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Soybeans Consumption and Production in China:

Sustainability Perspective

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ABSTRACT

China is the world's top consumer and largest importer of soybeans used as human food and livestock feed. Since the 1980s, China's meat consumption has been growing despite this being an inefficient way of feeding the world's largest population. It diverts resources which can be used directly for human consumption. If the Chinese people were to maintain or expand their high consumption of soybean-based foods instead of switching to a meat-rich diet, greenhouse gas emissions would be reduced and natural resource use improved.

This chapter examines the trends in soy consumption and production in China and explores people's dietary preferences for soybeans, including concerns about the import of genetically modified soybeans. Without diverting soybeans to animal feed, the demand for them will decrease and will make China more self-sufficient. This study also provides educational guidance about the health benefits of plant-based foods and environmental damage associated with high consumption of animal-based products.

Keywords: Export, Food, Feed, Genetically Modified (GM), Import, Livestock, Self-sufficient, Social Marketing, Soy Milk, Tofu

INTRODUCTION

It is well known that China is not able to produce enough soybeans for processing to meet the growing demands for human soybean-based food and animal feed for livestock. With the increasing household incomes of the Chinese people, their demand for meat and other animal-based foods is also growing. Foods that were once

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considered unaffordable or foreign are now part of the transition to more western style dietary habits (Ma et al., 2017).

Although pork continues to be the dominate animal protein, there is surging interest in beef and poultry with China's total and per capita meat consumption on the rise since the 1980s (Nam et al., 2010). Meat production reached 86.45 million tonnes in 2014 and annual meat consumption was 61.82 kg per person per year in 2013 (Ritchie & Roser, 2018). In 2014, the number of livestock animals raised for human consumption in China included 480 million pigs, 114 million cattle and 5.58 billion poultry compared to respectively 326 million, 52 million and 1.18 billion in 1980 (Ritchie & Roser, 2018).

Since the discovery by animal nutritionists that combined with grain, soybean can be used very efficiently as feed for livestock and poultry to boost the production of animal protein, soybeans have been consistently given to farm animals (Brown, 2011). As China's appetite for animal-based products, such as meat and milk grew, so did the conversion of soybeans to animal meal (Brown, 2011). According to Brown from the Earth Policy Institute (2011, p. 95), "since half of the world's pigs are in China, the lion's share of soy use is in pig feed. Its fast-growing poultry industry is also dependent on soybean meal".

This is in sharp contrast with the traditional use of soy which was domesticated as a garden plant by Chinese farmers around 1100 BC (NC Soybean Producers Association, 2014). The legume plant was named "miracle crop" because of its versatile properties and its ability to produce oil and other byproducts suitable for human consumption, such as tofu and soy drinks (U.S. Soybean Export Council, 2006). More recently, soybeans have been grown commercially all around the world for animal feed. In this day and age, "[s]oybean oil is the most widely used edible oil in the world and soybean meal is the leading protein and energy source for animal feeds" (U.S. Soybean Export Council, 2006, p. 4). Soy is also used in cosmetics, pharmaceutical, manufacturing and other industries, as a lubricant, in inks, paints and varnishes as well as biofuel.

The list of applications is long, but nowhere is soy as wanted as it has been as animal feed. This has led to land clearing and conversion to grow soy in some of the most important from a biodiversity point of view places, such as the rainforests of the Amazon (Brügger et al., 2016). The conflict between the use of soybeans as food and feed on a limited planet has escalated to enormous proportions and China (together with all other high-meat consuming countries) is contributing to large scale deforestation, greenhouse gas emissions, biodiversity loss and inefficient ways for feeding the human population (Schmidinger et al., 2018). Instead of being used for feeding people directly, soybeans are prepared as animal meal and fed to livestock. In the case of pork – the most popular meat choice in China, 11 calories are fed to the animal to produce 1 calorie for human consumption (Eshel et al., 2014). The respective figures for beef are 38 and for poultry 9 (Eshel et al., 2014).

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A solution to the global demand for soy has been through genetic engineering and the development of genetically modifies (GM) versions of soybeans. More than 90 % of the soy planted in the US is genetically engineered with the assertions that this helps increase yields and reduce the use of pesticides (Brookes & Barfoot, 2017). However, some disagree with such a view (e.g. Satheesh, 2012) and are of the opinion that GM seeds have not delivered better performance than conventional soy. There are also serious concerns raised about the ethics, risks and impacts (often unknown) on human wellbeing and the health of the planet from GM crops. Such concerns are widely spread across the globe (Bawa & Anilakumar, 2013; Bodnar, 2018) and this is an area with a large gap between public perception and scientific position – 88 % of scientists believe that it is safe to eat GM crops while only 37 % of the general public are of the same opinion (Funk & Rainie, 2016). These concerns are particularly valid for China as the country currently imports large amounts of soybeans to be used as animal feed and human food, including from USA and Brazil where GM seeds are allowed.

Although in the last few decades China has experienced a growing human consumption of soybeans, the direct use for food products, such as tofu, soy drinks and soy sauce, remains low. It has increased from 10 % of the crop is used directly as food products in 2010 (Brown, 2011) to 14% in 2017 (China Industrial Information Network, 2018). The remaining 86 % are used as pressed oil and animal feed. It is well established that plants and soy in particular are more environmentally friendly than meat production and generate lower greenhouse gas emissions, less pollution and have less requirements for land (Raphaely & Marinova, 2016). Research also shows that soybeans food products are recognized as the best protein alternatives to meat as they contain a complete set of essential amino acids (Marsall & Marinova, 2019). Therefore, promoting soybeans food consumption in China – the country with the world's largest population, becomes an urgent task when tackling environmental issues locally and globally.

This chapter elaborates on the issue about soy production and consumption in China making the argument that if soy is used for direct human consumption with a shift to nutritious and healthy plant-based food options, there will be much less need for this versatile crop to grown in the current excessive amounts. Hence, there will also be no need for genetic engineering and genetic modifications to artificially increase the already healthy yield capacities of this miracle crop. The chapter examines first China's soybean production and trade. Then it analyses the actual soybean consumption in the country, including presenting an overview of some soy-based meat alternatives. It finally makes policy recommendations to encourage behavior changes away from high meat consumption which will be beneficial for China from a human health as well as planetary wellbeing point of view, and given this country's population size such a transition will be advantageous for the entire globe.

This chapter examines the changing trends of soybeans consumption and production in China and explores people's dietary changing structure between the consumptions of soybean and meat products. Most importantly, this study aims to improve Chinese

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consumers' awareness of considering the environment when making decisions about what to choose to eat and encourages their soybean consumption, relative to meat intake, in order to achieve the decoupling between food consumption and production and the environmental damage, simultaneously maintaining better health. In addition, this study highlights the importance of social marketing and policy interventions in balancing vegetarianism and meat consumption to maintain the sustainability of modern society.

SOYBEANS PRODUCTION AND TRADE IN CHINA

China has a long history of soybeans production, which has been playing an essential role in poverty reduction by providing plant protein resources and a healthy edible vegetable oil for Chinese people. Planting soybeans domestically in rural areas of the country has contributed significantly in the agricultural sustainability. With soybean being a legume, it transfers the atmospheric nitrogen into the soil and does not require as much fertiliser while improving the fertility of the land. The Rhizobia bacteria which infects the roots of all legumes, supplies enough nitrogen to the plant from the air and also helps with nitrogen fixing of the soil (Mosaic Company, 2018). Farmers learn to rotate the crops, maintain the nitrogen cycle and reduce the need to use fertilisers with soybeans fixing naturally and biologically the soil's fertility. In temperate and tropical climates, atmospheric nitrogen transfer to the soil through the symbiotic association between the Rhizobia bacteria and the legume plants, including soybeans, represents a renewable source for fixing soil fertility even for arid and semi-arid lands (Zahran, 1999). The Chinese government is keen to promote sustainable soybeans production for optimizing the planting structure and balancing the supply and demands of soybeans with other agricultural crop (Ministry of Agriculture and Rural Affairs of the People's Republic of China, 2016).

Due to population growth, industrialisation and fast urbanisation, China's planting areas for soybeans have been generally decreased in the past 20 years (see Figure 1). The amount of land for soybean planting peaked in the years 2004 and 2005 to over 9.5 million hectares but in recent years has been lower at around 6.5 million hectares. Although total soybeans output per hectare has remained relatively stable since 2011 (see Figure 2) due to improved agricultural technology, planting innovation or favourable weather conditions (FAO, 2016), the overall production has decreased because of the shrinking amount of available land.

Figure 1. Soybeans planting areas in China and annual change (1000 hectare), 1997–2016
Source: National Bureau of Statistics of China (1997–2016)

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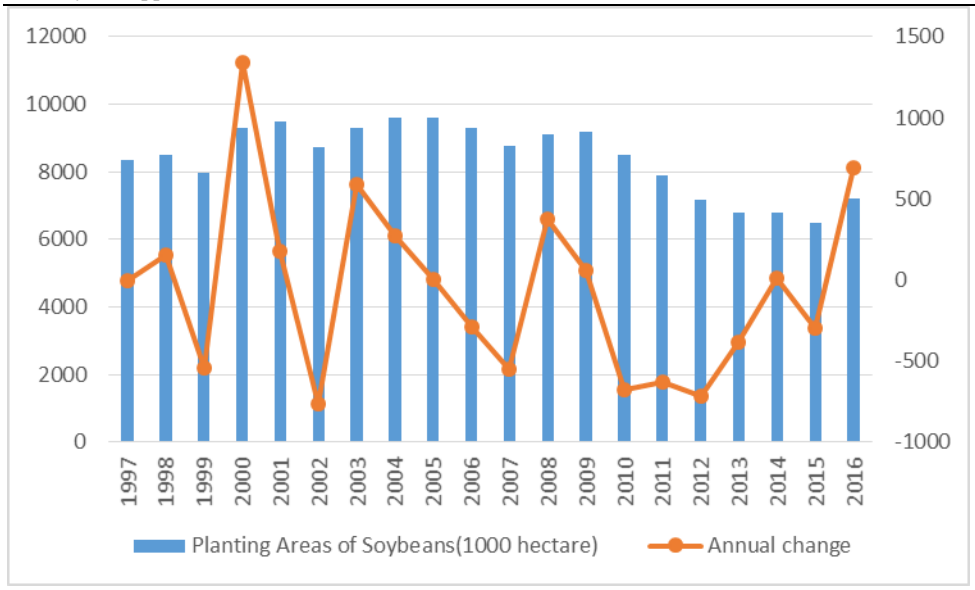
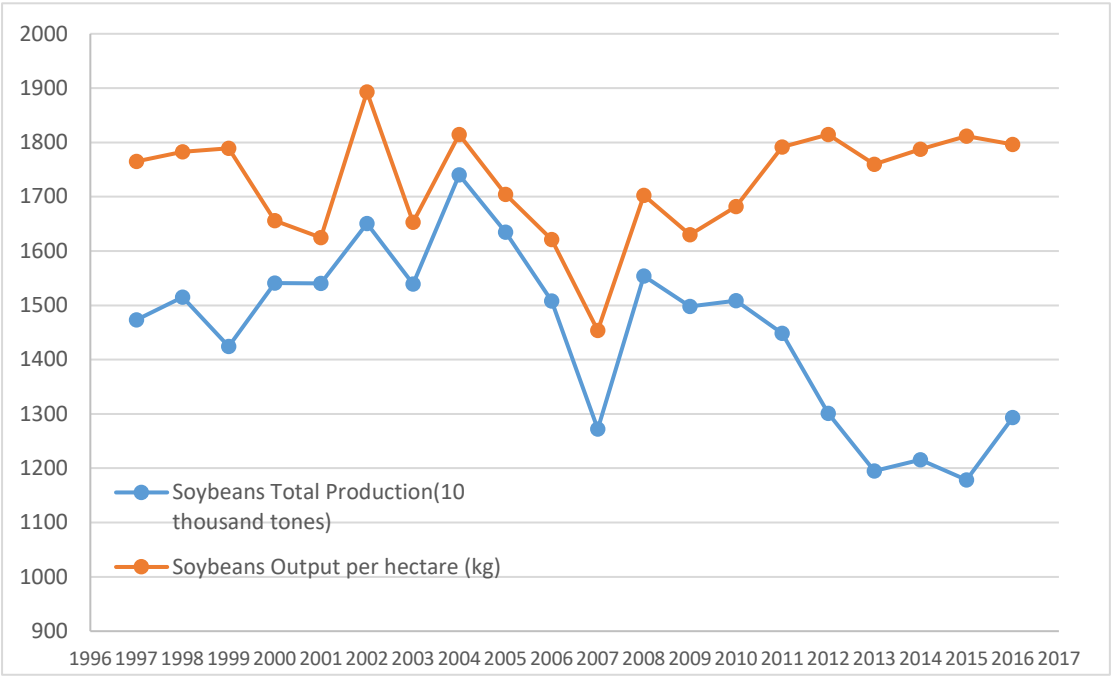


Figure 2. Total production of soybeans (10 thousand tonnes) and soybeans output per hectare (kg) in China, 1997–2016
Source: National Bureau of Statistics of China (1997-2016)



In 2016, the planting area for soybeans started to increase after six years of decrease. It is expected that China will continue to restoratively increase its soybeans planting areas in 2018 at an 1.1 % annual growth rate towards achieving a total output of 15 million tonnes (Xinhua, 2018). In 2017, the total soybeans production was already 14.3 million tonnes (Wang, 2018). The domestic sources of soybeans outputs were mainly from the traditional agricultural provinces – Heilongjiang (41%), Anhui (11%), Inner Mongolia, Henan and others. As a matter of priority, the Chinese

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Government is encouraging farmers to continue to increase the land areas available to grow soy in order to reduce the country's current reliance on imports (Wang, 2018). This however will not be enough for the current demand for soy products. Since 1994, China has been a net importer of soybeans and due to the large trade volumes, it has been the top soybeans importer in the world since 2013 (The Statistics Portal, 2018). China's gradually growing imports of soybeans (see Figure 3) reached over 83 million tonnes in 2016 followed by a further drastic 14.8 % increase to 95.5 million tonnes in 2018 (Wang, 2018).

Due to this continuous demand for soybeans products, including for human consumption and as animal feed, the soybean import is likely to be maintained at a high level (Central People's Government of the People's Republic of China, 2018b). The shortage of land availability for soybeans planting means that with the current consumption patterns China will continue to depend on imports from foreign countries for the supply of this valuable commodity for domestic use. In 2017, 87% of all domestically consumed soybeans were imported (Wang, 2018) and China in fact accounts for two-thirds of the global imports (Sheldon, 2018). A lot of the imported soy comes from the two major players on the global market – USA and Brazil (Sheldon, 2018). The two countries are the world's largest producers of soybeans and essentially dominate the global market. In 2017, Brazil supplied half (namely 53 %) of China's soybeans imports whilst another third (namely 34 %) came from USA (Wang, 2018). These two countries are also the world's largest producers of genetically modified crops (Reuters, 2018a), including a lot of the soybeans exported to China.

In 2018, the China Agriculture Outlook Report 2016-2025 issued by the Ministry of Agriculture emphasizes the need for China to focus on steady growth in its soybeans production. However, given the limited area available for cultivation and the large scale of demand from a growing population and fast-expanding livestock sector, it will be very challenging for China to achieve self-sufficiency in soybean production. Therefore, imported soybeans will continue to be in large demand as a supply channel in the future (Food Business Net, 2016). Together with this, the concerns about GM crops will also remain.

Figure 3. Soybeans export and import and the net import in China, 1980–2016
Source: National Bureau of Statistics of China (1997-2016)

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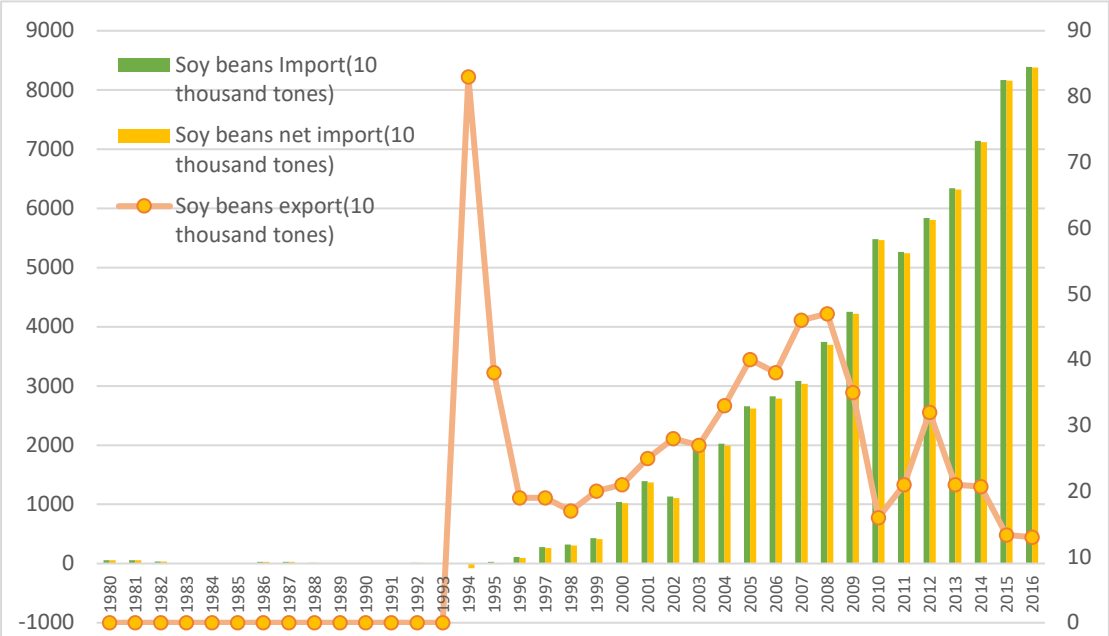

SOYBEANS CONSUMPTIONS IN CHINA

Until mid-20th century China was the largest soybean producer in the world (Jamet & Chaumet, 2016). Since then, China has become the world's largest consumer of soybeans and this consumption is continuously increasing. According to the National Agricultural Market Research Centre of the Agricultural University of China (2018), China's soybeans consumption grew over 4% in 2017. The Chinese customs data report even higher growth of more than 14% for both domestic supply and imports of soybeans (Wang, 2018). These recent changes are driven by growing domestic demand which is shifting not only in volumes but also in nature.

Overview

China has a long history of plantation and consumption of soybeans. The consumption volume was relatively stable before 1984 at around 800 tonnes from which 70 % were consumed as human food products, 20 % as pressed products, such as soy oil and animal meals, and the remaining 10 % were used directly as animal feed, seeds and loss in the agricultural system. After 1985, the amount of pressed products, including animal meals, increased significantly between 28 % and 45 %, while the use for human food products decreased to 50 %–60 %. This trend continued in the 1990s and 2000s. At the moment, the pressed products dominate China's domestic consumption at 83 % while direct human food consumption is at 14% and direct animal feed at 2% (China Industrial Information Network, 2018). Seeds for re-planting represent only 0.8 % of the soybean consumption and the loss in the system is low at 0.2 %.

Soybeans for Animal Consumption

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It is very important to unpack the pressed oil category as it combines products destined for industrial use and animal feed. In 2017, 80 % of the pressed soybeans (or 66.4 % of the total consumed soybeans) were used to manufacture animal soybean meals (China Industrial Information Network, 2018). Together with the 2 % directly used as feed, this means that more than two-thirds of the soybeans consumed in China, namely 68.4 %, are used to feed livestock animals (see Figure 4). China's pig, cattle and poultry livestock are fed mainly from soybean meals, which has intensified both, the demand and consumption of soybeans. This is not surprising given the high numbers of these animals raised for human consumption (see Figure 5).

Figure 4. Soybeans use in China [%], 2017
Source of data: China Industries Information Net (2018)

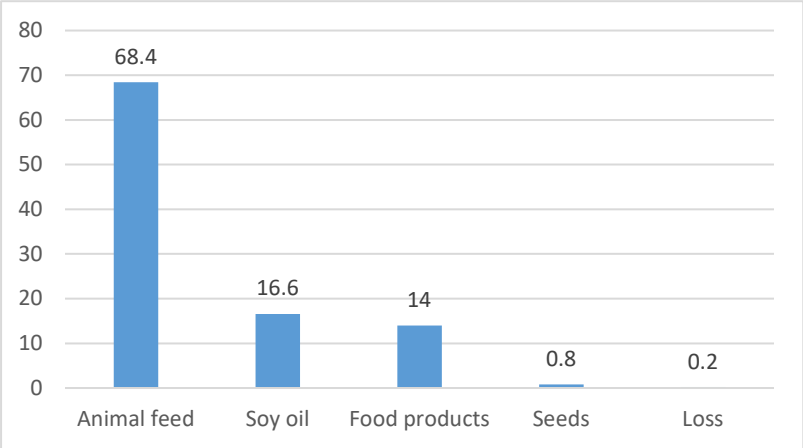
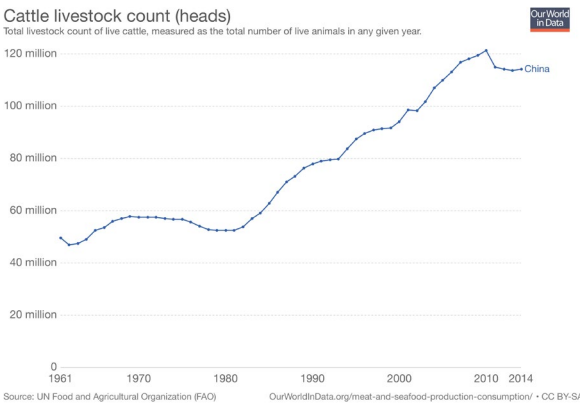


Figure 5. Cattle, pig and poultry livestock counts (heads) in China, 1961–2014
Source: Ritchie & Roser (2018)



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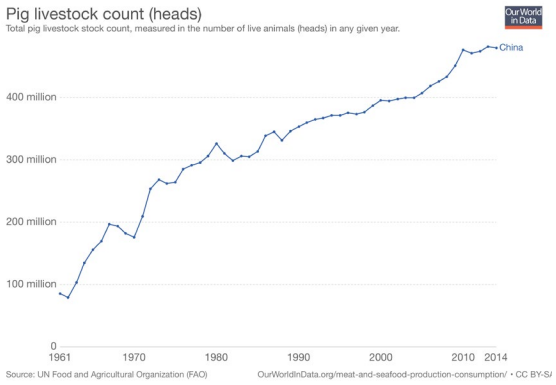

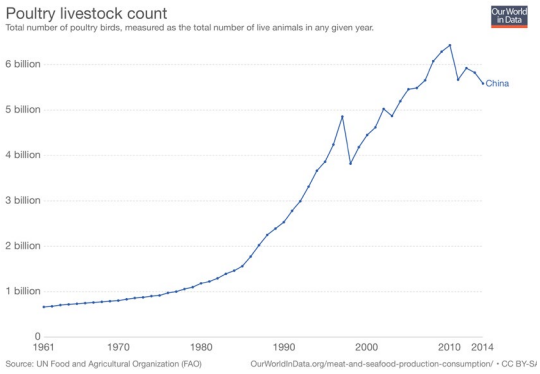

Soybeans for Human Consumption

Figure 6 presents the versatility of uses of the soybeans. Direct food products and soy oil represent less than a quarter (namely 30.6 %) of the total soybean consumption despite the myriad of uses. Of particular interest because of their nutritional value are the bean products (the middle column of Figure 6) for direct human intake which in 2017 were only 14 % of the total soybean consumption in China. From the category of fat products, soybean oil can be used for cooking and is sold at a reasonable price.

The other soybean products have many specialised applications within and outside the food industry. For example, from the group of deeply processed soybeans products, soy lecithin which supports the development of the human nervous system is widely used in the confectionery food industry as well as for medicines, paper and in the leather industries.

Figure 6. Use of soybeans in China
Source: The Authors.

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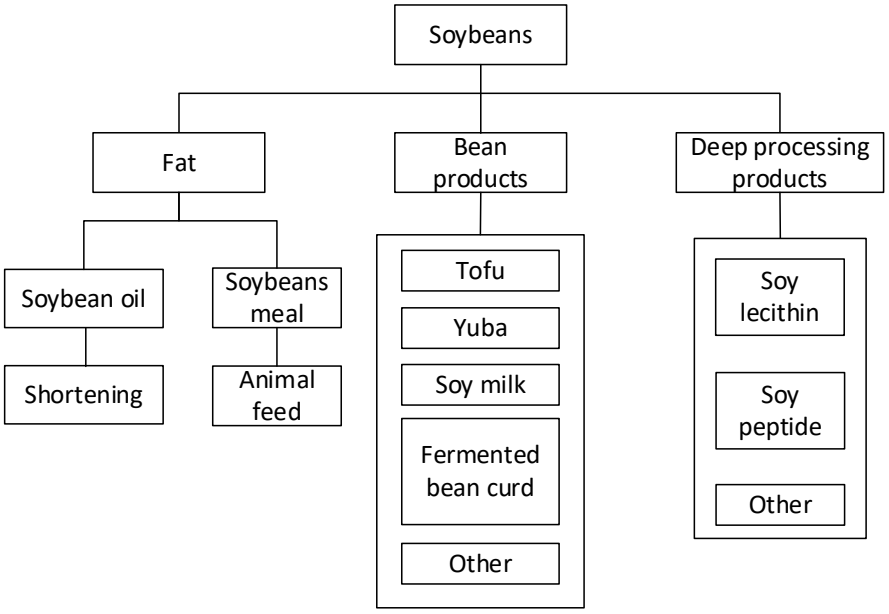

The soybean products include non-fermented varieties, such as tofu (including water tofu and dried tofu), yuba (referred also as tofu skin or bean curd sheet), soymilk and others, and fermented varieties, such as fermented bean curd, stinky tofu, bean paste, soy sauce etc. Other bean products cover bean sprouts, fried soy products, smoked soy products, frozen soy products, soy flour etc. The soy flour can be used to make a variety of foods, including baby foods. All bean products contain the nine essential amino acids and are complete high-content proteins which can replace meat and other animal-based products.

In the past, the bean products were widely used in traditional recipes and typical Chinese dishes; however, in more recent years with the country's fast economic growth leading to increasing household incomes, there has also been a dietary shift towards increasing demand and intake of animal products. The liberation of trade since the 1979 open door economic policy, allowed imports of soybeans which fuelled their use as animal feed. Previously, China did not have enough feed to support large livestock production, but the soybean imports allowed this sector to expand (Jamet & Chaumet, 2016). Increased supply of domestic meat – coupled also with meat imports, also as a result from trade liberalisation (Guo et al., 2016), resulted in a fast expansion of the place of animal proteins in the Chinese dietary preferences (see Figure 7). The humble soybean, the miracle crop, caused a dietary revolution that affects not only the Chinese population but also all populations on this planet.

Figure 7. Per capita meat supply in China [kg], 1961–2013
Source: Ritchie & Roser (2018)

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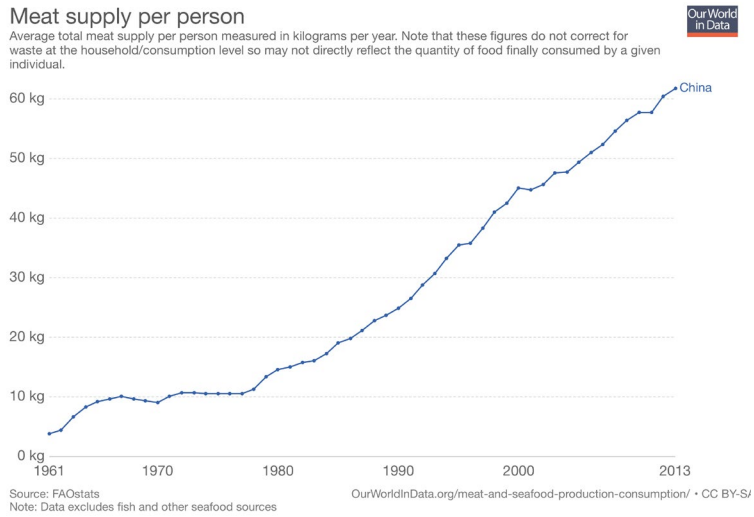

Dietary Changes

There is ample research evidence demonstrating the positive role of plant-based foods (e.g. Raphaely & Marinova, 2016; Craig, 2018), and particularly soybeans intake (Barret, 2006), in the human diet. Furthermore, there is convincing evidence about the negative impacts of excessive meat consumption on human health, including in the case of China (Campbell & Campbell, 2006). However, China has been on a dietary trend of increased meat consumption (see Figure 7) with the westernisation of diets spreading not just in urban centres but also to rural people (see Figure 8). Although the direct consumption of soybeans products has increased recently, this was accompanied with higher increases in the consumption of meat-based foods. This is fuelling the demand for soybeans, establishing a strong dependence on imports and with it, creating concerns about GM products.

Figure 6. Per capita consumptions of soybeans, meat and poultry by rural residents [kg], China, 2007–2016
Source of data: National Bureau of Statistics (2018)

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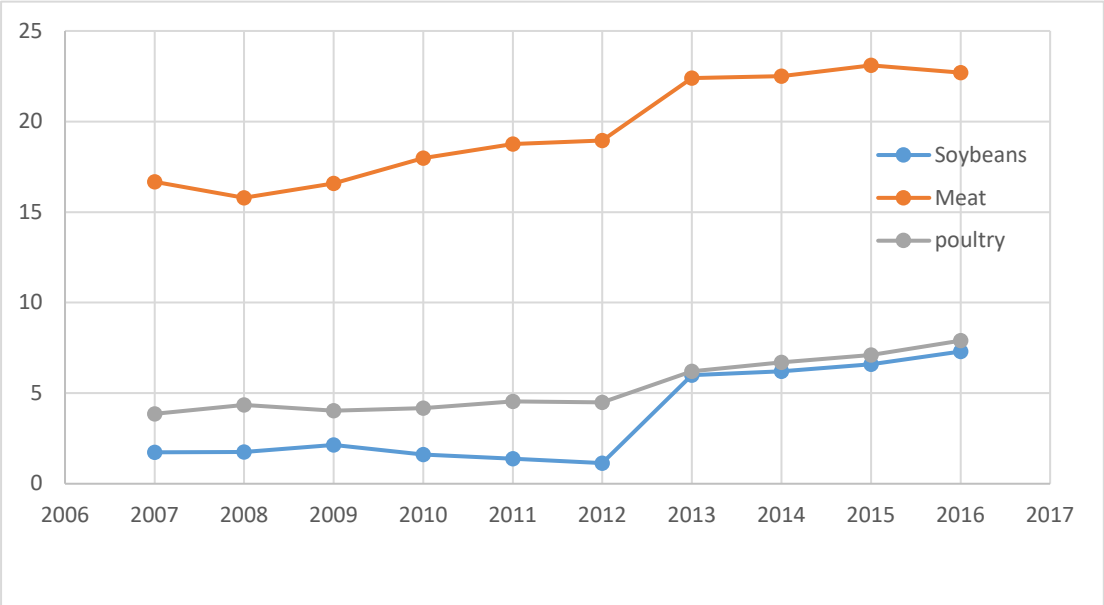

The response from the Chinese Government has been two-pronged. On the one hand, farmers are encouraged to grow more soybeans which should play the leading role in domestic food consumption (China Economy Net, 2018). The aim is to make sure that at least the domestic human consumption is self-sufficient. On the other hand, China's latest dietary guidelines are recommending significant cut in the current levels of meat consumption in line with other reputable international health bodies. They are calling for an intake of 40 g to 75 g of meat per day and overall halving of the country's current meat consumption (Froggatt & Wellesley, 2016). This will also reduce the environmental and climate change pressure caused by the country's large livestock sector – a move, strongly supported by the global community (Milman & Leavenworth, 2016).

With China having the largest meat consumption in the world, a replacement of animal-based proteins with soybeans will reduce greenhouse gas emissions, improve land use, reduce competition for water and contribute towards better health outcomes (Aleksandrowicz et al., 2016). Soybean products are essentially meat replacement alternatives with a much smaller environmental impact.

Halving meat consumption in China's will also pave the way to restoring the traditional beauty of soy-based products as a healthy dietary choice. It will allow China to lead a global transformation along the lines of those initiated by international non-government organisations, such as Greenpeace (2018). This will further reduce the pressure on imports and the global demand for ever-increasing yields of soybeans. Even if GM soy is to be shown to be harmless in the long run, the opportunity to take a more precautionary approach in preserving and cultivating a diversity of local strains will be beneficial for biodiversity conservation.

POLICY IMPLICATIONS

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There is always need for future research to find out people's reaction to the strong messages about reducing meat consumption in China. Dietary behavioural changes are easy as an avenue to pursue because they do not require large investment in technology. They are however very difficult to implement as they often go against the zones of comfort or habit that we all have. Smart strategies are required to shift people's perceptions and encourage them to implement personal changes with multiple individual and societal co-benefits. Below is a list of suggestions for policy interventions which can target more sustainable food consumption in China.

Promote Consumption of Local Soybean Products

With Chinese people being concerned about the imported genetically modified soybeans, particularly those from the US and Brazil, it is important to promote the consumption of local soybean products as healthy and tasty meat alternatives. Given that local soybeans are believed not to be genetically modified, this will reduce the anxiety about soybean foods. Indirectly it will also send the message that human health is a priority for the government while global scientists cooperate to solve the puzzle around GM foods.

Promote the Health Benefits of Soybeans Consumption

At this moment in time, the Western world is rediscovering the health benefits of soybeans and their nutritional values associated with high content of complete proteins and low cholesterol (The Dutch Soy Coalition, 2008). The Chinese doctors often recommend patients with obesity and high risk of type 2 diabetes, heart disease and high blood pressure, to eat tofu. Such recommendations should be given to everybody as a preventative measure.

Barriers of people to consume soybeans include unclear information, particularly the source of the soybeans beans (Wong & Chan, 2016), nutritional values and benefits. Possible interventions can include getting people familiar with soy-based products, such as soy milk. According to Ahenkora et al. (2012, p. 188), "acceptability is influenced by the degree of familiarity with soymilk and high satisfaction derived from exposure influenced consumer intention to purchase". There should also be ways to communicate the latest research results about the effects of soybeans consumptions on humans, for example, in reducing cancer incidents and mortality (Lu et al., 2017), improving metabolic diseases and cardiovascular health (Liu et al., 2016).

Subsidies to Soybean Farmers

China implemented an urgent campaign to increase soybeans output (Reuters, 2018b). The government encourages Chinese citizens to consume soybeans as food through implementing a structural reform on the agricultural supply side and accelerating soybeans planting (Soybeans Association of Heilongjiang Province, 2018). To maximize growers' economic profits, the government also provides subsidies to the soybeans planting farmers and in guarantees higher floor prices for the government purchasing of soybeans (Yoon, 2018). Through agricultural innovation and

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technology, the outputs can be improved and the quality of soybeans increased which is beneficial to the oil yield. For example, farmers in China's north-eastern provinces were offered higher subsidies for growing soybean than for corn directing their choice of crops (Reuters, 2018c).

The authorities are also guaranteeing higher floor prices, recently raising the government purchase price for soybeans.

Media Influence

The media can be used to encourage the consumption of soybeans products (AIC Technology, 2017) by providing educational materials and well-balanced perspectives on the qualities of soy products, including baby food.

According to the Medium and long-term planning outline for China's food and nutrition development 2011–2020, by 2020, China's per capita soybean consumption should reach 13 kg. The media can influence the uptake of soybean products by offering a platform for advertising quality and brand competition to provide excellent products, services and consumer experiences.

Social Marking

According to Firestone et al. (2017), social marketing is playing an important role in improving health on a global scale where the benefits are for the greater good. Bogueva et al. (2018) specifically examined social marketing opportunities for reduction in meat consumption. For example, Sun et al. (2007) described the success social marketing has already had Guizhou, China for the use of iron-fortified soy sauce in enhancing women's knowledge, attitudes, perceptions about benefits and barriers, willingness to buy, and consumption.

Soybeans products and technology exhibitions are held frequently and are an idea opportunity for social marketing. For example, the Eighth China International Exhibition of Soyfood Processing Technology and Equipment (2018) was held in Shanghai in 2018. During the event, there were many activities conducted, such as the annual soybeans enterprises conference, soybeans food festival, soybeans food tasting, local soybeans products exhibition and soybeans processing technology and innovation exhibits.

Investment in Research and Development

There is a need to provide more variety and new products on the market. Investment in research and development at a company level can deliver such innovative quality products in response to the needs of different customer groups. China's soybean food processing technology and equipment also need to adapt to the increasing consumer demands for soy products with good and strong technical support for the soybean food production enterprises.

CONCLUSION

Irrespective as to where one sits within the current debate surrounding GM soybeans and their impacts on the ecosystems of the planet, public health needs to be protected and environmental harm avoided (Maghari & Ardekani, 2011). An easier alternative to achieve this is to divert the inefficiently used feed calories into direct human nutrition. The current and increasing consumption of soybeans as animal feed can be circumvented by influencing human diets towards decreased intake of animal products and taking advantage of the numerous benefits plant-based diets have.

In 2017, China's domestic soybeans consumption was over 1.1 billion tonnes with 68.4% of this amount used as animal feed. This is an inefficient use of resources as well as a pathway which leads to economic dependence on imports. Encouraging people to consume directly more soy-based products, such as tofu, yuba and soy milk, is beneficial for their personal health, offers environmental co-benefits and allows to build a self-reliant domestic market for human consumption. Rather than succumb to the westernisation of the Chinese diet, China should focus its efforts on achieving the goal of halving the current levels of meat production. The miracle crop has a special place in this process.

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KEY TERMS AND DEFINITIONS

Fermented: A food which has been through the process of fermentation, that is, chemical breakdown of its substance by bacteria, yeast or other microorganisms.

Genetically Modified (GM): (also genetically engineered) Applied to food crops and organisms whose genetic material, namely deoxyribonucleic acid (DNA) has been altered in a way that does not occur in nature.

Import: Goods or commodities brought into a country across its borders

Protein: An organic substance – polymer chains of amino acids, considered an essential nutrient for the human body; there are 20 types of amino acids representing the building blocks for the human proteins – 11 are non-essential which can be synthesized by the human organism and 9 are essential which need to be provided by food.

Social Marketing: Marketing which aims at inducing a behavioural change and maintaining such behaviour for the greater social good, including benefits for the individual and society as a whole.

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Soy: (also used as soybean and soya) A legume plant native to East Asia with a high content of complete protein and beneficial nutritional value.

Soybean Meal: A product prepared from soybeans to be used in animal feed as a source of protein; very often soybean meal is made from the residue after the oil from the soybean has been extracted.

Trade Liberalization: Removal of barriers or other restrictions to the free movement of goods and commodities between countries.

Tofu: Soy bean curd often used as a meat alternative; it is very popular in Asian countries, such as China and Japan, and more recently has started to also be in a western type of diet.

Yuba: (also tofu skin, bean curd skin, bean curd sheet or bean curd robe) A food product made from soybeans during the boiling of soy milk; the thin skin formed at the top of the boiling pan is collected and dried in sheets which can be used as wraps.