Use of Soy Proteins in Bakery Products[1]

WILLIAM J. HOOVER, Kansas State University, Manhattan, Kansas 66502

ABSTRACT

A brief description of the products from soy used in the baking industry is given. The functional properties and the nutritional values are discussed. Emphasis is upon the production of high protein soy fortified yeast leavened breads, tortillas, unleavened breads, and chemically leavened products, such as cookies, cakes, and doughnuts. The nutritional significance and economics of such products also are explained.

INTRODUCTION

The largest commercial food usage of soy flour in the U.S. is in bakery products. Commercial sales to the bakery trade in 1972 were estimated by one source to be 65 million lb soy flour and grits and 9 milllion lb soy concentrate (1). This market has developed rather slowly but steadily since World War II, when soy flour was first used as a substitute for milk powder in bread. To this day, the main usage of soy flour in breadstuffs is as a replacement for nonfat milk solids (NFMS).

BREADS

It seems reasonable to begin a discussion of the role of soy flour in bakery products by describing the functional reasons for using milk solids in bread formulations. NFMS is used in the U.S.: (A) to increase moisture adsorption, (B) to provide lactose which gives browning reaction upon toasting, (C) to tenderize, (D) to give body and resilience, (E) to serve as a buffering aid, and (F) to provide nutrition.

The price of NFMS has skyrocketed to over 50 cents/lb, and it does not appear that it will be lower in the future. D.J. Kirk, Land O'Lakes, in a recent speech, reported that the NFMS production in 1973 was 940 million lb in the U.S. and is expected to be down to 600-750 million lb in 1974 (2). He predicted that this will lead to even further use of soy flour alone or in combination with whey solids or sodium casienate.

The soy flours of the mid-1940's were of poor functional quality for use in baked goods. The bad experiences with raw beany flavored and off colored products brought about a prejudice against soy flour in the bakery trade that the soy industry has been able to overcome only by product improvement and by the work of cereal chemists developing an understanding of the factors necessary for optimum use of soy flour in bread.

The soy industry now supplies a wide range of products for the baking industry: (A) enzyme-active soy flour (used up to 0.5%), (B) toasted soy flour, (C) chemically treated soy flour, (D) lecithiated soy flour, (E) full-fat soy flour, (F) concentrates, and (G) soy isolates. Through process improvement and better quality control, the industry is now producing lighter colored, blander soy products with better functional properties for baking.

Secondly, cereal chemists, such as Ofelt, et al. (3)., Finney, et al., (4), Pomeranz, et al., (5), and Tsen, et al., (6-8) have shown that by raising absorption, decreasing mixing time, increasing oxidant (bromate) treatment, and reducing fermentation time, the baking performance of flours to which defatted soy flour has been added will be improved.

The "U.S. Standards of Identity" for enriched white bread (9) allows the use of up to 3% NFMS or soy flour as optional ingredients. There is no limitation on nonstandardized breads. With today's soy flours, at the 3% level of substitution for NFMS, bakers do not find any appreciable change in absorption, mix, and oxidant requirements. The only real concern by some bakers is the effect upon flavor. Elaborately controlled taste panel studies have given mixed results. Some studies have indicated that panels could tell a difference and preferred the breads made with NFMS, while others found no detectable difference.

Soy flour will provide, functionally, better water absorption, and, at least, as good a tenderizing effect, body, and resilience as will NFMS. The degree of color reaction can be controlled by partial substitution of dextrose or liquid reducing sugars in place of the sucrose in the formula. The buffer value of NFMS is only significant when long sponge fermentation and floor times are used. With the trend toward shorter time processes, this factor is not too significant. Nutritionally, soy flour contributes slightly more than NFMS in bread at these levels. Generally, the protein efficiency ratio (PER) of unfortified white bread is considered to be 0.7 (relative to a value of 2.5 for casein). Turro and Sipos (10) found that bread containing 3% NFMS had a PER of 0.75 and breading containing 3% soy flour had a PER of 0.83.

The current price of defatted soy flour in the U.S. is ca. 13 cents/lb compared to over 50 cents/lb for NFMS. It is obvious that soy flour will find increasing usage in bread as long as this situation exists. Cotton (1) estimated that ca. 50 million lb soy flour was used in U.S. breads last year.

DONUTS

Ca. 7 million lb soy flour is used in donut mixes and cakes each year. In donuts, soy flour has the special advantage of reducing oil pickup during drying, which results not only in a better quality donut, but is economical in that it lowers frying oil costs. Used in the range of 3-3.5% of the formula, soy flour also gives donuts a good crust color, improved shape, higher moisture absorption with the resultant improvement in shelf-life, and a texture with shortness or tenderness.

OTHER BAKERY PRODUCTS

In cakes, soy flour again is being used as a replacement for NFMS (11). It often is observed that cake tenderness and texture are improved. In addition, however, cake formulations are more tolerant to process and ingredient variations when ca. 2% soy flour is used. Cotton (1) reports better results with high fat soy flours in cakes than low fat or defatted soy flours. A good deal of research needs to be done to determine the interrelationships between various soy products, shortening levels, and emulsifying systems in cakes and donuts.

Soy flours are used in the 2-5% range in many bakery snack items. Although very little has been published about these usages, Cotton (1) believes that 14 million lb soy are being used each year in specialty bakery items. Some of the functional properties claimed are improved machinability of cookie doughs, with a resultand reduction of cripples; improved browning and improved flavor for pie crusts; and desired color and flavor for snack crackers.

NUTRITIONALLY IMPROVED BAKERY PRODUCTS

To set the development of protein fortified bakery products in proper perspective, it is helpful to look briefly at the history of products and voluntary agency programs offered

[1]One of 13 papers presented in the symposium, "Soy Protein," at the AOCS Spring Meeting, Mexico City, April 1974.

under Title II, Public Law 480. When this program began in the early 1950's, primarily raw agricultural commodities, such as wheat and corn, were distributed. Later, processed commodities, such as wheat flour, NFMS, and vegetable oil, were added. In 1966, a significant amendment to the law permitted the distribution of formulated food commodities which led to the programs based upon corn soy milk, wheat soy blend (WSB), and other blended foods. Institutional feeding programs gradually became more sophisticated and attempted to prepare fortified food items using these commodities with which the consumer was familiar. For example, buns and bread were prepared using flour with rather high levels of NFMS and vegetable oil, or cookies were prepared using a proportion of WSB or soy fortified bulgur.

In 1969, Pomeranz and others (5) reported that the use of sucrose esters permitted up to 16% soy flour in bread without adverse effects upon loaf volume and texture. This encouraged others to find chemicals, approved for use in foods, which would accomplish the same result. Tsen and others reported finding that sodium stearoyl-2-lactylate (SSL), calcium stearoyl-2-lactylate (CSL), or ethoxylated monoglyerices also provided a system which permitted the addition of levels of soy flour which would improve the nutritional value of breadstuffs significantly without detrimental effects upon their eating qualities.

Prior to these developments, the addition of high levels of soy flour to wheat flour based breads resulted in greatly reduced loaf volumes; coarse, open texture; off-white or yellowish color; and an off-flavor best described as "beany." The addition of small amounts of the previously mentioned chemicals does permit the addition of soy flour at levels which significantly improve nutritive value of the protein without altering the acceptability of the product. The resultant bread has normal loaf volume, fine, even crumb characteristics, color that is very close to a nonfortified bread, and normal bread flavor.

Nutritionally, the addition of higher levels of soy flour brings about some dramatic changes in protein nutritive value. The PER, it will be recalled, for white bread is ca. 0.7 and for bread with 3% soy flour added ca. 0.83. When the soy flour is increased to the 6% level, the PER climbs to 1.3, and, at the 12% level, the PER becomes 1.95. In addition to improvement in protein quality at the 12% soy flour level, there is 50% more protein in the fortified bread. Feeding studies with rats indicate a three-fourfold increase in growth rates of rats fed diets based upon the fortified bread compared to unfortified white bread.

In August 1972, the USDA issued purchase specifications for 2 types of soy fortified flour, i.e. 6% soy fortified flour and 12% soy fortified flour to be used in Title II, Public Law 480 programs. The specifications describe the wheat flour, the defatted lightly toasted soy flour, the SSL, and the vitamins and minerals added as enrichment. A baking performance test also is required for the final blend. At the present level of understanding of the functional values of soy flours for baking purposes, there is no chemical or physical test or specification available to predict the baking quality short of conducting a controlled baking test.

The first purchase of soy fortified flour was made in October 1972, and, since that time, over 120 million lb have been used in school and institutional feeding programs in some 20 countries. An increase in the rate of usage is expected during the next fiscal year.

In addition to the highly acceptable properties of the fortified bread previously mentioned, at least two more positive attributes must be noted. The first, which is of significance in some markets, is the especially good toasting qualities of the bread. The second, which is of great value everywhere, is an extended or increased shelf-life. For breads normally thought to begin to be noticeably stale after 3 days, the same degree of staling would not be noticed until after 5 days when the soy flour and SSL are incorporated. This is due to the increased moisture absorption and retention of soy flour and to the known enchancement of "softness" of bread by SSL. On the other hand, the soy fortified flour breads will become moldy faster than regular bread, because of a slightly higher moisture content and because they are a better nutrient medium for mold growth. Addition of calcium propionate is suggested where longer periods before consumption are anticipated.

Fortunately, the introduction of soy fortified flour into bakery products requires very little change in bakery technology and no changes at all in bakery equipment. Good breads have been made using straight dough, sponge dough, short time dough, and continuous procedures. Similarly, all types of breadstuffs have been successful with the soy fortified flour. Three minor changes from normal baking procedure will result in optimum breads from soy fortified flour.

First, the increased absorption of the soy requires that three-fourths to one part water be added for every part soy flour. Thus, on a 100 part 12% soy fortified flour formula, 9-12 parts more water would be required for optimum dough development and workability. If water is added to "feel of dough," the bakery will add the right amount automatically.

Second, less mixing than normal dough will result in optimum bread quality. This is also a blessing, because most small bakeries in underdeveloped countries use either hand-mixing or slow speed mixers and the doughs tend to be undermixed. This means that the baker will be closer to optimum mixing for soy fortified flour breads than for his regular flour breads.

Third, a shorter fermentation time than normal is best for soy fortified flour breads. Bakers interested in increasing capacity or throughput will find this to their benefit.

Soy fortified flour fortunately has a remarkable versatility for many uses. If this had not been the case, its value as a Title II commodity would have been limited. As already stated, all types of breads, including unleavened arab bread, french bread, buns, sweetrolls, and pan breads can be made from soy fortified flour. Some institutional feeding programs are using cookies made from soy fortified flour. Actually, all types of cookies can be made with excellent quality. Normal sugar cookies are ca. 5% protein (PER = 0.5), whereas soy fortified flour sugar cookies are 8% protein (PER = 1.5). Cakes of excellent quality also can be made from soy fortified flour. For both cookies and cakes, an ingredient savings can be realized, because less shortening than normal is required when using soy fortified flour.

Oriental noodles, based upon soy fortified flours, are now available in Taiwan. Soy fortified flour has been used in the Kansas State Laboratories as a weaning food by simply preparing it as a gruel. Similarly, soy fortified flour has been demonstrated to make excellent gravy.

COSTS

Several viewpoints can be taken to evaluate the costs of soy fortified bakery products. One example is to consider the ingredient costs for white pan bread using the relative costs for wheat flour, soy flour, SSL, and shortening. Because breads using soy fortified flour can be made with reduced or even no shortening levels, the ingredient cost of soy fortified bread is essentially the same as white bread without 3% NFMS and, of course, less expensive than bread with 3% NFMS.

Since the procurement of soy fortified flour under Title II, Public Law 480 began, the cost of soy fortified flour has run rather consistantly 5-6% more than regular wheat flour. However, there is a 6-7% increase in yield of bread from soy fortified flour that offsets the increased flour cost.

Still another viewpoint is the school lunch program, such as the one in the Philippines, which previously was based upon a fortified bread, the formula for which called for

flour, NFMS, and vegetable oil. Using soy fortified flour, the same nutrition is being provided in a bun which has a cost of nearly 1 cent/child/day less than the product it has replaced.

Commodity prices and price relationships vary so widely in the world because of freight differentials, governmental agricultural pricing, and taxing policies that each country must be examined individually to determine the cost of soy fortified bakery products in relation to the prevailing breadstuffs. There are times, as it appears at present in Brazil, when the cost of 100 parts wheat flour is more than a blend of 88 parts wheat flour, 12 parts soy flour, and 0.5 parts SSL.

This paper would not be complete without at least mention of full-fat soy flour, soy protein concentrates, and soy isolates in nutritionally improved breadstuffs. Actually, full-fat soy flour seems to be more functional that defatted soy flour in breads. For example, up to 24 parts full-fat soy flour can be used in formulas and produce the same type of bread quality achieved when using only 16 parts of defatted soy flour. While full-fat soy flour is more expensive in the U.S. than defatted soy flour, it may be the product of choice in countries where a solvent extraction industry does not exist or where pricing makes it economically attractive. At the same protein level of addition, soy concentrates and soy isolates show no advantage over defatted soy flour and are, of course, more expensive. It may be, however, that in certain bakery products where particularly high protein levels are wanted, these products will find some usage.

FUTURE

Soy fortified bakery products appear to be the best vehicles for protein improvement in the diets in many parts of the world. Generally, breadstuffs are the number one convenience food eaten and liked daily by large masses of the population. This, coupled with the convenience of central fortification at flour mills, simplicity of technology, and the fact that the net cost on a nutritional basis, or sometimes on any basis, is lower than any other food that can be used in nutritional feeding programs, makes the future of soy fortified bakery products seem bright.

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