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9. ABSTRACT

This article describes how Blend K, a fortified wheat flour, has been developed as a promising means of combatting protein-calorie malnutrition throughout the world. As a result of huge shipments of wheat to Latin America and Asia under the P. L. 480 program, bread consumption is rising rapidly in developing countries. While bread produced in the U.S. has long been fortified with vitamins and minerals, flour milled in most developing countries is not yet being enriched. Soy flour has long been recognized as an excellent means of fortifying the proteins of cereal grains because of its high content of a protein rich in lysine. Corn-soy and wheat-soy products are extensively used in nutritional programs, but, because of secondary effects of their properties, they have not been used in significant quantities in baked foods such as bread. Attempts to fortify wheat flour with soy flour beyond the 3% to 5% level have caused adverse effects on absorption, mixing, and fermentation, as well as on the volume, crumb, color, and flavor of bread. In 1971 Tsen and Hoover at Kansas State University found that the use of three dough conditioners, SSL, CSL, and EM, permitted production of high-quality breads even when high levels of nonwheat protein were in the formula. K-State workers have found that bread of acceptable quality could be made with 16% soy flour or 24% full-fat soy flour in the formula. The bread costs no more per loaf than ordinary bread, and it stays soft several days longer than regular wheat flour bread. The nutritional significance of this development is apparent. Soy flour is a valuable additive for bread not only for its high-protein content but for its 3.2% to 3.8% lysine, compared to 0.38% in wheat flour. The lysine content of a mixture of wheat fortified with 12% soy flour more than doubles, up to 0.76% to 0.83%. The soy-fortified bread has a protein content of about 11.5% compared to about 8% for conventional bread. Feeding studies at Kansas State have shown that the growth rate of weanling rats fed soy-fortified enriched bread over a four-week period was seven

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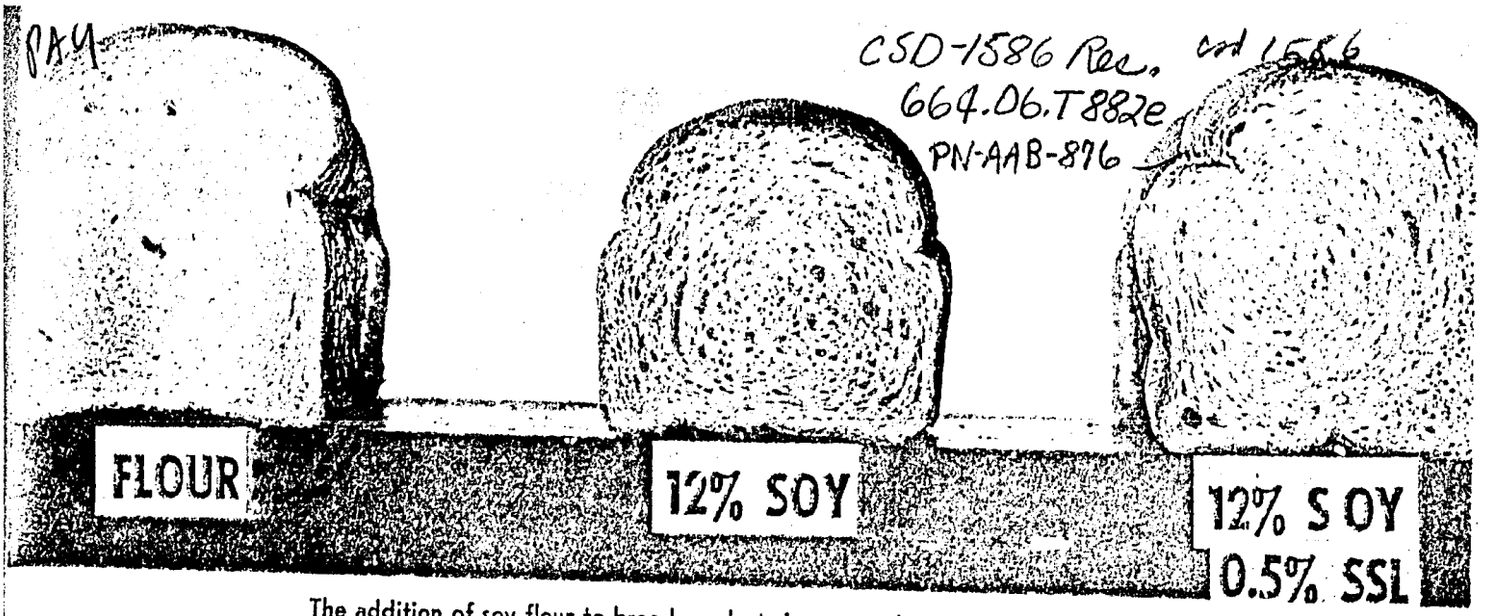

The addition of soy flour to bread products increases the number of air bubbles, thus increasing loaf volume, in addition to improving nutritional quality.

Blend K Bread

By WILLIAM J. HOOVER
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THE CONSUMPTION of bread is rapidly increasing in the developing countries of the world. This is particularly true in the corn and rice consuming areas of Latin America and Asia. This rising popularity of bread can be directly attributed to the huge shipments of wheat under P. L. 480 and to the effective wheat marketing programs supported by that law which has been so important to the increasing exports of U. S. agricultural crops.

Through a persistent effort to introduce the consumption of bread by training bakers and establishing a baking industry, bread has now become a staple food that is looked on as a status symbol in Latin America and Asia.

An integral part of the introduction of bread into diets where it has not been a staple is its use in school lunch and institutional feeding programs. Bread has been quickly recognized as a highly acceptable ready-to-eat food that can be centrally prepared by a contract baker.

Bread as the means for nutritional improvement has long been recognized because of its high consumption, wide acceptance, and low price. Enrichment of bread with vitamins and minerals over the last 30 years in the U. S. has resulted in a significant improvement of the nutritional status of the population. This has become taken for granted. Export wheat flour shipments under P. L. 480 are enriched with vitamins and minerals but flour milled in most developing countries is not as yet being enriched.

The development of an indigenous milling industry provides the mechanics for controlled enrichment of baked products by enriching the flour at the mill. The most obvious way for nutritional improvement of national diets in developing countries is through protein-fortified enriched wheat flour.

While it is true that many diets in the developing world are lacking in vitamins and minerals, the most important deficiency is the lack of protein of good nutritional quality. The protein content of the cereal grains averages from 8% to 13%, which would not be extremely low if the protein were of good nutritional quality. Unfortunately, the proteins of the cereal grains are relatively low in the amino acid, lysine, which limits their nutritional effectiveness.

Soy flour has long been recognized as an excellent means of fortifying the proteins of the products of cereal grains because of its high content of a protein rich in lysine. Cereal-soy products, such as Corn-Soy-Milk (CSM) and Wheat-Soy-Blend (WSB), have rapidly become the backbone of nutritional programs sponsored by governments, voluntary and international agencies. Unfortunately, because of functional property limitations, these products cannot be used in significant quantities in baked foods.

Soy flour in bread

Wheat gluten is unique among proteins in its ability to stretch, expand, and form a structure to

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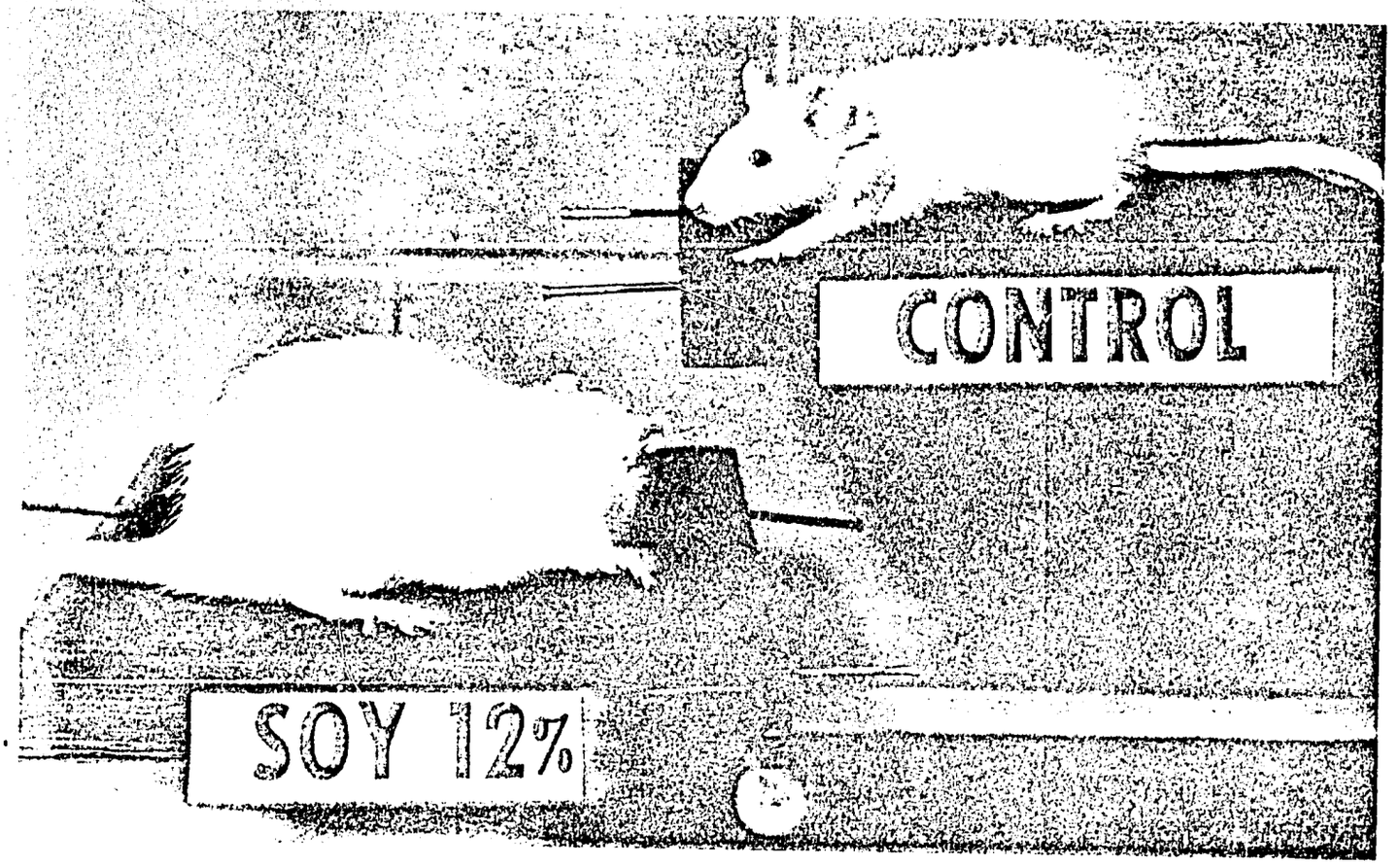

The growth rate of weanling rats fed soy-fortified enriched bread over a 4-week period was seven times the growth rate of rats fed standard enriched bread.

hold the small bubbles of gas generated during the fermentation of dough and during baking. This unique property permits bread to rise and results in bread with good volume and fine crumb structure. It has been axiomatic that the addition of starch or flour from grains other than wheat or the addition of nonwheat protein dilutes or even interferes with the functionality of wheat gluten. Whatever the mechanism may be, it is true that attempts to fortify wheat flour with soy flour beyond the 3% to 5% level have caused adverse effects on absorption, mixing, and fermentation, as well as on the volume, grain or crumb, color, and flavor of bread.

Over the years, research has lead to the improvement of soy flours for use in baked products. Heat treatment or toasting soy flour inactivated enzymes in the product, which adversely affected the baking properties. Toasting also alleviates the objectionable "beany" flavor, but too much toasting darkens the color of the baked product. Particle size of the soy flour or grits has also been found to be important. A grit with a coarse or medium granulation gives more appetizing breads and overcomes the objectionable brown color of breads containing finely powdered soy flours.

Modifying the baking process also improves breads containing soy flour. It has been found that raising the water absorption level in dough, decreasing mixing time, increasing oxidant treatment, and reducing fermentative time all improve baking performance of flours fortified with soy products.

These advances, however, still did not permit the production of high-quality bread when soy flour was added at levels that would result in significant nutritional improvement of the protein in the bread.

In 1969, Pomeranz, Shogren, and Finney[1] found that adding natural wheat glycolipids or synthetically produced sucroesters to wheat flour permitted adding up to 16% soy flour to bread formulas without a significant loss in physical properties. Unfortunately, natural wheat glycolipids are uneconomical and approval of sucroesters for use in food has not been requested of the Food and Drug Administration.

Tsen and Hoover[2], at Kansas State University, studied the actions of various surfactants in the production of protein-fortified breads. They found that the use of three dough conditioners, sodium stearoyl-2-lactylate (SSL), calcium stearoyl-2-lactylate (CSL), and ethoxylated monoglycerides (EM) permitted the production of

high-quality breads even when high levels of nonwheat protein from many sources were in the formula.

Of all protein-rich foodstuffs now available, soy flour is the most attractive in price, quantity, and quality. Using the dough conditioners, the K-State workers found that bread of acceptable quality could be made using up to 16% soy flour or 24% full-fat soy flour in the formulas. The breads not only had good volume and crumb texture but were light in color and had no trace of soy flavor. The basic result of this research is shown on page 14.

A significant "plus" factor was that the soy breads stayed soft or fresh for several days longer than the regular wheat flour bread. The ingredient cost of the high-protein bread should be essentially the same per loaf as regular bread.

Nutritional significance

The nutritional significance of this development can be easily seen. Soy flour is a valuable additive for bread not only for its high-protein content but also for its 3.2% to 3.8% lysine, compared with 0.38% in wheat flour. The lysine content of a mixture of wheat fortified with 12% soy flour more than doubles, up to 0.76% to 0.83%. The soy-fortified bread has a protein content of about 11.5% compared to about 8% for conventional bread.

Feeding studies at Kansas State have demonstrated (opposite) the remarkable benefits to be gained from soy flour fortification of wheat flour. The growth rate of weanling rats fed soy-fortified enriched bread over a 4-week period was seven times the growth rate of rats fed standard enriched bread.

One measure of the nutritional effectiveness of a protein is the protein efficiency ratio (PER). Foods are fed to rats under standardized conditions and the ratio is determined as the amount of weight gain divided by the amount of protein consumed. Casein is taken as the reference standard protein and has a PER of 2.5. White bread has a PER of around 1.0 while the 12% soy flour fortified bread was determined to have a PER of 1.95.

Blend K

Based on these findings, a specification for a protein-fortified wheat flour has been proposed for inclusion in P. L. 480 purchase programs. This product, tentatively called Blend K, would consist of 100 parts bread wheat flour, 12 parts soy flour, 0.5 parts SSL, and would be enriched with vitamins and minerals. It is felt that such a program will find ready acceptance for institutional feeding programs both in the U. S. and abroad which utilize bread as a basic commodity. Blend K would appear to be a complementary addition to the CSM and WSB family of fortified foods.

Blend K is now being tested in many countries and it is hoped that it will be a commercial reality in the very near future.

Fortified bakery products

Encouraged by the results with bread fortification, a great deal of effort has been extended to other baked or fried dough products. High-protein cookies of excellent quality have been produced that offer an exciting possibility in child feeding programs.

An example of the wide range of potentially commercial protein-fortified baked or fried wheat-based foods is the yeast-raised doughnut. Doughnuts of excellent quality, having doubled the normal protein content and only two-thirds the normal level of calories, have been produced. The ingredient cost for these doughnuts is slightly less than the regular doughnuts. Two of them and a glass of milk meet the nutritional requirements for the "Engineered Breakfast" recently proposed by USDA for domestic school breakfast programs.

Conclusion

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

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

Reprinted from November 1971 Soybean Digest, Hudson, Iowa 50643.

[1] Pomeranz, Y., Shogren, M. D., and Finney, K. F. Improving Breadmaking Properties of Glycolipids. I. Improving Soy Products with Sucroesters. Cereal Chem. 46:503 (1969).

[2] Tsen, C. C., Hoover, W. J., and Phillips, D. The Use of Sodium Stearoyl-2-lactylate and Calcium Stearoyl-2-lactylate for Producing High Protein Breads. Baker's Digest 45 (2): 20, 74 (1971).