

# Chapter 11

## Soy and Soy Products, Isoflavones, Equol, and Health

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### ABSTRACT

*In Asian countries, soybeans have been used as food and food ingredients for centuries and their consumption have been associated with beneficial health effects. In addition to their nutritive value, soybeans have many active chemical compounds, among which isoflavones are the most important. Isoflavones are plant-derived phytoestrogens, chemically comparable in their structure and properties to human estrogens. For isoflavones to become bioavailable, their activation and/or conversion into more active metabolites, such equol from daidzein, must occur. Equol is the isoflavone metabolite with the greatest estrogenic activity and antioxidant capacity. Epidemiological studies have suggested that high intakes of isoflavones reduce the symptoms of menopause as well as the incidence of hormone-dependent and aging-associated diseases such as osteoporosis, cardiovascular disease and cancer. This chapter reviews soy consumption, isoflavone metabolism, and briefly summarizes the results of recent clinical trials on, and meta-analyses of, the effects of isoflavone consumption on human health.*

### GENERAL INTRODUCTION

Soy (“Shu” in ancient Chinese) -*Glycine max* (Linnaeus-Merril)- is an annual herbaceous legume of the family *Fabaceae*. It is native to China, where it has been cultivated for some 5000 years (Qiu & Chang, 2010). Originally, soy was a subtropical crop, but numerous varieties have now been adapted to very different climates. The United States, Brazil, Argentina and China are the current leaders in soybean production. Like some other long-domesticated crops, the relationship between modern cultivated soy and wild-growing species can no longer be traced back with any degree of certainty.

From a nutritional point of view, dry, mature, raw soybeans typically contain 8.5% moisture, 36.5% protein, 30 carbohydrates, 20% lipids and about 5% ash (National Nutrient Reference Database of the

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United States Department of Agriculture [USDA]; <http://ndb.nal.usda.gov/>). Soybean oil contains large amounts of monounsaturated (22.8%) and polyunsaturated (57.7%) fatty acids. Soy protein ranks the highest among vegetable proteins; its nutritional value equals that of milk and egg proteins (Food and Agriculture Organization/World Health Organization, 2013). In addition, soybeans contain large amounts of many bioactive polyphenols (Kang et al., 2010), among which the phytoestrogenic isoflavones are the most important; their consumption has been associated with positive health effects (del Rio et al., 2013; Crozier et al., 2009).

The consumption of soy and soy-derived products varies widely between human communities (Mulligan et al., 2013; Zamora-Ros et al., 2012; Boker et al., 2002). Those of Asian countries (especially China, Japan and Korea), where soy and soy products have been used for centuries as food and food ingredients (Qiu & Chang, 2010; Guan et al., 2008), remain the largest consumers. A soy protein intake of approximately 6-11 g/day, along with a soy isoflavone intake of 25-50 mg/day, has been reported for elderly Japanese people (Messina et al., 2006). Large surveys undertaken in the USA and Europe have reported intakes ten times lower than in Asian nations (Bai et al., 2013; Peeters et al., 2007; Boker et al., 2002). Nonetheless, the growing evidence of the multiple health benefits of soy has raised interest in its consumption (Jing & Wei-Jie, 2015; He & Chen, 2013; Wei et al., 2012; de Cremoux et al., 2010; Harland & Haffner, 2008).

## **Soy Products**

Soybeans can be eaten freshly boiled or steamed or after processing in different ways. Traditional Asian soy products are typically divided into two categories, unfermented (e.g., soymilk, tofu and okara) and fermented (e.g., soy sauce, natto, miso, and tempeh) (He & Chen, 2013). Soymilk is produced by soaking dried soybeans in water and then grinding them. It contains amounts of protein and fat similar to those seen in cow's milk, but it is free of lactose and cholesterol. Tofu is a curd made by coagulating soy protein using mineral salts (calcium, magnesium) or an acid (glucono- $\delta$ -lactone). The precipitation of soy protein produces a jelly-like curd similar to a fresh cottage cheese. This curd can then be converted into different types of product. Okara is the residual solid that results from soymilk extraction. It typically contains 80% moisture, 3.2% protein and 1.7% fat. It is used as a food ingredient in Asia, although it is most commonly employed as a livestock feed. Soy sauce is the most common seasoning in China and was in use at least as early as 160 AD (He & Chen, 2013). Traditional soy sauce is manufactured by fermenting a mix of wheat and soybean. This involves several microorganisms, including *Aspergillus*, lactic acid bacteria and yeasts. The resulting sauce has a very complex flavor and aroma, the products of chemical and biochemical reactions that occur during manufacturing and ripening. Natto is a traditional Japanese soy food made by fermenting boiled soybeans with *Bacillus subtilis* Natto strains. The smell, flavor and slimy texture of natto resemble those of some very strong cheeses. Tempeh is a fermented soybean product from Indonesia. It is made by fermenting dehulled and partially cooked soybeans with a *Rhizopus* mold. The extensive network formed by its mycelium binds the soybean together to form a block, producing a fermented soybean loaf. Miso is a popular Japanese food made by fermenting rice and soybeans with a mixture of molds, yeast and bacteria. Traditional miso manufacture starts by fermenting cooked rice with koji spores (i.e., spores from *Aspergillus oryzae*). This is followed by a second fermentation of the fermented rice with cooked soybeans, involving a mix of molds, yeasts and bacteria, to yield a paste with a complex flavor.

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