NUTRITIONAL AND HEALTH BENEFITS OF CEREAL-BASED FOODS SUPPLEMENTED WITH SOYBEAN PRODUCTS

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Summary

Cereals are the main source of calories and proteins for practically all inhabitants of the planet. These grains provide more than 60% and 50% of the total caloric and protein intakes respectively for an average person.[1] The dependance on cereal grains increases with the level of poverty so low socioeconomic groups normally consume 80% of their calories and proteins from cereal-based foods. Unfortunately, cereals' lack of good quality protein and key micronutrients to sustain proper growth and development of preschool infants so marasmus, kwashiorkor, anemia, and vitamin deficiencies still prevail in many regions of the world.[2] Numerous scientific studies have demonstrated that the wide array of soybean products greatly benefit the nutritional status and health of all physiological stages of humans. This is because soybeans normally contain from 4 to 9 times more protein, at least 10 times more lysine, 6 to 20 times more folates and 5 times more iron and zinc compared to most cereal grains.* These nutrients make soybeans ideally suited to enrich or fortify the main staples of the world population and prevent protein malnutrition, cognitive deterioration and micronutrient deficiencies like anemia, infantilism, pellagra, beriberi etc. In terms of prevention of chronic diseases, soybeans are viewed as an excellent food option to diminish obesity, oxidative stress, diabetes, cancer, fibrosis, osteoporosis and cardiovascular diseases (CVD) because they are excellent sources of both soluble and insoluble dietary fiber, prebiotics, antioxidants, bioactive peptides, vitamins, especially folic acid, minerals and a wide array of phytochemicals.

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SOYBEANS NORMALLY CONTAIN FROM 4 TO 9 TIMES MORE PROTEIN, AT LEAST 10 TIMES MORE LYSINE, 6 TO 20 TIMES MORE FOLATES AND 5 TIMES MORE IRON AND ZINC COMPARED TO MOST CEREAL GRAINS

*https://www.nal.usda.gov/human-nutrition-and-food-safety/food-composition

Soybean Nutrients and Phytochemicals

The soybean seed is a relevant source of five groups of regular nutrients and phytochemical compounds that are summarized below:

a) Protein and bioactive peptides:

The soybean seed contains about 36% of highly digestible and good quality protein chemically classified as globulins. The seed contains at least twice the amount of protein in meat. More importantly, the removal of the oil concentrates proteins to around 50% and the further refining of the proteins yields concentrates or isolates with 65 and 90% protein (4 and 5 times more protein than meat). These products normally contain relevant amounts of micronutrients, phytonutrients and dietary fiber discussed below. The most important features of soybean proteins are the high rate of digestibility, the excellent profile of the nine essential amino acids and that proteins are ideally suited to complement the essential amino acid balance of cereal-based foods.[2-5] Defatted soybean flour and isolates normally contain at least 10 and 20 times more lysine compared to cereal grains. Generally, the supplementation of 6 to 10% defatted soybean meal or 5 and 3% concentrate or isolate significantly improves protein quality, growth and wellbeing especially through the strengthening of the immune system. The soybean protein is the only vegetable protein that compares with the best animal protein sources like milk, meat and fish. Numerous studies have shown that consumption of soybean proteins lower levels of serum homocysteine and blood lipids and cholesterol, highly associated with prevalence of CVD, promote muscle mass deposition, and help to burn adipose tissue and therefore considered anti-obesity.[6-9] Soybeans are one of the main sources of bioactive peptides that are generated after the proteolytic digestion of soybean proteins in the human system. These protein fragments or peptides exert many positive health effects because they act as antioxidants, antiobesity, antihypertensive, anticholesterolemic, antidiabetic, anticarcinogen and as antiaging. Recently some bioactive peptides known as opioids have been linked to brain functioning and mood.[10-11]

b) Lipids:

Whole soybeans contain approximately 17 to 20% oil rich in polyunsaturated fatty acids and other lipids that are known to exert positive effects on human health. The main minor lipophilic compounds are phospholipids, normally known as lecithin, phytosterols, and tocopherols. The soybean oil contains more than 50% of polyunsaturated fats comprised mainly of an omega-6 fatty acid known as linoleic and an omega-3 known as linolenic. These fatty acids reduce blood cholesterol and prevent CVD that are the main cause of death worldwide.[12-13] Lecithin is known to also prevent CVD and neurodegenerative diseases through the generation of important metabolites like choline and inositol. On the other hand, phytosterols are known to diminish blood cholesterol and favor the ratio between good and bad cholesterol or the HDL vs LDL index. Finally, the tocopherol or vitamin E prevents oxidative stress, cancer, fibrosis and cardiovascular diseases. Among soybean products only the full fat soybean meal and soybean milk or extract contain significant amounts of these lipophilic compounds. The defatted soybean meal or flour, protein concentrates and isolates are practically free of these important lipophilic compounds.

c) Dietary Fiber and Prebiotics:

Soybean seeds are considered a rich source of dietary fiber. More importantly, the fiber is rich in insoluble

Soy flour is a versatile ingredient
for a wide range of nutritious foods.

Photo credit: Soy Nutrition Institute Global

and soluble fractions that exert different health benefits. Besides lowering the caloric density of foods, the insoluble and soluble dietary fibers help to lower glycemic index and blood glucose levels and prevent constipation, hemorrhoids and gastrointestinal cancers.[15] The soluble fiber is rich in prebiotic compounds that help to prevent dysbiosis of the microbiota of the hind gut. The soluble fiber helps to produce more Lactobacillus and Bifidobacterium which synthesize volatile short chain fatty acids that are known to lower blood cholesterol. More importantly, these bacteria affect the expression of key genes associated to oxidative stress and metabolism of cholesterol and glucose. The different soybean products contain different amounts of total, insoluble and soluble dietary fiber. The products that contain the highest amounts are Okara, which is the name of the bagasse obtained after soybean milk or extract production, followed by the full-fat and defatted soybean flours.[15]

d) Micronutrients:

The different soybean products are considered as one of the best vegetable sources of micronutrients that include essential minerals and vitamins. The most relevant micronutrients for enrichment or fortification of cereal based foods are iron, zinc, and B-vitamins (thiamin, riboflavin, niacin, pyridoxine and folates). Iron and zinc are normally present in low amounts in cereals especially when milled into refined flours or meals. The soybean products normally contain 5 times as much of these essential micronutrients that prevent anemia, infectious diseases and promote adequate infant growth. Among the B-vitamins, soybeans normally contain 10 times more folates compared to cereal grains and therefore significantly increase the content of this important vitamin in enriched products. Folate deficiency is a significant global health issue that affects millions of people and causes severe adverse effects because it functions as a cofactor in the synthesis of nucleic acids, metabolism of amino acids, and methylation of hormones, lipids and proteins. Folate is particularly important for cell division in pregnant and lactating women so its deficiency can cause birth defects, neurological and cognitive problems in the newborn, anemia, and fatigue.[16-17] Furthermore, folate is intensively studied for its role in decreasing the risk of CVD in adults, several sorts of cancers and cognitive disorders. Its implication in prevention of CVD is mainly through lowering serum homocysteine levels.[18] For the aforementioned reasons, many federal health agencies enacted the enrichment of cereal flours with B vitamins, iron and zinc like refined wheat and dry masa flours.[19-20]

e) Phytonutrients:

Soybeans contain relevant types of phytochemicals that help oxidative stress and prevalence of chronic diseases and cancer.[8, 21-22] The soybean products contain significant amounts of phenolics, flavonoids, isoflavones, soyasaponins and the lipophilic phytonutrients mentioned above. These important classes of phytochemicals prevent oxidative stress, modulate the expression of key genes involved with chronic and neurodegenerative diseases and interact with soybean proteins, lipids, minerals and vitamins enhancing health. Particularly, the isoflavones or phytoestrogens enhance calcium absorption in postmenopausal women[7] and isoflavones and soyasaponins or triterpenes prevent all sorts of cancers.

Effects of Soybean Supplementation of Cereal Foods

There is clear scientific evidence of the positive nutritional and health promoting effects of soybean supplementation of cereal-based foods like different types of breads,[23-24] pasta, cookies, both corn and wheat flour tortillas,[3-4, 25-28] extruded breakfast cereals, snacks and others. The main positive effect is in terms of protein quality[5] because the addition of relatively small amounts of soybeans (4 to 10% of the formulation) improves the amounts of essential amino acids lysine and tryptophan which are scarce or limiting in all cereal grains. For example, the addition of 6 to 8% defatted soybean flour, 4 to 6% concentrate or 3 to 4% isolate to wheat flour, corn flour or grits, rice flour or nixtamalized corn flour increases about 20% the protein content and greatly improves protein quality because the supplemented or enriched food normally contains twice as much lysine compared to the normal counterpart. Using this strategy, excellent quality yeast-fermented breads (table or pan bread, baguettes, donuts, croissants, pita bread, rolls etc), whole wheat or white tortillas, corn tortillas, corn chips, tortilla chips, extruded rice-based snacks and other cereal related foods are produced with similar organoleptic and functional properties. Furthermore, the gastrointestinal digestion of soybean proteins yield relevant bioactive peptides like lunasin and soymorphins which prevent multiple chronic diseases, and cancer.[10-11] The most notorious biological effects are the reduction of blood pressure, triglyceride and cholesterol levels and protection against cancer. The enrichment strategy also significant increases dietary fiber, especially in cereal food products generated with refined flours, essential minerals like iron, zinc and copper, B-vitamins, especially folic acid, and phytochemicals that affect expression of key genes. The overall result is that the enriched cereal-based foods contain a much better nutritional and phytochemical profile that helps to diminish child and elderly malnutrition and better protect humans against obesity, oxidative stress and chronic diseases currently responsible of approximately 65% of the deaths. The combination of a better protein quality, generation of bioactive peptides, higher levels of vitamins, minerals and insoluble and soluble dietary fiber, phytochemicals and substrate for the microbiome prevents all chronic diseases and aids to strengthen the immune system and maintain the proper functioning of the brain. These positive effects are related to the up or down regulation of key genes associated to metabolism and chronic diseases and the improvement of the microbiota of the hind gut.

The production of soybean enriched cereal staples has been proposed since the 1950´s first in terms of upgrading protein quality. Recently, sound scientific studies have demonstrated that the production of soybean enriched breads, corn tortillas, wheat flour tortillas, arepas, extruded puffs and other cereal foods improve infant growth, immunity, newborn weight, brain development and functioning, school and athletic performance and infant life expectancy.[26-31]

Research related to fortification of corn tortillas with different soybean proteins have demonstrated that the sacred and most relevant staple food of Mexico and Central America upgrades its protein quantity and quality, the levels of important micronutrients like iron, zinc, and B- vitamins and brain development and performance in laboratory animals.[25-27, 29-30] A blind study conducted for two years in Queretaro, Mexico which compared two indigenous neighboring populations administered either regular or 6% soybean-enriched nixtamalized flour for tortilla and related foods production clearly indicated that the supplemented population had better nutrition and health.[31] The pregnant women gave birth to newborns with higher birth weight, the infants grew better and recover from infectious diseases faster and had better performance in school (Bayley test) and even athletic performance. These overwhelming positive results forced investigators for ethical reasons to also supplement the control group.[31] Similar results have been observed in different countries with other supplemented cereal foods like bread, arepas, flour tortillas and snacks. Recently, most scientific studies have focused on the positive effects of soybean supplementation in terms of prevention of obesity, metabolic syndrome, chronic diseases, osteoporosis, and cancer. The daily administration of 20 gr of soybean protein is known to diminish these ailments or disorders. The soybean protein plus the high amounts of minerals, vitamins and phytochemicals makes soybeans ideally suited to prevent oxidative stress, diabetes, cardiovascular diseases, high cholesterol, osteoporosis and fibrosis. The positive effects are attributed to the antioxidant properties and regulation of key genes and the microbiome of the hind gut. All these positive effects are very cost effective because the supplementation of staple cereal-based foods like breads, arepas, tortillas and others only increase about 5 to 10% the production cost. This small difference in price surely pays off via the potential reduction of medical costs and the improvement of the wellbeing and life quality of the general population. In my humble opinion, soybeans offer the most effective and cost-benefit way to upgrade nutritional quality of cereal foods and health of all physiological stages of the human being.

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