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Potential Use of Soybean Flour (*Glycine max*) in Food Fortification

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<http://dx.doi.org/10.5772/52599>

1. Introduction

Protein-energy malnutrition (PEM) results from prolonged deprivation of essential amino acids and total nitrogen and/or energy substrates. Growth which is a continuous process results from the complex interaction between inheritance and environment. Protein-energy malnutrition (PEM) also results from food insufficiency as well as from poor social and economic conditions [6, 20]. Malnutrition originates from a cellular imbalance between nutrient/energy supply and the body's demand to ensure growth and maintenance [22]. Dietary energy and protein deficiencies usually occur together, although one sometimes predominates the other and if severe enough, may lead to the clinical syndrome of kwashiorkor (predominant protein deficiency) or marasmus (mainly energy deficiency).

The origin of PEM can be primary, when it is the result of inadequate food intake, or secondary, when it is the result of other diseases that lead to low food ingestion, inadequate nutrient absorption or utilization, increased nutritional requirements and/or increased nutrient losses [13]. In as much as protein-energy malnutrition applies to a group of related disorders that develop in children and adults whose consumption of protein and energy is insufficient to satisfy the bodies nutritional needs, about one third of children worldwide suffer from malnutrition [8]. This continues to be an important problem mostly in developing countries. One way to curb the global menace of PEM is through food fortification of plant origin. Food fortification is broadly aimed to allow all people to obtain from their diet all the energy, macro- and micronutrients they need to enjoy a healthy and productive life [3].

Legumes are one of the world's most important sources of food supply especially in the developing countries in terms of food, energy as well as nutrients. It has been recognized as

an important source of protein and in some cases oil. As a legume, soybeans are an important global crop that provides oil and protein for users. It is the richest sources of protein among the plant foods. Features that motivate researchers to explore its utility in a wide range include the good quality and functionality of its proteins, surplus availability and low cost. Soybeans in the form of full fat flour, concentrate, isolate and texturised proteins have been used in a wide range of food products. These attributes made soybeans to be considered as an ideal food for meeting the protein needs of the population.

The objective of this chapter is to briefly describe the quality attributes of soybean and the potential use of its flour in food fortification.

2. Soybeans

Soybeans (*Glycine max*) belonging to the family *leguminosae* constitute one of the oldest cultivated crops of the tropics and sub-tropical regions, and one of the world's most important sources of protein and oil. Soybeans are probably the most important oil seed legume which has its origin in Eastern Asia, mainly China. The cultivar *Glycine max* is thought to be derived from *Glycine ussuriensis* and *Glycine tomentosa* which grow wild in China, and can be found in great quantities in Asian countries such as Japan and Indonesia [16].

The seeds vary in shape and colour depending on the cultivar. In shape, they can be spherical to flatten while the colour varies from white, yellow and brown to black. Also, the chemical composition of each variety of soybeans differs from each other. Due to the long and tedious processing technique of soybeans, Japan which is one of the largest suppliers of soybean has developed highly advanced processing technologies in the processing and manufacturing of highly acceptable and palatable soya products [14]. As a result of high protein content in soybean, it can be used as a substitute for expensive meat and meat products [5].

Soybean is particularly very unique for different reason and hence classify as a valuable and economical agricultural commodity. In the first instance, it possesses agronomic characteristics with its ability to adapt to a wide range of soil and climate; and its nitrogen fixing ability. This makes it to be a good rotational crop for use with high nitrogen – consuming crops such as corn and rice. Secondly, soybean unique chemical composition on an average dry matter basis is about 40% of protein and 20% of oil. This composition makes it to rank highest in terms of protein content among all food crops and second in terms of oil content after peanut (48%) among all food legumes. Furthermore, soybean is a very nutritious food crop.

3. Nutritional content of soybean

Soybean (*Glycine max*) first emerged as a domesticated crop in the eastern half of North China around the 11th century B.C of Zhou Dynasty. It is easy to grow and has adaptability to a

wide range of soils and climate. Because it contains high amount of protein and oil, the soybean was considered one of the five sacred grains along with rice, wheat, barley and millet [4]. The protein and oil component of soybean are not only high in terms of quantity but also in quality. For instance, soy oil has a highest proportion of unsaturated fatty acids such as linoleic and linolenic acid making it a healthy oil to use. Soybeans are known to be typical of such crops that contain all three of the macro-nutrients required particularly for human nutrition. They also contain protein which provides all the essential amino acids in the amounts needed for human health. Most of the essential amino acid present in soybean is available in an amount that is close to those required by animals and humans. The protein – digestibility – correlated amino acid score is close to 1, a rating that is the same for animal proteins such as an egg white and casein. The profile of various nutrients in raw matured seeds of soybeans as highlighted in USDA Nutrient database is as indicated in Table 1 below. Additionally, soybean contains phytochemicals which have been shown to offer unique health benefit. Soybean also has versatile end uses which include human food, animal feed and industrial materials [10].

4. Utilization of soybeans

Soybean can be processed to give soy milk, a valuable protein supplement in infant feeding, soycurds and cheese [23]. It is also used to produce soysauce used extensively in cooking and as a sauce. Soybeans are also used for making candies and ice cream and soybean flour which could be mixed with wheat flour to produce a wide variety of baked goods such as bread and biscuits [16]. Soybean oil is used for edible purposes, particularly as a cooking, and salad oil and, for manufacture of margarine [16]. The oil can also be used industrially in the processing of paints, soap, oil, cloth and printing inks. The meal and soybean proteins are used in the manufacture of synthetic fibre (artificial wool) adhesives and textile [14]. Soybeans could be made into such products as tempeh, miso and natto which may include other sub-products [16].

Soybean protein fibre has been reportedly produced from bean dregs that are produced when extracting oil [14]. From these, globular protein is extracted, made into a spinning solution of a consistent concentration with the addition of a functional auxiliary, and spun into yarn by the wet method [21]. Effect of fermentation on soybean has the tendency of altering the features of the arising dregs when oil is so extracted from soybean. This thus has tendency of either skewing up or otherwise the various arrays of benefits known to accrue from the development of soybean fiber blends with other fibers [21]. [7] has also reported on the chemical composition and total digestible nutrients (TDN) of fermented soybean paste residue. This is usually exploited for the utilization of such residues in livestock rations. Furthermore, [9] had suggested the likelihood of the use of fermented soybean paste residue for livestock feed in the near future as a form of turning waste to wealth and thus serving as anchor for many other accruing benefits.

Nutrient	value per 100g
Energy	1,866kJ (446kcal)
Carbohydrates	30.16g
Sugars	7.33g
Dietary fiber	9.3g
Fat	19.94g
Saturated	2.884g
Monounsaturated	4.404g
Polyunsaturated	11.255g
Protein	36.49g
Tryptophan	0.591g
Threonine	1.766g
Isoleucine	1.971g
Leucine	3.309g
Lysine	2.706g
Methionine	0.547g
Phenylalanine	2.122g
Tyrosine	1.539g
Valine	2.029g
Arginine	3.153g
Histidine	1.097g
Alanine	1.915g
Aspartic acid	5.112g
Glutamic acid	7.874g
Glycine	1.880g
Proline	2.379g
Serine	2.357g
Water	8.54g
Vitamin A equiv.	1µg (0%)
Vitamin B6	0.377mg (29%)
Vitamin B12	0µg (0%)
Vitamin C	6.0 mg (10%)
Vitamin K	47 µg (45%)
Calcium	277mg (28%)
Iron	15.70 mg (126%)
Magnesium	280 mg (76%)
Phosphorus	704 mg (101%)
Potassium	1797 mg (38%)
Sodium	2 mg (0%)
Zinc	4.89 mg (49%)

Table 1. Source: USDA Nutrient database, Percentage relative to US recommendations for adults Nutritional content of raw mature seeds of soybean

5. Antinutritional factors in soybeans

Flatulence is characterized by stomach cramps, nausea, diarrhoea, intestinal and gastric discomfort resulting from the production of large amounts of gas in the gastrointestinal tract. Although all the causative factors in flatulence formation are still unknown, it has been suggested and generally accepted that low-molecular weight oligosaccharides, primarily raffinose, stachyose and verbascose present in most legume seeds are linked to flatulence [2]. Researchers have suggested practical procedures for the reduction of flatulence in cooked and processed soybeans. These include fermentation, removal of seed coat prior to cooking or processing, soaking in water, germination and cooking with a mixture of sodium carbonate and bicarbonate [11]. Oligosaccharides can also be reduced through fermentation thereby leading to elimination of flatulence.

6. Soybean in food fortification

In many developing nations, cereal based foods are widely utilized as food and as dietary staples for adults and weaning foods for infants including Africa where it accounts for up to 77% of total caloric consumption. The major cereal based foods in these regions are derived mainly from maize, sorghum, millet, rice, or wheat. Oilseeds are the largest single source for production of protein concentrates. Of these, soybeans, in terms of tonnage produced, are the most important source. Properly defatted soybean flour will contain 50% or more of protein. By removing soluble carbohydrates and minerals, concentrates containing up to 70% protein can be prepared, and dispersible isolates containing 90% or more of protein are being made. The isolates are of interest as highly concentrated fortification media and also as bases for a variety of high-protein beverages, desserts, and similar products. Soybean concentrates have the virtue of low cost and good nutritive value. Fortification of staple cereals with soybean can help improve their nutritive value and may aid in alleviating malnutrition in developing countries [17].

[12] determined the effect of germination and drying on the functional and nutritional properties of common red bean flour and evaluated the effect of incorporating different levels of cowpea and a constant level of soybean into red bean flour on the functional properties of the composite. Incorporation of soybean and cowpea flour into germinated bean flour at levels of 10 and 30%, respectively, produced a composite with higher functional properties. [15] studied the effect of fermentation with *Rhizopus oligosporus* on some physico-chemical properties of starch extracts from soybean flour. Their study revealed that the length of fermentation with *R. oligosporus* within the period of 0–72 h on soybean (*G. max*) affected many physico-chemical properties of starch extract as well as pasting characteristics of extracted starch. The physico-chemical attributes of starch 'extract' from fermented soybean flour revealed that water binding capacity, water absorption capacity, swelling capacity and solubility power decreased slightly with increases in fermentation period. Also, while the starch yield and amylose content decreased and amylopectin contents increased with fermentation

period. The pasting characteristics of starch 'extract' from the fermented soybean flour revealed the potential use of the flours in weaning food formulation due to reduce viscosity trend as fermentation period increased.

[1] also worked on the effect of soybean substitution on some physical, compositional and sensory properties of kokoro (a local maize snack). Kokoro which is a finger-shaped snack made from maize is widely acceptable and consumed by children and adults, especially in the southwestern part of Nigeria in the Oyo and Ogun states. Soybean (*Glycine max*), which has high quality protein with high contents of sulphur-containing amino acids, is a good supplement in maize products. Because Snacks provide an avenue for introducing plant proteins such as soybeans to people who normally resist trying any unfamiliar food, kokoro was prepared from maize–soybean flour mixtures in ratios of 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50. The physical, compositional, and sensory characteristics of kokoro were evaluated. Protein and fat contents increased, while carbohydrate content decreased as the soy flour proportion of the flour mixture used in the kokoro was increased.

The bulk density and water-holding capacity increased with increasing proportion of soybean flour, while the swelling capacity was found to decrease. High soy-substitution significantly reduced the sensory acceptance of kokoro. Sensory evaluation indicated that maize:soybean

flour mixture ratios of 100:0 and 90:0 were the most acceptable to the panellists. Several studies have been conducted to improve the protein quality of food products by fortification with plant proteins such as soybean, which is less expensive. Amino acid fortification was suggested by [18]. [19] also determined the acceptability of fermented maize meal fortified with defatted soy-flour in traditional Ghanaian foods.

7. Conclusion

Soybean flour has huge potentials of being used to enrich foods in order to provide adequate nutrients for individuals not meeting daily needs. Based on the available information on the nutrients profile of soybean including the amino profiles, human consumption of soybean flour can be promoted because of its positive effect on nutritional enhancement on different fortified food products. However, more efforts need to be directed at addressing associated technological issue which is flatulence to further increase effective utilization of the food product in food fortification.

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