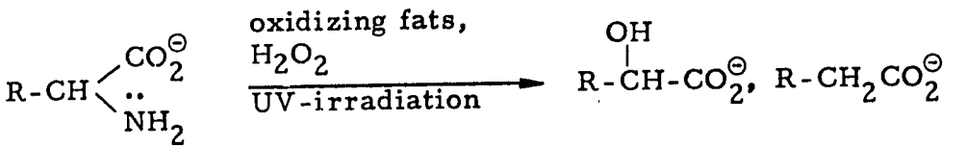


N.B. No ammonia is evolved because equilibrium favors the combined form with carbonyl.

DESTRUCTION OF AMINO ACIDS UNDER OXIDIZING CONDITIONS

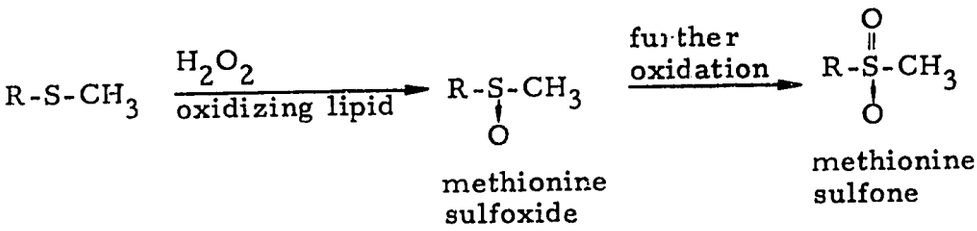
free alpha-amino acids



(Yong and Karel, 1976)

both free and "bound" (as in proteins) amino acids

1. Methionine



(Tannenbaum et al., 1969; Cuq et al., 1973)

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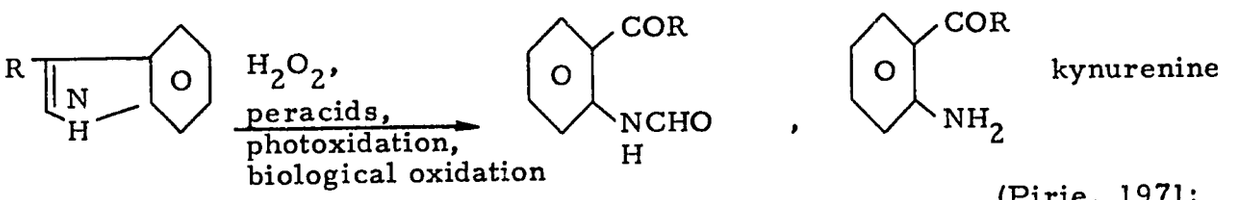
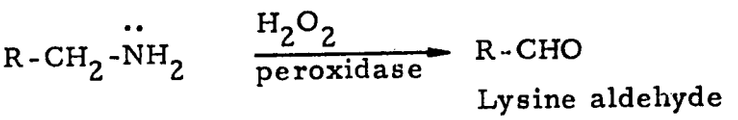
2. Tryptophan



N-formylkynurenine

(Pirie, 1971; Dalgliesh et al., 1951; Savige, 1975)

3. Lysine

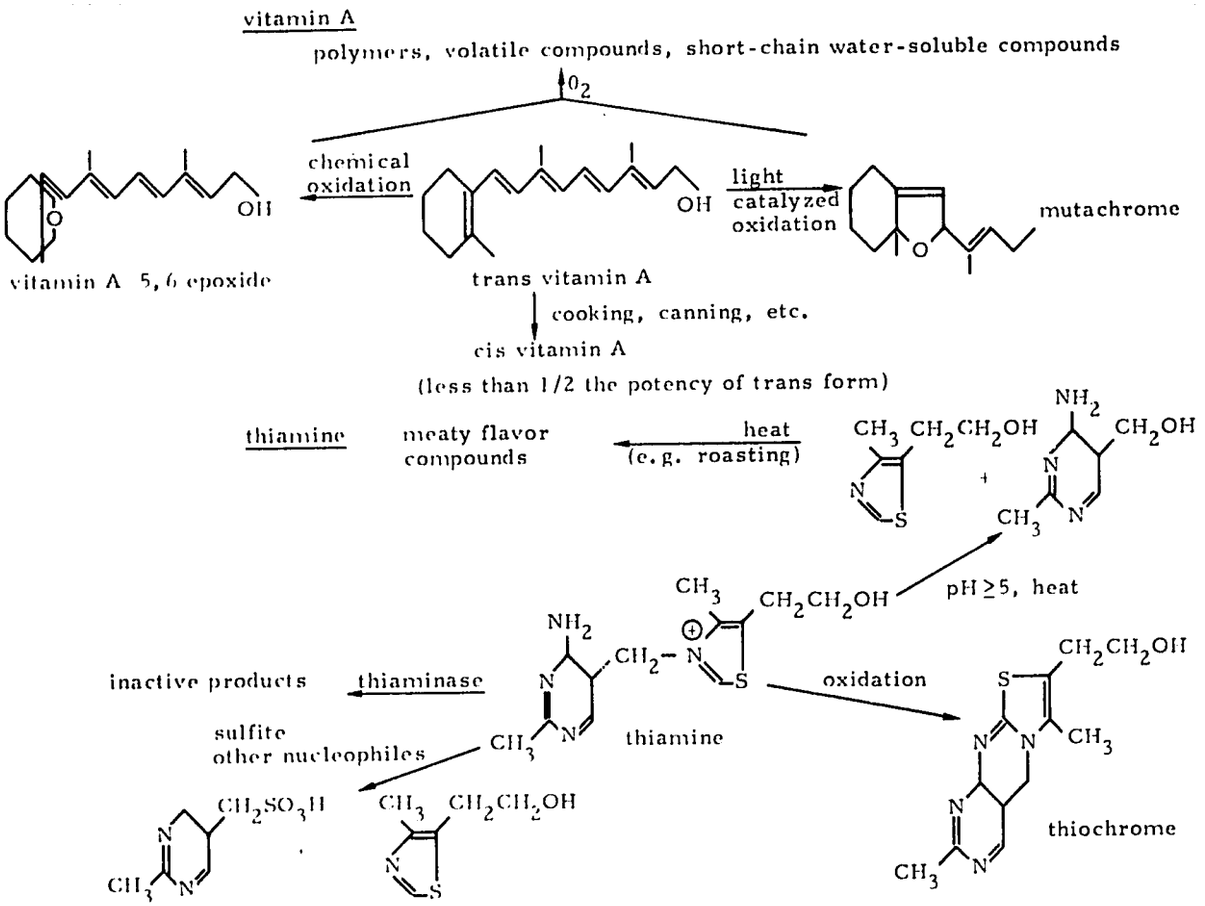


(Stahman, 1976)

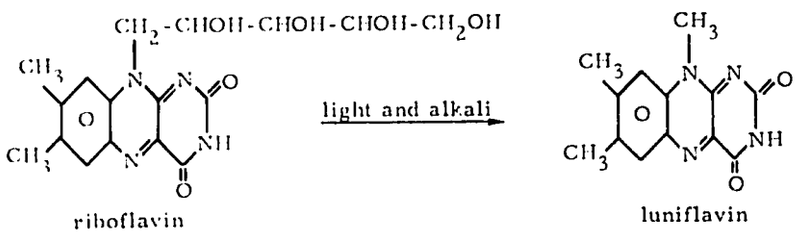
APPENDIX O

SCHEMATIC REPRESENTATION OF REACTIONS LEADING TO VITAMIN DEGRADATION

SCHEMATIC REPRESENTATION OF REACTIONS LEADING TO VITAMIN DEGRADATION



N.B. Sulfite is often used to prevent browning in dehydrated fruits



APPENDIX P

MOISTURE CONTENT OF CEREALS AT DIFFERENT ATMOSPHERIC HUMIDITIES AND TEMPERATURES

Fortified cereals are consumed in areas where transportation and storage take place over a wide range of temperature and humidity. It is desirable to know how these environmental variables influence the moisture content because of its importance in the chemical and microbial stability of cereals. Experimentally determined changes in moisture content of cereals are given on the table in the following page. On the table, one can observe that the equilibrium moisture content of cereals is primarily determined by the atmospheric humidity. Although lower temperature is associated with higher equilibrium moisture content at a given relative humidity, temperature (70-100°F) and the type or form of cereals have little effect on the equilibrium moisture content. At this point, it must be emphasized that the equilibrium moisture content does not reflect the actual moisture distribution in bulk grain/flour under fluctuating atmospheric humidity and temperature. In the absence of an efficient aeration system within the bulk, ambient temperature and humidity fluctuations result in accelerated inequilibrium in moisture distribution. Migration of moisture from hot to cooler zones of the bulk takes place as differential thermal gradient is established and convection currents set in. Moisture then condenses when the dew point is reached, creating "hot" spots of high water activity where molds and fungi can florish. This phenomenon is accelerated in the tropics (Majumder and Natarajan, 1963). Vulnerable "hot" spots can also result from the addition of fortificant premix to bulk cereals if such premix has higher hygroscobicity than the carrier cereal. Simulated rice kernels, which were used in the Thailand Study, have been reported to clump together during storage under a humid atmosphere due to their hygroscobicity (Mitsuda and Yasumoto, 1974).

COMPARISON OF EQUILIBRIUM MOISTURE CONTENTS OF CEREALS AT VARIOUS RELATIVE HUMIDITIES AND TEMPERATURES

Type of Cereal	Temperature (F)	Percent relative humidity of atmosphere						
		30	40	50	60	70	80	90
bulgur (cracked, white)*	65	8.4	9.4	10.2	11.4	12.9	15.4	21.0
	78	8	9	9.7	10.8	12.4	14.6	19.7
	90	7.8	8.8	9.3	10.4	12.2	14.5	19.7
parboiled rice**	77	9.5	10.9	12.2	13.3	14.1	15.2	19.1
	100	8.4	9.8	11.1	12.3	13.3	14.8	19.1
white rice**	77	9.2	10.5	12	13.4	14.8	16.4	18.8
whole wheat	77-82.4	8.6	9.0	11.2	11.8	13.9	17.1	21.2
wheat flour***	70	-	-	12	13.5	15	18	27.5

*Ferrel et al (1966)

**Houston and Kester (1954)

***Gur-Arieh et al (1965)

APPENDIX Q

SOCIAL COSTING AND THE SHADOW PRICING OF FOREIGN EXCHANGE

Social Costing and the Shadow Pricing of Foreign Exchange

This Appendix briefly discusses (1) the principles of social costing and (2) the application of shadow pricing to the resource to which it is most likely to be applicable in the analysis of protein fortification programs, namely foreign exchange. The discussion attempts only to lay out the basic principles. For more thorough discussion of the points made here, as well as presentation of the underlying theory and discussion of alternative approaches, the reader is referred to the excellent treatise of Romer and Stern (1975), upon which the discussion here is primarily based, or to the social cost/benefit manuals of the OECD (1968) and UNIDO (1972).

In the text we referred to two principles of social costing: (1) that all inputs which have alternative uses anywhere in the society (and only such inputs) should be included in the costing and (2) that all inputs included should be valued at the benefits forgone in their best alternative use. We shall now consider the major issues of inclusion and valuation that are likely to arise in the evaluation of protein fortification projects.

In terms of practical procedure, the most convenient way to carry out a social costing is to start with a costing in nominal terms, such as those presented in text Tables 6.1 and 6.2. The problem is then reduced to one of deciding what adjustments must be made to convert from nominal to social cost. Three separate kinds of adjustments may be required:

1) Deletion of nominal cost items which fail to meet the alternative-use criterion stated above;

2) Addition of social cost items which do meet that criterion but which may have been omitted from the nominal costing because they were borne by agencies other than those principally concerned with the execution of the project or by program participants;

3) Revaluation of items which are included both places but whose nominal costing does not adequately reflect benefits forgone in the best alternative use.

We shall discuss each of these points in turn.

1) Exclusion

In general, payments made to acquire resources needed to undertake a project and included in a nominal costing will reduce the quantity of resources available to society for other purposes and thus should be included in a social costing of the project. Possible exceptions include tax payments and payments for the use of pre-existing assets, such as land.

Most taxes can be regarded as transfer payments rather than payments for the use of specific resources and should thus be excluded from social costing. This is true of all direct taxes, such as income taxes, and also of most indirect taxes, such as sales or excise taxes. The exception is the user charge, a tax which is directly related to the use of some service or facility provided by the government. Straightforward examples of user charges include property tax surcharges for improvements in water, power or sewerage facilities and highway and bridge tolls. Many other taxes, such as fuel and vehicle taxes, are less clear-cut cases. Most project analysts regard them as contributions to general government revenue rather than user charges and therefore disregard them in calculating social cost.

Land and other pre-existing assets represent a "sunk cost" because they do not have to be produced for the purpose of the project. This does not necessarily mean, however, that they should be disregarded in social costing. The key question is whether they have alternative uses. If they do, they should be included in the costing, priced at their value in the best alternative use, which could be measured by the price which they would bring if sold in a competitive market. Only if the land or other pre-existing asset has no alternative use should it be excluded from the social costing.

In the program example used in the text, we note that land appears explicitly as an element of capital cost in Table 6.1 and may also be present implicitly (as part of the cost of regional warehouses) in Table 6.2. This is urban land, which almost certainly has alternative uses. It should therefore be included in the social costing and no adjustment is needed, provided that the land is already priced at its market value.

2) Inclusion

The nominal costing should already include costs borne by secondary agencies or participants, but if it does not it is important that the social costing do so. This inclusiveness is essential for maintaining fidelity to the basic objective of measuring the project's impact on society as a whole.

Fortification projects tend to be relatively self-contained, so assuring full inclusion may be less of a problem than with some other kinds of project. Hidden participant costs are not likely to be present. Tables 6.1 and 6.2 provide for services, such as training and propaganda, which in other cases might be supplied by secondary agencies.

3) Revaluation

Once the proper list of program inputs from the social costing point of view has been attained, the next question which arises is whether they have been correctly priced, i.e. priced to reflect their social opportunity cost. According to economic theory, the prices which prevail in perfectly competitive markets do measure social opportunity cost, based on consumers' preferences for various goods and services and the resources required to produce them. Although perfectly competitive markets exist only in textbooks of economic theory, real world markets sometimes approximate them. As stated in the text, program input prices should be corrected to accord better with social opportunity cost when these prices are significantly distorted relative to the competitive outcome and when the input in question makes up a significant share of program cost. There is no objective standard for either of these significance tests; both are matters of judgment.

Shadow prices are synthetic prices which are calculated to correct for distortions of this kind. They may be used to correct the effects of taxes, subsidies, foreign exchange overvaluation, interest rate ceilings, minimum wage laws, administered wages and salaries, monopolies, monopsonies and many other elements which cause real world prices to deviate from the competitive norm. Two types of input are most commonly shadow priced: anything purchased with foreign exchange and unskilled labor. Many governments of low-income countries overvalue their currencies, i.e. keep the price of foreign exchange at a subequilibrium level by such means as import duties and quotas, export subsidies and restrictions

on foreign payments. Since foreign exchange is in effect rationed at this artificially low price, its cost to the person fortunate (or well-connected) enough to obtain it does not measure the cost to society. Some excluded potential users would have been willing to pay more. Hence the need to shadow price foreign exchange at a higher rate in terms of domestic currency than that maintained by the government in the form of the official exchange rate.

It has been noted in the text that foreign exchange outlays represent a large fraction of the program costs tabulated in Tables 6.1 and 6.2, and are likely to do so in other protein fortification projects as well. If the exchange rate of the program country is significantly overvalued, therefore, the need to shadow price foreign exchange is inescapable. We must thus consider how this can be done.

Roemer and Stern suggest a simple method of calculating the shadow exchange rate. An import rate is calculated by correcting the official rate for import duties and for any price premium produced by the existence of controls. An export rate is similarly calculated by correcting the official rate for any export taxes or subsidies. Finally, a weighted average of these two rates is calculated, giving the shadow exchange rate.*

To illustrate the method with a wholly hypothetical example, say that the official exchange rate is 4 units to the dollar and that there is evidence of overvaluation, such as smuggling and a black market for foreign exchange. The average rate of import duty is estimated to be, say, 20 percent. In addition, imported goods appear to sell in local markets at, say, 30 percent above their c.i.f. value as a result of the scarcity created by import licensing. The effective import rate is therefore 50 percent greater than the official rate, i.e. 6:1. Let us assume that there are no significant taxes or subsidies on exports, so that the effective export rate is 4:1. The effective exchange rate which we want to use in our analysis therefore must lie between 4:1 and 6:1. Technically, the weighting of the two rates should reflect the relative supply elasticities of imports and exports. Since imports are generally more responsive to price changes than exports, the rate should probably be closer to 6:1 than 4:1. Under these circumstances, it

*For a more detailed discussion of this methodology and the rationale for it, see Roemer and Stern (1975): 46-54. This approach is only one of several proposed in the literature, which is reviewed in Bacha and Taylor (1971).

might be warranted to use 5.5:1 as the shadow exchange rate, testing out the sensitivity of the analysis to alternative rates, such as 6:1 and 5:1, if it seems at all likely that their use would affect the outcome of the analysis. A project in which imports make up 50 percent of nominal capital cost and 80 percent of nominal annual operating cost is really this much more expensive in social cost terms if foreign exchange is shadow priced:

Shadow exchange rate (percent)	Increase in capital cost (percent)	Increase in annual operating cost (percent)
5:1 (i.e. +25)	12.5	20
5.5:1 (+37.5)	18.75	30
6:1 (+50)	25	40

We can appreciate that nutritional planners will often be reluctant to get into the unfamiliar intricacies of calculating a shadow exchange rate. As noted in the text, this should have been done for them by a central planning or budgeting agency. If it has not been done, however, then it is important for the nutritional planner to make at least a rough calculation of this kind, since imported inputs can account for such a large share of program cost that program costs will be substantially understated otherwise.

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Michael Roemer and Joseph J. Stern (1975). The Appraisal of Development Projects: A Practical Guide to Project Analysis with Case Studies and Solutions (Praeger Publishers: New York).

APPENDIX R
REGIONS

Regions

I

Department of: Totonicapan
Quezaltenango
Retalhuleu
San Marcos

II

Department of: Huehuetenango
Quiche

III

Department of: Guatemala
Sacatepequez
Chimaltenango
Escuintla
Solola
Suchitepequez

IV

Department of: Progreso
Baja Verapaz
Alta Verapaz

V

Department of: Santa Rosa
Chiquimula
Jalapa
Jutiapa

VI

Department of: Izabal
Zacapa

APPENDIX S

BASIC ELEMENTS IN FORTIFICATION FEASIBILITY ANALYSIS

APPENDIX S

BASIC ELEMENTS IN FORTIFICATION FEASIBILITY ANALYSIS

Introduction

The purpose of this Appendix is to set forth the basic questions and calculations that an analyst should consider in determining the feasibility of a fortification intervention. As such this represents a distillation of the full methodology presented in the chapters; accordingly, the reader can refer to the corresponding chapters for detail and discussion of the elements.

Feasibility will depend on how well the fortification intervention addresses five potential barriers: nutritional need, commodity system structure, technology, consumer acceptability, and intervention economics.

The starting point for any intervention should be a thorough diagnosis of the nutritional problem -- who is suffering what type and severity of nutrient deficiencies and why. For fortification this is critical to determining kind and quantity of nutrient fortificant to use and to selecting the food to be fortified. Examining the structure of the commodity system to be selected as the carrier is necessary to determine whether adequate coverage of the target group will be possible. Furthermore, the structure will also carry many implications for the kind of organizational and administrative system needed to operate and control the intervention. The technological problems to be examined can arise in the design of both the fortificant and the fortification process. Even with nutritional, administrative, and technical feasibility, implementation can falter if the consumers find the fortified product nonacceptable. Consumer acceptability can be influenced not only by organoleptic and cultural factors but also by price increases due to the costs of the intervention. Both the size and incidence of the cost burden require careful examination in determining the economic feasibility of the project.

The key questions that an analyst should consider in examining each of these potential barriers will now be presented.

Nutritional Needs

For Problem Diagnosis:

(1) What information (dietary, biochemical, clinical) exists to develop a nutritional profile of the population?

(2) What nutrient deficiencies exist in the population? in specific groups within the population?

(3) What is the magnitude of the deficiency?

(4) Who are most severely affected?

For the Choice of Carrier:

(5) What is the typical dietary pattern of the population? For the Target Groups?

(6) What food is appropriate as the fortificant carrier?

(7) How much of the carrier is consumed by specific target groups?

(8) Are different amounts of the fortificant mix needed to address regional deficiencies?

For a Protein/Amino Acid Fortificant:

(9) Is protein intake inadequate?

(10) Is the caloric intake adequate?

(11) If the caloric intake is inadequate, would simply increasing the calories alleviate the protein problem?

(12) If calories are adequate, is it a specific amino acid that is lacking, or is it simply total nitrogen?

For Other Nutrient Supplements:

(13) Will the positive impact of the amino acid supplement be offset by other nutrient dificiencies?

(14) In addition to, or in place of, the amino acid supplement, what mix of nutrients should be added?

(15) Is toxicity a problem at the level at which the fortificant is to be added?

(16) For a mineral mix, is there a competition for absorption between substance to be added?

(17) Does anything in the carrier (phytate or fiber) interfere with absorption?

(18) If absorption is hindered, would another carrier be more appropriate?

General Issues:

(19) What is the health status of the population? target group?

(20) Does a problem with infection negate the probable results of the fortification effort?

(21) What is being done to monitor the health status of the population being served while the fortification effort is underway?

Commodity System Structure

Target Group Coverage:

(1) What portion of the target group use the commercial system to mill their grain?

(2) How nutritionally needy are those families who mill their grain in-house?

(3) Which mills supply which population groups?

(4) Are there distribution channels which would reach the most needy?

Organizational Implication:

(1) To what extent is the grain centrally processed?

(2) Using central mills would lead to what magnitude of overcoverage?

(3) To what extent is the milling structure decentralized?

(4) How targeted will the decentralized system permit the fortification program to be?

(5) How much additional administrative costs will have to be incurred under the decentralized as compared to the centralized system?

(6) How do these costs compare with the savings from reduced over-coverage?

(7) What is the volume of grain milled in each mill and how much fortificant would this quantity require? Given the consumption patterns and deficit levels among the consumers served by that mill?

(8) What is the seasonal milling rate pattern?

(9) To what extent will the fortification program cause operational problems or an economic burden for the miller?

(10) How is the miller likely to react to these factors?

(11) What incentives or tactics can be employed to increase miller receptivity?

(12) How resistant will millers be to the increased government intention implied by the program?

Technology

For the fortificant:

(1) Will the fortificant as proposed affect the organoleptic characteristics (taste, appearance, texture, odor) of the product. If yes, what are the consequences?

(2) What is the stability of each of the nutrients in the proposed form?

(3) Will the dosage of the fortificant as proposed have any harmful side effects?

(4) How well will each of the nutrients in the proposed mix be absorbed?

(5) Is there a tradeoff between a lower absorption and greater taste acceptability?

(6) What price differential exists between the various forms in which the nutrient can be supplied? What will be the most cost effective?

(7) Will a nutrient imbalance be created by the fortificant mix?

(8) Will large scale fortification interventions create a relative or absolute shortage of raw materials?

(9) Will fluctuations in the availability and cost of nutrients affect the program? How?

(10) Will chemical reactions in the fortificant mix alter nutrient digestion, absorption or metabolism?

For the Fortification Technology:

(11) Can a quantity and quality control system be built into the program?

(12) What are the storage capabilities of the mix?

(13) Can the vitamin-mineral-amino acid premix be centrally produced? If not, is the technology feasible?

(14) Can uniformity in the premix composition be attained?

(15) How easily can premix composition be tested in the field?

(16) Can the fortificant mix as proposed be incorporated into a carrier that will reach the target groups?

(17) Is the necessary equipment easily available within the country?

(18) What is the cost of each processing method?

(19) What effect will the local cooking practices have on the fortificant mix as proposed?

(20) Will microbial contamination of the nutrient mix occur? How can this be controlled?

(21) What are the optimal processing and storage conditions for each of the specified nutrients?

Consumer Acceptability

Feasibility Questions:

(1) What is the role of the staple cereal in the folk medical system?

(2) Is the proposed fortification program compatible with the existing beliefs and uses? If not, can the project be altered to become acceptable?

(3) How are labor and decision-making power allocated relative to procurement, processing and preparation of the staple cereal? Is the fortification program reinforcing or antagonistic to the existing allocations?

(4) Are the color, flavor, texture, storage qualities or cooking characteristics changed by the fortificant? Are these changes desirable or undesirable? How can the adverse effects be minimized?

(5) Who must make the decision to adopt the fortified product?

(6) Who influences the decision makers?

(7) What characteristics of the decision makers are favorable or unfavorable to adoption of the program?

(8) Who are likely to be the initial acceptors?

(9) What are the primary concerns of the target population with regard to food and health? Are these perceived needs reinforcing or antagonistic to the introduction of the fortificant?

(10) Are there other needs which must be addressed before the fortification intervention can be implemented?

(11) Who stands to benefit from the project and how can this be communicated?

(12) Who stands to lose from the program and how?

(13) Are there risks involved in the program participation? How can these risks be minimized?

(14) What formal or informal communications networks can be utilized to reach decision makers?

(15) What local leaders are influential in matters pertaining to food and health and how can their help be enlisted?

(16) Has the community had previous experience with similar programs? What were the results and how does this influence your current endeavor?

Intervention Economics

About the Nature of the Problem:

(1) What subgroup of the population is affected? i.e., What is the potential target population for the program?

(2) What is the nature of the problem in nutritional terms? i.e., What symptoms of deprivation are present?

(3) What are the known or suspected economic and social consequences?

About Alternative Program Designs:

(4) What types of programs might be addressed to these problems? How do fortification programs fit into the range of possibilities?

(5) What alternative fortification program designs are worth considering seriously? (Extensive and targeted approaches, in particular, should be thought about as potential alternatives.)

(6) What potential fortificant packages should be considered?

About Intervention Costs:

(7) What inputs will be required, and in what quantities, for each program alternative?

(8) What will these inputs cost, delivered at the time needed and to the place where needed?

(9) How does the cost structure of each program break down in terms of cost categories, i.e., fortificant cost, fortifying process, logistics, control?

(10) What does sensitivity analysis show about the extent to which the cost estimates could be affected by variations in timing, prices of key inputs and other contingencies?

(11) Are price distortions (especially of tradeable goods inputs) sufficient to warrant conversion from a nominal cost basis to a social cost basis?

About Potential Program Impact:

(12) How fully will the program cover the target population (in relation to program cost)?

(13) What quantity of nutrients will be delivered to the target population (in relation to program cost)?

(14) What biological effectiveness measures are appropriate for program evaluation?

(15) How do alternative program formulations compare in terms of various cost-effectiveness measures?

(16) Is there any possibility of valuing at least some key benefits in money terms and carrying out benefit/cost analysis?

About Program Financing:

(17) What possible methods are there of financing the program?

(18) What are the advantages and disadvantages of each method, in terms of social efficiency, equity and consistency with the nutritional objectives of the program?

Program Costing

This final section provides more specific guidance on how to computer the costs of a fortification intervention. The cost components are basically for the fortificant, logistics, administration plus capital equipment outlays.

Fortificant Costs:

To calculate the fortificant cost per kilogram of carrier fortified four steps are needed:

(1) First one should determine the quantity of nutrients needed to fill the nutritional deficits identified (i.e., the difference between the recommended daily allowance and the actual nutrient). This will emerge from the nutritional need analysis but certain judgements are necessary. The degree of deficits will vary among target population individuals and so one will have to decide whose deficit to fill. One approach is to use an average deficit and another is to use the maximum deficit; the latter improves potential impact but also increases total costs. In using the maximum approach, one should also determine the risk of toxicity.

(2) Having calculated the nutrient need, one next verifies the daily consumption quantity of the food to be fortified. The quantity of fortificant to be added will vary depending on the carrier consumption level.

As an example, let us assume equal nutrient deficits in preschoolers in two different villages. Village one preschoolers consume 100 grams of tortillas per day and village two consumes 200 grams daily. The fortificant formula in village one would have to contain twice the nutrient level in order to fill the nutrient inadequacies.

(3) The next step is to determine the cost per kg of each nutrient included in the fortificant (see tables S-1, S-2 through S-4 for fortificant costs).

(4) To compute the 20 fortificant costs per kg of carrier, one combines the calculations made in the first three steps. For example, in 1977 Thiamine Hydrochloride cost $25/kg of thiamine. Assuming the nutrient need and consumption level required 21.4 mg of thiamine/kg maize, then 1 mg of thiamine costs $0.000025 and 21.4 mg equals $0.000535/kg maize fortified.

In summary the computation formulae are:

(1) $F_q = N_d \div C_q$

where:

F_q = quantity of the fortificant to be added to 1 kg of carrier

N_d = nutrient specific deficit per day

C_q = quantity of the carrier consumed daily in kilograms

(2) $F_c = F_q \times F_p$

where:

F_c = cost of fortificant per kg of carrier

F_q = as computed in (1)

F_p = price per kg of the fortificant being added

Total fortificant costs are computed simply by multiplying the quantity of carrier fortified during a given period (say one year) by the cost fortificant per kilogram calculated above.

Logistical and Administrative Costs

In addition to the direct fortificant costs, one should also add the costs of transporting, storing, and handling the fortificant. Furthermore, the administrative costs attributable to the intervention should be computed. These include personnel, supplies, etc., costs and can be sizable if the program involves a decentralized village level fortification system. Expenditures may also be necessary for training personnel, educating consumers, and providing special incentives to millers to elicit the necessary cooperation.

Capital Equipment Costs

Fortification interventions are not very capital intensive but investments are necessary for mixers and blenders either for centralized or decentralized milling systems.

References

The reader should consult chapter six for further details on costing methodology. Also, the case studies in chapters seven to nine provide more complete illustrations of the application of the methodology in the context of actual country situations.

Table S. 1

Current and Past Prices of Vitamins (U. S. $/kg)

Vitamins		1977	1975	1972
Vitamin A	palmitate beadlet (250,000 IU/g)	15	15	13.1
	palmitate in oil (10^6 IU/g)	30	-	-
	acetate beadlet (500,000 IU/g)	23	-	-
Thiamine (hydrocholoride or mononitrate)		25	23	14
Niacin	nicotinic acid	5	5	3.75
	nicotinamide	5.25	5.25	4.0
Riboflavin		42	40	28

Note: Prices are quoted for food-grade, "stabilized" vitamins in quantities greater than one kg fob N.J. Vitamin premixes for cereal fortification can be made by blending these ingredients at desired levels.

Source: Hoffman - La Roche, 1977.

Table S. 2

Current Prices of Commercially Available Calcium Sources Important for Cereal Fortifications

Calcium source	Cost per kg (U.S. $)	Percentage of contained calcium	Cost per kg calcium (U.S. $)
Calcium carbonate[a]	0.15	40	0.375
Calcium phosphate, dibasic (dicalcium phosphate)	0.792	23.3	3.40
Calcium phosphate, tribasic (tricalcium phosphate)	0.792	38.8	2.04
Calcium sulfate	0.638	23.3	2.74

Note: Prices are quoted for food-grade calcium sources in bulk quantities (e.g., 15 x 100 lb bags, 5 x 225 lb drums).

Source: Mallinckrodt, Inc., 1977.

a. Calcium carbonate is supplied by Pfizer Inc., N.J.

Table S. 3

Current Prices of Commercially Available Iron Sources Important for Cereal Fortification

Iron source	Cost per kg (U.S. $)	Percentage of contained iron	Cost per kg iron (U.S. $)
Ferrous sulfate, dried	0.66	32.1	2.05
Ferrous sulfate, heptahydrate	0.84	20.1	4.16
Chemically reduced iron	1.56	96.0	1.63
Electrolytically reduced iron	2.55	97.0	2.64
Ferrous fumarate	2.24	32.9	6.82
Ferric orthophosphate	1.63	28.6	5.70
Sodium iron pyrophosphate	1.80	14.5	12.45

Source: J. T. Davidson and M. E. Russo, "Iron Fortification in Breakfast Cereal", Cereal Foods World, 21 (1976), Pg. 534.

Table S. 4

Current and Historical Prices of Synthetic Amino Acids for Cereal Fortification

	U.S. $/kg			
	L-lysine·HCl	L-threonine	L-tryptophan	DL-methionine
1972	3.80	-	-	4.20
1973	3.80	-	-	4.20
1974	7.30	57.70	86.80	4.20
1975	5.60	57.70	86.80	5.30
1976	5.60	57.70	86.80	5.30
1977	5.60	57.70	86.80	5.30

Notes: Prices are quoted for food-grade L-lysine and DL-methionine in bulk quantities (a ton or more); for L-tryptophan and L-threonine, prices are quoted for pharmaceutical-grade in quantities greater than 50 kg. Except for DL-methionine prices, which are obtained from Chemical Marketing Reporter, amino acid fob Japan prices are estimated from the "delivered prices" given by Ajinomoto Co., U.S.A., using the following formula:

estimated price = delivered price/(100 percent + handling and transportation charge and customs duty)

where customs duty is 6 percent for L-lysine·HCl and L-threonine, 12.5 percent for L-tryptophan; and transportation and handling charge is estimated at 6 percent.

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APPENDIX T

ESTIMATES OF THE SIZE OF THE NONCONTROLLED SYSTEM DERIVED FROM RECORDS OF GRAIN PURCHASES TO THE CONTROLLED SYSTEM

Estimates of the Size of the Non-Controlled System Derived From Records of Grain Purchases to the Controlled System

	Version I (Using Autoconsumption Est. from 1965-8 Food Consumption Survey)	Version II (Using Autoconsumption Est. from Study of the Tunisian Grain Marketing System)	Version III (Using Autoconsumption Est. from Chapter 9)
A. Grain Purchases by the Controlled System	291,344	291,344	391,344
B. Sales from Purchasing Centers	-4,985	-4,985	-4,985
C. Change in Stocks	-32,000	-32,000	-32,000
D. Imports	+364,100	+364,100	+364,100
E. Total Grain Supply in the Controlled System	618,459	618,459	618,459
F. Autoconsumption	514,825	578,000	635,482
G. Total Grain in Controlled System and Autoconsumption	1,133,284	1,196,459	1,253,941
H. Total Availability of Grain	1,523,000	1,523,000	1,523,000
I. Total Grain in the Non-Controlled System (H - G)	389,716	326,541	269,059
J. Non-Controlled System as % of Total Availability of Grain (I ÷ H)	36%	21%	18%
K. Total Human Consumption of Grain	1,225,000	1,225,000	1,225,000
L. Grain in Non-Controlled System % Human Consumption	32%	27%	22%

Source: A,B,C,D from Table 10.02.
F(I) from 1965-8 Food Consumption Survey, ibid.
F(II) from Study of the Tunisian Grain Marketing System, ibid.
F(III) from Appendix 3.
H,K from Table 8.01.

APPENDIX U

OUTLINE OF GROUPS WHICH PARTICIPATE IN THE CONTROLLED SYSTEM, NONCONTROLLED SYSTEMS AND AUTOCONSUMPTION

Outline of Groups Which Participate in the Controlled System, Non-controlled Systems and Autoconsumption

	CONTROLLED SYSTEM			NON-CONTROLLED SYSTEM & AUTOCONSUMPTION	
	A Processed Semolina	B Bakery Bread	C Off.Cer.Grain	D Grain for Couscous, etc.	R Grain for Tabuna Bread
I North	1. In central area of large cities (Tunis, Bizerte, almost everyone		Few people mainly rich people.	1. In fringes of Tunis, some poor people.	
	2. In small cities, towns, and villages, mainly rich non-farmers and middle-class (government employees, schoolteachers).			2. In fringe areas of cities and towns, almost everybody.	
	3. In cities, towns, and villages, lower income people when NCS grain not available (in winter bad harvest or areas with little grain, like fishing villages)			3. A few people of all income levels in central urban areas.	5. In towns with no bakery, everyone
		4. In fringe areas of Tunis.		4. In small towns, villages, and rural areas almost everyone (except as noted in I, 2)	
II Center	1. In central area of large cities (Sousse, Sfax); almost everyone. Sfaxiannes also frequently eat NCS barley couscous and bread.		A few people of all income levels, mainly in winter when no grain is available in NCS or prices in NCS are high.	1. In fringes of large cities (Sousse and Sfax) almost everybody.	
	2. In small cities, towns, villages, mainly rich non-farmers and middle class.			2. In Sfax, most people of all income levels buy barley for use once or twice a week.	
	3. In cities, towns, villages and rural areas when NCS grain is not available or the price is unusually high. (In winter, bad harvest, or in areas with little wheat grown such as western mining towns, eastern fishing villages, cloth weaving towns.)			3. In small cities (e.g. Kairsvan), towns, villages and rural areas, almost everyone, most of the time (unless NCS grain is not available, or if price is unusually high).	
					4. In towns with no bakery, everyone.
III South	1. In cities and towns, almost everyone.			1. Some lowland farms and mountain villages.	1. Mainly lowland grain farmers, mountain villages and Bedouins.
	2. In lowland agricultural villages, most people in winter, when their homegrown grain supply is depleted.			2. Most people both rich and poor buy small amounts for s special occasions.	
	3. In date palm oases, almost everyone, throughout most of the year.			3. Bedouins buy regularly.	

APPENDIX V

FIRST ESTIMATE OF NUMBER OF MILLS AND GRINDERS

First Estimate of Number of Mills and Grinders
I. Northwest (Beja, Le Kef and Jendouba)

	A. Total No. of Units	B. No. of Units Inter-viewed	C. No. of Mills Located	D. No. of Grinders Located	E. Av. No. of Mills Located Per Unit C÷B	F. Av. No. of Grinders Located Per Unit D÷B	G. Est. Total No. of Mills All Units A×E	H. Est. Total No. of Grinders All Units A×F
Large Cities 100,000+	0	-	-	-	-	-	-	-
Medium Cities 50,000-99,999	0	-	-	-	-	-	-	-
Small Cities 20,000-49,999	2	2	14	19	7	9.5	14	19
Large Towns 10,000-19,999	1	1	4	7	4	7	4	7
Medium Towns 5,000-9,999	7	5	20	20	4	4	28	28
Small Towns 2,000-4,999	17	9	23	24	2.6	2.7	45	46
Villages 100-1,999	880	13	28	29	2.2	2.2	1936	1936
					Sub Total:		2027	2036

Villages of 50-99: 613
Estimated 50% have one mill with one grinder = 50% x 613 = 307
Grand Total: Mills: 2027 + 307 = 2334
Grinders: 2036 + 307 = 2343

Estimate of Number of Mills and Grinders, Version 1
II. Northeast (Tunis, Bizerte and Nabeul)

	A. Total No. of Units	B. No. of Units Inter-viewed	C. No. of Mills Located	D. No. of Grinders Located	E. Av. No. of Mills Located Per Unit C÷B	F. Av. No. of Grinders Located Per Unit D÷B	G. Est. Total No. of Mills All Units A×E	H. Est. Total No. of Grinders All Units A×F
Large Cities 100,000+	1	1	7	7	7	7	7	7
Medium Cities 50,000-99,999	1	1	3	8	3	8	3	8
Small Cities 20,000-49,999	5	2	5	6	2.5	3	13	15
Large Towns 10,000-19,999	9	4	23	28	5.8	7	53	63
Medium Towns 5,000-9,999	15	5	12	16	2.4	3.2	36	48
Small Towns 2,000-4,999	12	8	10	10	1.3	1.3	16	16
Villages 100-1,999	325	17	22	26	1.3	1.5	424	489
					Sub Total:		552	646

Villages of 50-99: 102
Estimated 25% have one mill with one grinder: 25% x 102 = 26
Grand Total: Mills: 540 + 26 = 578 mills
Grinders: 632 + 26 = 672 grinders

Estimate of Number of Mills and Grinders, Version 1
III. Central Region (Sousse, Sfax, Kairouan and Kasserine)

	A. Total No. of Units	B. No. of Units Inter-viewed	C. No. of Mills Located	D. No. of Grinders Located	E. Av. No. of Mills Located Per Unit C÷B	F. Av. No. of Grinders Located Per Unit D÷B	G. Est. Total No. of Mills All Units AxE	H. Est. Total No. of Grinders All Units AxF
Large Cities 100,000+	0	-	-	-	-	-	-	-
Medium Cities 50,000-99,999	2	2	31	36*	b	b	31	36*
Small Cities 20,000-49,999	4	4	28	36	7	9	28	36
Large Towns 10,000-19,999	5	3	16	16	53	53	27	27
Medium Towns 5,000-9,999	17	7	25	26	3.6	3.7	62	63
Small Towns 2,000-4,999	31	8	15	18	1.9	2.3	59	72
Villages 100-1,999	665	8	14	14	1.8	1.8	1197	1197
						Sub Total:	1404	1431

Villages of 50-99 (Sousse, Sfax and Kairouan): 386
Estimated 25% have one mill with one grinder: 97
Villages of 50-99 in Kasserine: 243
Estimated 10% have one mill with one grinder: 15
Grand Total: Mills: 1404 + 97 + 25 = 1526
Grinders: 1431 + 97 + 25 = 1553

[b] Disparity is too wide for meaningful average. It was estimated.

[*] Minimum.

Estimate of Number of Mills and Grinders, Version 1
IV. Southern Region (Gafsa, Gabes, and Medenine)

	A. Total No. of Units	B. No. of Units Inter-viewed	C. No. of Mills Located	D. No. of Grinders Located	E. Av. No. of Mills Located Per Unit C÷B	F. Av. No. of Grinders Located Per Unit D÷B	G. Est. Total No. of Mills All Units AxE	H. Est. Total No. of Grinders All Units AxF
Large Cities 100,000+	0	-	-	-	-	-	-	-
Medium Cities 50,000-99,999	0	-	-	-	-	-	-	-
Small Cities 20,000-49,999	2	2	10	19	5	9.5	10	19
Large Towns 10,000-19,999	6	4	9	15	2.3	3.8	14	23
Medium Towns 5,000-9,999	6	2	11	12	5.5	6	33	36
Small Towns 2,000-9,999	18	6	18	22	3	3.7	54	67
Villages 100-1,999	258	22	47	55	2.1	2.5	542	645
						Sub Total:	653	790
						Grand Total:	653	790

Villages of 50-99: 129
Assumed to have no mills.