In addition, the lipoxygenase produces peroxides, which in turn oxidize the carotinoids of the flours, producing a whiter bread.

The quantities of enzyme active soy flour that are being used vary between 0.2 and 1% wheat flour, depending upon the quality. In addition, products like ascorbic acid, potassium bromate, and iodate will add to the oxidation process.

In doughs made for the production of toast bread and rusks, with more complex recipes and higher fat and sugar contents, we advise using enzyme inactive soy flour at higher percentages, ca. 5% wheat flour. It is the physical properties of the soy proteins that are important, especially their ability to retain water, thus producing a softer product that keeps longer. Since it is this action of the protein we are most interested in, we recommend using defatted enzyme inactive soy flour.

I would like to add, however, to achieve the full effect of the soy proteins, one should not use less than 5% with good quality wheat flours. With lower quality flours, there will be a decreased volume. However, this can be adjusted easily by hydrating the dough more and by adding emulsifying agents and oxidants, if desired.

Certain manufacturers of soy flours recommend the use of conditioners based upon soy flour containing special additives for the manufacture of toast bread, rusks, and viennoiseries. In this case, there is better tolerance of the dough; a better workability; a larger volume of the finished product; a finer and more aerated crumb; a finer crust with a good color; higher yield; lower fat, sugar, and possibly egg content; a softer crumb due to the higher moisture content of the finished product; and an improved taste.

These conditions also will facilitate the freezing of viennoiserie products. Unbaked or partially baked doughs dry out much less and reduce the denaturation of the yeast, while permitting work under more constant rheological conditions.

Beside all the functional advantages of soy flour, I also would like to mention its use in enriched bread, hypocaloric and hypoglucidic bread containing 15, 20, or 30% proteins, according to new French law on dietetic products. From this bread one can produce rusks with 20, 33, and 52% proteins. In these particular applications, soy flour can replace 50% normal added gluten.

Finally, I would like to mention the use of soy flour in sweetened doughs, which is the starting point for pastries and biscuits. In pastry making, the enzyme inactive soy flours are used especially for their ability to retain water and their emulsifying powers. Because of the presence of phosphatides and soluble proteins, they permit the production of a less expensive product, since the amount of eggs and fat can be reduced, while the finished product contains more water. In addition, the equilibrium relative humidity will be lowered, leading to a finished product with a longer shelf life. The quantity of soy flour to use varies between 10 and 20% wheat flour.

In biscuit production, the enzyme inactive soy flours also are used in quantities of ca. 5%. The advantages include a better yield, the possibility of manufacturing products that are less fragile and crisper, and the reduction of the formation of a gluten network which causes less retraction during the fabrication process. In addition, it allows for easier reuse of trimmings, controls the gelatinization of starch during baking, and gives a product which is more easily detached from the mold.

To conclude, we can say that the good quality soy flours one finds today on the European market have many applications in bakery products, pastry, and biscuits for a competitive price.

In the enzyme active types of soy flours, the action of the lipoxygenase is the most important quality, while, in the enzyme inactive flours, the functional and nutritional properties of the proteins take precedence. Soy proteins also supplement the amino acid lysine, which is usually low in most cereals, especially wheat.

Use of Soy Products in Cereal Products

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WHEAT FOODS AS VEHICLE FOR NUTRITIONAL IMPROVEMENT

Wheat based foods are the most logical vehicle for nutritional improvement via vitamin or mineral enrichment or protein fortification with soy flour because: (A) wheat foods are widely consumed and accepted, (B) modern mills provide focal points in developing countries for nutrient additive, (C) bread and cookies are often the only centrally prepared convenience food in the marketplace, and (D) the basic technology for providing soy fortified bakery products with high acceptability now is known.

Soy flour is the only consistent, economical protein resource currently available for fortification programs of any significant size. Protein fortification in developing countries must be based upon imported soy flour until indigenous protein resources and processing industries can be developed.

SOY FLOUR IN BREAD

Soy fortified wheat flour now is being purchased under Title I and Title II, PL 480, for use in school lunch, institutional feeding, and other commodity distribution programs aimed at nutritional improvement. Two forms of the soy fortified flour are available, i.e. containing 6% and 12% soy flour. The 6% product contains 94% bread wheat flour and 6% defatted toasted soy flour. The 12% product contains 88% bread wheat flour and 12% defatted soy flour. Both products are enriched with vitamins and minerals and contain sodium stearoyl-2-lactylate, a dough conditioner which offsets the detrimental functional and flavor effects associated with addition of high levels of soy flour.

These blended products have been shown to be quite versatile and are being used in breads of all types, cookies, sweet goods, cakes, noodles, and baby food gruels.

The protein efficiency ratio (PER) of bread is normally in the range of 0.7-1.0, and bread normally will have a protein content of 8%. Bread made with 6% soy fortified flour will have a PER of 1.3 and a protein content of 10%. Bread made with the 12% soy fortified flour will have a PER of 1.9 and a protein content of 11.5%.

Cookies have a PER of 0.5 and a protein content of ca. 5%. Cookies made with 12% protein fortified flour will have a PER of 1.5 and a protein content of 8%.

FLOUR COST

Over the last year, the price of soy fortified wheat flour has been ca. 10% more expensive than wheat flour. This increase in flour cost is offset partially by savings in

preparation and yield of the final baked foods. In bread, there is an increase in wet dough yield of 6-7%, and shortening is not needed. In many countries soy fortified wheat flour is replacing mixtures of wheat flour and non-fat milk solids in nutritional feeding programs at a substantial savings. In cookies, the nutritionally improved product likely can be made at a lower cost than the conventional cookie because of the savings resulting from a lower level of shortening usage.

The economics of introducing soy fortification of wheat flour for large population groups will vary from country to country. Generally, improved nutrition through soy flour fortification of wheat flour will result in increased production costs. It is felt that governments can best initiate massive nutrition programs by subsidizing the increased costs incurred for fortification of wheat flour with soy flour. From a protein standpoint, soy fortified wheat flour currently represents the greatest value/unit of cost for preparation of any food consumed by man.

Use of Soy Flour in Composite Flours

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INTRODUCTION

In the last decade, much research has been devoted to developing procedures for the production of high protein flours from soybean, peanut, fish, yeast, leaves, and algae. Many of these efforts have been successful in obtaining nutritionally valuable flours, but their utilization in the production of human food is only in its very beginning. Most advanced is the use of soy flour, but even there its utilization is limited.

One of the reasons why the utilization of high protein flours in the battle on malnutrition is still limited to incidental cases must be that insufficient ways have been found to work these flours into generally accepted foods. For this reason Food and Agriculture Organization developed a Composite Flours Program to stimulate the utilization of nonwheat flours in the production of bread, biscuits, and pasta products. Food items like these are excellent carriers for protein enrichment, because of their centralized production and the convenience of admixing protein concentrates in the production.

Another cause impeding the utilization of nonwheat flours in the production of bread and other baking products lies in the fact that the price of these flours is, in general, higher than that of wheat flour.

Another argument in favor of starting a Composite Flours Program was the anticipated stimulation in developing countries of the cultivation and processing of tropical crops required for the production of nonwheat flours. An additional advantage would be a decline in the need for imported raw materials which otherwise would be required.

In the Composite Flours Program, the use of soy flour is emphasized. This is quite understandable with regard to the worldwide cultivation of the soybean, its protein content, and nutritional protein quality.

Two approaches have been followed in the Composite Flours Program: nonwheat flours were either added to wheat flour as a base or used as such. In the latter case, the flours were mostly mixtures of a high protein component and a starchy component.

PROTEIN-ENRICHED WHEAT-BASED PRODUCTS

In those cases where the principal objective is protein enrichment, the addition of high protein flours to wheat flour is the solution close at hand. Admixture of a high protein component up to ca. 5% wheat flour used in breadmaking does not seriously affect taste or color of the bread crumb and exterior bread characteristics. Further increase in the percentage of the high protein flour, however, does impair bread quality. Higher requirements have to be imposed upon the nonwheat component regarding its color and taste. Besides, to maintain a good bread quality with higher percentages of the nonwheat flour, it generally will be necessary to modify the breadmaking procedure. Solutions to these problems have been developed in The Netherlands (Institute for Cereals, Flour, and Bread TNO, Wageningen), in England (Tropical Products Institute, London), and in the U.S. (Kansas State University, Department of Grain Science and Industry, Manhattan). A large variety of wheat-based breads with 30% nonwheat flours have been made and are satisfactory.

ENTIRELY NONWHEAT PRODUCTS

If, besides protein enrichment, the objective is to stimulate agriculture and processing of agricultural crops in developing countries, it may be necessary to consider the preparation of bakery products and pasta goods entirely from nonwheat flours. One should be aware, then, that the resultant products may have characteristics different from those of the wheat-based products for which they are intended to be a substitute.

Breads prepared from a composite flour made up of 80 parts cassava starch and 20 parts defatted soy flour have been developed by the Institute for Cereals, Flour, and Bread TNO. Also biscuits were developed on the basis of cassava-soy or cassava-soy-milk protein mixtures. These biscuits contain 12% and 20% protein.

TABLE I

Biological Evaluation of Protein Quality

Product	Flour composition	Proportions	Protein content, %	PER[a]
Bread	White wheat flour	100	10.9	0.82
Bread	Wheat-rice	70/30	9.9	0.98
Bread	Wheat-rice-soy	70/27/3	11.0	1.37
Bread	Wheat-rice-soy	70/25/5	11.8	1.51
Bread	Cassava-soy	80/20	11.3	2.40
Biscuits	Cassava-soy	67/33	12.0	1.90
Biscuits	Cassava-soy-milk protein	50/17/33	20.0	3.20
Biscuits	Cassava-soy-caseinate	50/30/20	20.0	2.23
Casein (reference protein)		100		2.50

[a]PER = protein efficiency ratio = g wt gain of experimental animals/g protein consumed.