Breast cancer is one of the most lethal female diseases in Western countries. While the incidence of breast cancer in Caucasian women is higher than that in Hispanic and Asian women, the disease has been increasing in China.

The precise aetiopathological factors for breast cancers are still unclear. It has been shown that variant dietary factors partially account for the differing incidence of breast cancer among Caucasian, Hispanic and Asian females. In terms of dietary factors, there exists a marked difference in the consumption of soya bean products between Asian women and those from Western countries.

A number of epidemiological studies suggest that increasing soya consumption appears to be related to the decreased risk of recurrence and/or mortality. In this review, types of soya products and their nutritional functions, consumption and production are briefly described. Several lines of evidence are also presented, demonstrating the association of soya food consumption with the decreased incidence and prognosis of breast cancer. Several possible molecular mechanisms involved in the chemopreventive effects of genistein (Gen) on breast cancer are outlined.

**Nutritional value and health benefits**

Soya bean, called ‘shu’ in ancient Chinese, is one of the five main plant foods in China, along with rice, wheat, barley and millet. Soya bean originated in China and has been cultivated for approximately 5,000 years.

Soya bean was first introduced to Southeast Asia, later to Europe in the 18th century and to America in the 19th century. Since the 1940s, soya bean has become one of the chief economic crops in the United States (US). Currently, the US is the largest soya bean producer in the world, constituting more than 35% of global production in the 2011/12 season.

Soya bean has been widely cultivated, with a worldwide annual planting area of 102.77 million hectares and a harvest of 239.36 tons in the 2011/12 season, generating an income of $11.4 billion for producers. The US, Brazil, Argentina and China are the current global leaders of soya bean production, with a combined harvest of 205.27 tons in the 2011/12 season making up 86% of international production. Over the past eleven years, worldwide production of soya beans has been increasing.

The main commercial interest in soya is due to its oil and protein. Soya bean composition varies depending on variety, location, climate and farming practices. Dry, mature, raw soya beans typically contain 8.5% moisture, 36.5% protein, 19.9% lipids and 9.3% dietary fibre, according to United States Department of Agriculture (USDA) nutritional database.

**Second only to palm oil**

Protein and lipids combined constitute more than 60% of soya bean on a dry weight basis. Before the recent surge in interest in soya bean protein, oil was the main purpose of the commercial production of soya bean. According to a USDA report, soya bean oil (SBO) is the second-most produced vegetable oil in...
the world, with a total global production of 42.92 million tons, after palm oil’s 55.29 million tons produced in 2012/13.

SBO contains 15.6% total saturated fatty acids, 22.8% total monounsaturated fatty acids, and 57.7% total polyunsaturated fatty acids. Fat has long been considered a key issue in human diets and numerous scientific studies have focused on the impact of the consumption of various types of fat on health.

In the most recent release of the Dietary Guidelines for Americans, a USDA expert panel recommends consuming less than 10% of calories from saturated fat, and replacing them with monounsaturated and/or polyunsaturated fat associated with lowering the risk of cardiovascular disease.

SBO contains a very high level of unsaturated fatty acid and a significant amount of omega-3 fatty acids, which is considered part of the healthy fat group. Alpha-linolenic acid (ALA) (an omega-3 fatty acid) in SBO is an essential fatty acid for human nutrition, which means it cannot be synthesised by humans. Regular consumption of foods rich in omega-3 fatty acids can provide many health benefits, including reduced cardiac mortalities.

As more has been learned about soya bean over the past few decades, the focus has shifted to its other properties, especially its protein content. Protein provides amino acids (AAs) to human diets. Proteins from different sources have different AA compositions, which will affect its nutritional value in diets, especially concerning essential AAs.

Evaluation of nutritional quality

There are various methods to evaluate the nutritional quality of food proteins. The Protein digestibility-corrected amino acid score (PDCAAS) method is currently the most accepted one for such purpose, replacing the protein efficiency ratio (PER) method in 1989.

Soya protein’s PDCAAS score (1.0) is ranked highest among vegetable proteins, equalling that of milk proteins (casein, whey protein) and egg protein, which shows that soya protein provides complete AAs to human nutrition. In comparison, wheat gluten, another popular plant protein commonly found in vegetarian diets, only has a PDCAAS score of 0.25.

Recently, the FAO recommended a new method of evaluating protein quality – digestible indispensable amino acid score (DIAAS) – which is said to correct some of the limitations of the PDCAAS method. This will undoubtedly change the way people evaluate various proteins for their nutritional value.

However, there is a lack of available data to compare various proteins’ nutritional value using this new method, due to the fact that this recommendation was only recently released by the FAO. Unlike other proteins, soya protein’s health benefits reach far beyond simply providing AAs and there have been numerous studies on this subject over the past few decades.

For instance, Anderson et al. summarised 37 primary studies and concluded that the consumption of soya rather than animal protein significantly decreases serum concentrations of total cholesterol, low-density lipoprotein (LDL) cholesterol and triglycerides. Its mechanism was extensively studied.

Reducing the risk of heart disease

Crouse III et al. established a direct link of naturally occurring isoflavones in soya proteins and the lowering of total and LDL cholesterol. However, another study seemed to indicate that isoflavones did not play a key role in soya protein’s cholesterol-lowering effect.

On 26 October 1999, based on all the scientific evidences, the US Food and Drug Administration (FDA) issued a final ruling on the health claim of soya protein, petitioned by Protein Technologies International (PTI). The ruling states that diets low in saturated fat and cholesterol, which include 25g of soya protein a day, may reduce the risk of heart disease. In the ruling, the FDA proposed that soya-based food should contain 6.25g soya protein per serving in order to qualify for this health claim. This has been the most significant event for the soya bean growing and processing industry over the past few decades.

Since the FDA’s endorsement of the soya health claim, a number of studies have further demonstrated the link between soya product consumption and lowering the risk of congenital heart disease (CHD). In 2003, Hermansen et al. reviewed 50 research studies and confirmed the positive relation between soya consumption and improving cholesterol profile. In 2011, Anderson et al. reviewed a total of 43 studies from 1996 and 2008, concluding that consuming a median of 30g soya protein per day significantly improves the lipoprotein risk factor of CHD.

Beneficial to overall health

However, the soya protein health benefit is not without controversy. In 2006, the American Heart Association’s (AHA) science advisory panel reviewed 22 studies and found that isolated soya protein with isoflavones has mininal effect in lowering LDL. Although the finding does not agree with other studies, the panel still recommends that soya products are beneficial to cardiovascular and overall health because of their high content of polyunsaturated fats, fibre, vitamins and minerals and low saturated fat content.

The FDA’s confirmation of the soya health claim serves as fuel for soya product market growth, and has dramatically altered the status of soya in mainstream diets. Between 2000 and 2007, more than 2,700 new soya-based food products were introduced in the US market, and the soya market grew 4.5 times to 4.5 billion between 1996 and 2009. This market reached 5.2 billion in 2011.

According to information presented on the website of the Soyfoods Association of North America (SANA), energy bars and soya milk are the two largest categories, with soya-based energy bars overtaking soya milk’s number one position in 2011. The energy bars market also represents the largest growth from 2010 to 2011, with a 14.7% increase in total sales.
With a better understanding of soya protein’s health benefits and consumers’ increasing acceptance, soya product use has reached a wider market. In 2000, the USDA approved the use of certain soya products in school lunch programmes. This set a milestone in the soya industry, since it was the first time that soya products could be used in a USDA school lunch programme as 100% of the serving instead of only an additive.

A study of middle schools located in Maryland, US showed that students accept soya-based products just as well as other popular school lunch items. In February 2012, the USDA further approved tofu and soya yoghurts as a credit for meat or a meat alternative component in school meal planning. This policy came into effect on 1 July 2012.

The explosion of research on soya and its relation to human health has produced a large amount of information, offering a deeper understanding into soya’s health benefits on a molecular level, and many related subjects have been extensively studied. Since 1994, the International Symposium on the Role of Soya in Health Promotion and Chronic Disease Prevention and Treatment has been organised on a mostly biannual basis, with the 9th symposium held in Washington, DC in October 2010. Scientists from around the world shared their scientific findings and knowledge regarding various health issues impacted by soya consumption, including cholesterol, heart disease, breast cancers, prostate cancers, bone health, menopausal symptoms, weight loss, renal function and cognitive function, to name but a few.

Based on all these findings, soya products can play a critical and positive role in improving our health if incorporated into our diet, although there remains much to be understood, especially with regard to the mechanisms involved.

Summary
This paper outlines the available information regarding the consumption of soya-based foods, soya isoflavones and breast cancer incidence. Looking at the history and current status of soya bean production as well as several types of products and their nutritional functions, there has been an increasing trend in the production and consumption of soya foods in the US and around the world over the last few decades.

Several lines of epidemiological evidence indicate a linear relationship between increasing soya consumption and a decreased risk of recurrence of breast cancer and mortality, particularly among Chinese women. The possible molecular mechanisms involved in the chemo-protective effects of Gen on breast cancer include the impact of Gen as an agonist of oestrogen receptors (ERs), epigenetic and genome-wide effects, activation of peroxisome proliferator-activated receptors (PPARs), induction of apoptosis and stimulation of autophagy.

However, the precise molecular mechanisms are still far from being clearly understood. Given that Chinese women have traditionally consumed more soya bean-based foods, which is related to lower breast cancer incidence, and the fact that there is an increasing trend of breast cancer incidence in China – partially due to the recent switch to Western diets – it is essential to conduct further in-depth and more comprehensive studies on the molecular mechanisms underlying the positive effects of soya bean isoflavones on breast cancer.

Such studies would be valuable in paving a scientific basis for future prevention of the increasing occurrence of breast cancer in China, by switching back to traditional diets based on soya bean-derived foods.