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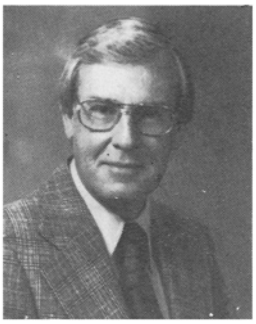

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Soya Protein Products in Cereal Grain Foods

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ABSTRACT

The largest food usage of soya flour is in bakery products. The soya industry now supplies a wide range of products for the baking inudstry, and these products in turn offer a wide variety of functional uses in different bakery foods. Although the technology for soya use in bakery foods is well established and reasonably simple, the functional properties and flavor are continually being improved through major research efforts. The current status of the use of soya products in bakery foods is presented in this paper, and a look to some of the future uses including a major worldwide potential for fortification of cereal grain products is offered.

INTRODUCTION

Soya products, because of their unique functional and nutritional properties, have become major ingredients in many food systems. The use of soya protein as an ingredient, extender, or analog has spread to every category of foods, and consumption of edible soya protein in the U.S. has grown from less than 100 million lb/year in the early 1960s to over one billion lb/year in 1978 (1). New and improved processing techniques have been developed, resulting in products having a wide range of properties adaptable to various food systems. In addition to these functional properties, the excellent nutritional quality of soya protein has become of increasing importance in recent years.

One of the food categories in which the use of soya products is gaining wide acceptance is bakery foods; one source reported the sale of soya flour to the baking industry as more than 132 million lb in 1978. This paper will review soy products which have gained acceptance in bakery foods and the benefits gained from their use.

QUALITY FACTORS

Soya protein products, particularly flours for bakery food applications, are specified on the basis of protein content, fat content, protein solubility, urease activity, lipoxidase activity and granulation. Of these, protein solubility is the major factor affecting functionality.

Protein solubility is a measure of the percentage total protein soluble in water under controlled conditions, and is a measure of the degree of heat treatment to which the soya flake has been subjected. The protein solubility is closely related to functional properties for bakery food applications. Several methods are used to determine protein solubility, the main tests being Nitrogen Solubility Index (NSI), the Protein Dispersibility Index (PDI) and the Protein Solubility Index (PSI). Each test indicates the percentage of total soluble nitrogen in water and the range of values is 0-100%. A lightly toasted soya flour will have a rating of 60-80%, whereas a heavily toasted soya flour will rate 10-20%.

The enzyme activity of soya flour is related to protein solubility, in that the heat treatment destroys enzyme activity. The primary enzymes in soya flour are lipoxidase, urease, amylase, lipase and protease. Thus, if a lipoxidase active flour is desired, a relatively high PDI flour should be used.

Nutritional characteristics are closely related to protein solubility. Soybeans contain some antinutritional factors which must be inactivated for maximal nutritional value. A prime example is an antitrypsin factor which retards the action of the trypsin enzyme. These factors are destroyed by heat, so an indication of protein denaturation (low PDI, PSI, or NSI) also provides an indication of inactivation of these antinutritional factors.

All of the quality factors mentioned indicate suitability of soy products for baker food use. However, none of these tests will replace the baking tests in determining the suitability of a soya product for a specific bakery application. The baking test is essential for determining if a particular product is the most desirable ingredient for a specific application.

The types of soya products available to the baking industry and a summary of bakery food applications are given in Table I.

DEFATTED SOY FLOUR

Defatted soya flour (a light-colored, bland-flavored flour) is produced by grinding defatted flakes to a particle size similar to that of wheat flour. Defatted soya flours having a wide range of PDI are available, and the bakery food application for any particular flour depends on the characteristics imparted by the degree of heat treatment as indicated by the PDI.

Early soya flours produced an excessive softening effect on bread doughs, which was corrected by the toasting process. However, excessive toasting reduced bread volume and produced inferior bread texture. Soya flours used in bread production have been treated sufficiently to destroy nearly all enzyme activity and to improve flavor, but not enough to impair baking quality. Most flours for bread use have a PDI of 50-75.

Defatted soya flours are permitted in standardized bakery items at a maximal level of 3%, flour weight basis (2). No maximum has been established for other bakery foods.

When used at the rate of 1-3% flour basis in bread and buns, soya flour increases absorption ca. 1 lb additional water for each lb of soya flour, improves crumb body and resilience, improves crust color (from sugars), and improves toasting characteristics. Defatted soy flour is an excellent economical, functional and nutritional replacement for nonfat dry milk in these products.

Defatted soya flour is used in cakes where water absorption and film forming characteristics are desired. Usage level is 3-6% soya flour, flour weight basis, and benefits include a smoother batter having a more even distribution of air cells, and a cake with a more even texture, and a softer and more tender crumb.

Recent work at the American Institute of Baking has shown that soya flour levels of 10-15% used in combination with certain starches can be used in high-ratio cakes in combination with unchlorinated cake flour. Presently, high-ratio cakes are made with chlorinated wheat flour and this usage of soya flour would become important only if chlorination of wheat flour were prohibited.

In sweet goods, 2-4% defatted soya flour improves water holding capacity, sheeting characteristics and finished product quality. The same levels should be used for yeast-raised doughnuts.

Cake doughnut quality is greatly improved by the addition of 2-4% defatted soya flour, based on wheat flour weight. The soya protein functions as a structure builder, producing a doughnut with an excellent star formation. Fat absorption during frying is reduced, producing improved texture and eating properties. The increased absorption and moisture retention increases yield and extends shelf life.

In hard (snap) cookies, the use of 2-5% defatted soya flour improves machining and produces a cookie with a "crisp" bite.

Toasted, defatted soya flours with a PDI of ca. 20 add color to the crumb and a nutty, toasted flavor to whole-grain, multigrain, or natural-grain bread.

ENZYME-ACTIVE SOYA FLOUR

Enzyme-active soya flour is defatted soya flour which has been processed to retain its lipoxidase enzyme activity. This enzyme effects changes in bread doughs which result in the bleaching of carotenoid pigments and which produce peroxides that strengthen gluten proteins (3,4).

A second type of enzyme-active soya flour is processed without removal of the fat, resulting in a full-fat, enzyme-active flour. This flour is not merchandised as such, but is blended with other ingredients, such as corn flour.

Enzyme-active soya flour is used primarily in white bread and bun production. The FDA Standards of Identity (5) permit a maximum of 0.5% enzyme-active soya flour, flour weight basis, in standardized bakery foods. There are no limits for nonstandardized bakery foods.

FULL-FAT, HIGH-FAT AND LECITHINATED SOYA FLOURS

One of the components of soybean oil which is removed in the processing of defatted soya flour is lecithin. Lecithin has a number of functional properties that are useful in the production of bakery foods. Among its uses are as an emulsifier, as a blending aid, and as a pan-release agent. Lecithin also is an antioxidant and enhances the stability

TABLE I

Bakery Food Applications

	White bread & rolls	Specialty bread & rolls	Cakes	Cake doughnuts	Yeast-raised doughnuts	Sweet goods	Cookies
Defatted soy flour	X	X	X	X	X	X	X
Enzyme-active soy flour	X						
Low-fat soy flour			X	X		X	
High-fat soy flour			X	X		X	
Full-fat soy flour			X	X		X	
Lecithinated soy flour			X	X			X
Soy grits		X					
Soy concentrates		X					
Soy isolates		X	X	X	X		
Soy fiber		X					

of vitamins in bakery foods.

Soya oil and lecithin are beneficial to many bakery foods, and a number of soya products have been developed to include these very functional ingredients. These products are used where a lecithin-type emulsifier is beneficial, and where shortening sparing action is desired.

Full-fat soya flour is processed to retain all of the fat present in the soybean. The bean is not subjected to solvent extraction but is subjected to a mild heat treatment to minimize enzyme activity.

High-fat soya flours (refatted) are defatted flours to which varying amounts of soya oil have been added. The most common high-fat flours contain 6% added soybean oil or 15% added soybean oil.

Several types of lecithinated soya flour are available, ranging from 6% added lecithin to as much as 35% lecithin and soya oil combinations.

High-fat, full-fat and lecithinated soya flours are often used in heavier cakes, such as sponge and pound cakes, because of the increased richness and emulsification functions they provide. In these applications, 3-5% of the soya flour, based on flour weight, is used with an increase in water of ca. 1-1.5 lb for each lb of soya flour used. In addition, the high-fat or lecithinated soya flour may permit reduction in eggs and shortening.

Lecithinated soya flour is recommended for doughnut formulas with minimal egg yolk levels, because lecithin is the natural emulsifier contained in egg yolks.

Short-pastry items, such as pie crusts, fried pie crusts and puff pastry can be machined more easily and retain freshness longer when lecithinated soya flour is used in the formula at levels of 2-4%, flour weight basis.

In "natural" bread products, lecithinated soya flours can be beneficial for both functional and nutritional reasons. Lecithin is a natural emulsifier and can be used to extend shelf life.

SOYA GRITS

In the processing of defatted soya products, the flakes may be ground to different degrees of fineness to produce a coarse particle product, called grits, or the fine product, flour. Grits have the same chemical analysis as flour; the only difference is in particle size.

Heavily toasted grits with a PDI of 20-30 are used in whole-grain, multigrain and natural-grain breads to add color and a nutty, toasted flavor. In this application, normal usage level is 2-4% toasted grits, flour weight basis. The same nutty, toasted flavor could be imparted to specialty cookies by using toasted grits.

SOYA PROTEIN CONCENTRATES

Soya protein concentrates are manufactured by extraction of the water-soluble carbohydrates, minerals, and other minor constituents, and inactivation of off-flavor producing enzymes and antinutritional factors. These products possess a low flavor level compared to the flavor associated with some soya proteins.

These concentrates vary in color, flavor, particle size, and water and fat absorption–all characteristics important to bakery food manufacture. Concentrates are used mostly for water and fat absorption and where protein levels higher than those in soya flours are required for nutritional purposes. For example, Onayemi and Lorenz (6) reported that the addition of up to 5% soya concentrate did not adversely affect white bread quality. Generally, unless higher protein levels are demanded, soya flour has the functionality and economics to be used in bakery products in the place of concentrates.

SOYA PROTEIN ISOLATES

In the manufacture of soy protein isolates, the protein is extracted from defatted flour and a curd is precipitated (isolated) from the soya whey. The isolated proteins are then neutralized to a pH of 6.5-7. These proteins are subjected to a variety of treatments to provide certain specific characteristics for various food applications. The important functional characteristics for food applications, as outlined by Johnson (7), are emulsification ability, gel formation properties, water holding properties, film forming properties, adhesive and cohesive properties, and aeration properties.

Onayemi and Lorenz (6) reported that soya protein isolates can be used at a level up to 5%, flour weight basis, without adversely affecting white bread quality. New systems based on soya protein isolates have been developed as milk replacers in cakes and cake doughnuts. The functional attribute making the isolates attractive for this application are the water binding capabilities. However, in any such system, the isolate must be specifically designed to functionally replace the nonfat dry milk, and a product developed for a specific bakery food application may be unsuited for a different application.

MILK REPLACER BLENDS

The greatest usage for soya products in the bakery foods industry is the combination with other ingredients, such as sweet dairy whey, to replace nonfat dry milk in the bakery food. Milk replacer blends are available at protein levels ranging from 20 to as high as 40%, and the blend is dictated by the functional and/or nutritional requirements for the product. Defatted flour is the primary soya product used in these blends, but concentrates and isolates also are used in combination with whey and sodium or calcium caseinate for special applications, as discussed under soy protein isolates.

Milk replacers are made either by dry blending the ingredients or wet blending, followed by spray drying. Dry blended products will perform as well as wet blended products in most bread and other yeast-raised bakery foods. However, in other applications, such as cakes and cake doughnuts, the wet blended products are more effective. Also, the soya/whey blend appears to be more adaptable to yeast-raised bakery foods as milk replacers, compared to use in cake products.

In cake-type products, the structure forming characteristic of nonfat dry milk is more critical than in yeast-raised bakery products, and any milk replacer must provide this function. Soya concentrates and isolates appear to be more functional than defatted flour blends for these applications.

The ingredients in typical milk replacers include sweet dairy whey, defatted soya flour, soya concentrate, soya isolate, corn flour and nonfat dry milk.

SOYA BRAN/FIBER

Soya bran/fiber is produced by toasting and grinding the seed coat portion of the soybean. This bran has a crude fiber content of ca. 38%, one of the highest fiber sources among commercially available vegetable products. It can be used in multigrain breads, in blended fiber systems or can be used as the sole fiber source in such breads (8). Usage in this application ranges from 5 to 20%, flour weight basis.

NUTRITION

Protein is essential for body growth and tissue repair.

Proteins are complex systems composed of 21 amino acids, of which all but 8 can be synthesized by the human body. These 8 are called essential amino acids because they must be obtained from the food we eat. A protein is like a chain with amino acids as the links, and the chain is not stronger than its weakest link. Therefore, proteins may be present in sufficient quantity but the contribution to nutritional value may be limited by the quantity of a particular essential amino acid in the protein. In wheat, the amino acid lysine limits the nutritional value of its protein; the limiting amino acid in soya is methionine.

Fortunately, proteins from different foods complement each other, and by combining proteins, the nutritive value of the food is dramatically improved. Such is the case of combining soya protein with wheat protein in the manufacture of bakery foods.

Hoover (9) reported that the addition of higher levels of soya flour brought about dramatic changes in the protein nutritive value of bread. The Protein Efficiency Ratio (PER) compares the nutritive value of a system with the protein nutritive value of casein at 2.5. By comparison, the PER of defatted soya flour, lightly toasted, is 2.03-2.3 (10).

The PER for white bread is ca. 0.7 and for bread with 3% soy flour added, ca. 0.83. When the soya flour is increased to the 6% level, the PER increases to 1.3, and at the 12% level, the PER is 1.95. In addition to the improvement in protein quality at the 12% soya flour level, the protein content is increased by 50%. Feeding studies with rats indicated a 3- to 4-fold increase in growth rates of rats fed diets based on the fortified bread, compared to unfortified white bread.

Tsen et al. (11) noted that high levels of soy flour produced depressed volume and poor bread characteristics. They found that the addition of sodium stearoyl-2-lactylate (SSL), or ethoxylated monoglycerides provided a system which permitted the addition of higher levels of soya flour to bread stuffs without detrimental effects on their eating qualities.

Tsen also reported (12) that excellent protein fortified cookies could be made using a blend of 88 parts bread flour, 12 parts defatted soya flour and 0.5 parts SSL.

Soya fortified flour has been used worldwide in mass feeding programs, including school lunch programs, since 1975. This commodity is available through the U.S. Food for Peace Programs (P.L. 480). Millions of pounds of this blended food are used each year in all types of bakery foods.

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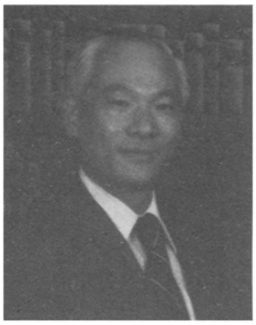

Soy Proteins for Foods Centering around Soy Sauce and Tofu

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ABSTRACT

In the Orient, soy proteins have been used for human consumption for centuries, during which various kinds of unique soy protein foods have been established. Some of these products, such as tofu, have a bland flavor, but there are also those products having a distinctive flavor and an aroma like fermented soy sauce. Both types are acceptable for worldwide populations. In earlier times, the consumption of these soy protein foods in the U.S. was mostly confined to Orientals. Recently, however, the koikuchi type of soy sauce has been consumed widely by non-Orientals through nationwide supermarkets. Annual production in the U.S. has reached more than 16,500 kl. Tofu has also become popular in the U.S. because of its bland flavor which enables it to be used in many dishes. Fermented soy sauce is completely different in the constituents of aroma and flavor from chemical soy sauce. Koikuchi shoyu is a typical Japanese type of fermented soy sauce characterized by a strong, appetizing aroma. The fermentation process consists of koji fermentation by *Aspergillus* species and the subsequent brine fermentation, which contains lactic acid and alcoholic fermentations. Miso is a paste product produced through a similar fermentation. Tofu is a soy milk curd product made through a nonfermented process from soy milk.

INTRODUCTION

There are significant differences in the use of soy proteins for human consumption in the U.S. and in the Orient. In the U.S., the use of soy protein as food is a new development. Soy proteins are used as ingredients of a wide variety of foods, e.g., hamburgers, sausages, meatloaves, dairy products, breads, pastries and cookies. In the Orient, however, soy proteins have been consumed for thousands of years, not as ingredients, but as characteristic, unique soy protein foods.

These traditional soy protein foods are divided into two groups: fermented and nonfermented. Fermented foods are