Soybean

The **soybean**, **soy bean**, or **soya bean** (***Glycine max***)[3] is a species of legume native to East Asia, widely grown for its edible bean. Soy is a staple crop, the world's most grown legume, and an important animal feed.[4]

Soy is a key source of food, useful both for its protein and oil content. Soybean oil is widely used in cooking, as well as in industry. Traditional unfermented food uses of soybeans include edamame, as well as soy milk, from which tofu and tofu skin are made. Fermented soy foods include soy sauce, fermented bean paste, nattō, and tempeh. Fat-free (defatted) soybean meal is a significant and cheap source of protein for animal feeds and many packaged meals.[4] For example, soybean products, such as textured vegetable protein (TVP), are ingredients in many meat and dairy substitutes.[4][5] Soy based foods are traditionally associated with East Asian cuisines, and still constitute a major part of East Asian diets, but processed soy products are increasingly used in Western cuisines.

Soy was domesticated from the wild soybean *(Glycine soja)* in north-central China between 6,000–9,000 years ago.[6] Brazil and the United States lead the world in modern soy production. The majority of soybeans are genetically modified,[7] usually for either insect, herbicide, or drought resistance. Three-quarters of soy is used to feed livestock, which in turn go to feed humans. Increasing demand for meat has substantially increased soy production since the 1980's, and contributed to deforestation in the Amazon.

Soybeans contain significant amounts of phytic acid, dietary minerals and B vitamins. Soy may reduce the risk of cancer and heart disease. Some people are allergic to soy. Soy is a complete protein and therefore important in the diets of many vegetarians and vegans. The association of soy with vegans and the misconception that soy increases estrogen production have led to "soy boy" being used as a derogatory term.[8]

Soybean

Scientific classification

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Fabales
Family:	Fabaceae
Subfamily:	Faboideae
Genus:	*Glycine*
Species:	***G. max***

Binomial name

Glycine max
(L.) Merr.

Synonyms[1]

- *Dolichos soja* L.
- *Glycine angustifolia* Miq.
- *Glycine gracilis* Skvortsov
- *Glycine hispida* (Moench) Maxim.
- *Glycine soja* sensu auct.
- *Phaseolus max* L.
- *Soja angustifolia* Miq.
- *Soja hispida* Moench
- *Soja japonica* Savi
- *Soja max* (L.) Piper
- *Soja soja* H. Karst.
- *Soja viridis* Savi

Etymology

The word "soy" derives from the Japanese *soi*, a regional variant of *shōyu*, meaning "soy sauce".[9]

The name of the genus, *Glycine*, comes from Linnaeus. When naming the genus, Linnaeus observed that one of the species formerly within the genus, which has since been reclassified to the genus *Apios*, had a sweet root. Based on the sweetness, the Greek word for sweet, *glykós*, was Latinized.[10] The genus name is not related to the amino acid glycine.

Description

Like most plants, soybeans grow in distinct morphological stages as they develop from seeds into fully mature plants.

Germination

The first stage of growth is germination, a method which first becomes apparent as a seed's radicle emerges.[11] This is the first stage of root growth and occurs within the first 48 hours under ideal growing conditions. The first photosynthetic structures, the cotyledons, develop from the hypocotyl, the first plant structure to emerge from the soil. These cotyledons both act as leaves and as a source of nutrients for the immature plant, providing the seedling nutrition for its first 7 to 10 days.[11]

Soybean

Chinese name	
Chinese	大豆
Literal meaning	"large bean"
Transcriptions	
Southern Chinese name	
Traditional Chinese	黃豆
Simplified Chinese	黄豆
Literal meaning	"yellow bean"
Transcriptions	
Vietnamese name	

Maturation

The first true leaves develop as a pair of single blades.[11] Subsequent to this first pair, mature nodes form compound leaves with three blades. Mature trifoliolate leaves, having three to four leaflets per leaf, are often between 6 and 15 cm ($2\frac{1}{2}$ and 6 in) long and 2 and 7 cm (1 and 3 in) broad. Under ideal conditions, stem growth continues, producing new nodes every four days. Before flowering, roots can grow 2 cm ($\frac{3}{4}$ in) per day. If rhizobia are present, root nodulation begins by the time the third node appears. Nodulation typically continues for 8 weeks before the symbiotic infection

Vietnamese alphabet	*đậu tương (or đỗ tương)* *đậu nành*
Chữ Hán	豆漿
Chữ Nôm	豆秝
Korean name	
Hangul	대두 백태(or 흰콩) 메주콩
Hanja	大豆 白太
Literal meaning	"large bean" "white bean" "bean for meju"
Transcriptions	
Japanese name	
Kanji	大豆[2]
Kana	ダイズ
Transcriptions	

process stabilizes.[11] The final characteristics of a soybean plant are variable, with factors such as genetics, soil quality, and climate affecting its form; however, fully mature soybean plants are generally between 50 and 125 cm (20 and 50 in) in height[12] and have rooting depths between 75 and 150 cm (30 and 60 in).[13]

Flowering

Flowering is triggered by day length, often beginning once days become shorter than 12.8 hours.[11] This trait is highly variable however, with different varieties reacting differently to changing day length.[14] Soybeans form inconspicuous, self-fertile flowers which are borne in the axil of the leaf and are white, pink or purple. Though they do not require pollination, they are attractive to bees, because they produce nectar that is high in sugar content.[15] Depending on the soybean variety, node growth may cease once flowering begins. Strains that continue nodal development after flowering are termed "indeterminates" and are best suited to climates with longer growing seasons.[11] Often soybeans drop their leaves before the seeds are fully mature.

The fruit is a hairy pod that grows in clusters of three to five, each pod is 3–8 cm (1–3 in) long and usually contains two to four (rarely more) seeds 5–11 mm in diameter. Soybean seeds come in a wide variety of sizes and hull colors such as black, brown, yellow, and green.[12] Variegated and bicolored seed coats are also common.

Fruits/pods

Seed resilience

The hull of the mature bean is hard, water-resistant, and protects the cotyledon and hypocotyl (or "germ") from damage. If the seed coat is cracked, the seed will not germinate. The scar, visible on the seed coat, is called the hilum (colors include black, brown, buff, gray and yellow) and at one end of the hilum is the micropyle, or small opening in the seed coat which can allow the absorption of water for sprouting.

Some seeds such as soybeans containing very high levels of protein can undergo desiccation, yet survive and revive after water absorption. A. Carl Leopold began studying this capability at the Boyce Thompson Institute for Plant Research at Cornell University in the mid-1980s. He found soybeans and corn to have a range of soluble carbohydrates protecting the seed's cell viability.[16] Patents were awarded to him in the early 1990s on techniques for protecting biological membranes and proteins in the dry state.

Small, purple flowers

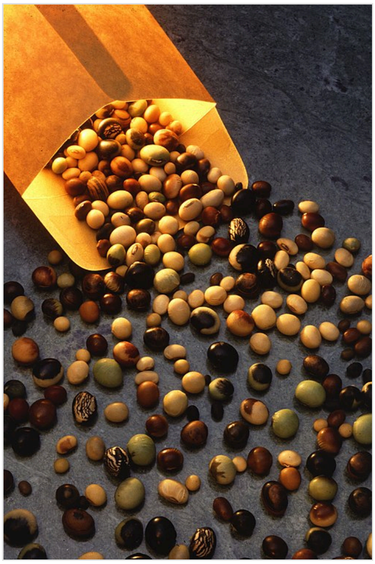
Chemistry

Dry soybeans contain 36% protein and 20% fat in form of soybean oil by weight. The remainder consists of 30% carbohydrates, 9% water and 5% ash.[17] Soybeans comprise approximately 8% seed coat or hull, 90% cotyledons and 2% hypocotyl axis or germ.[18]

Taxonomy

The genus *Glycine* may be divided into two subgenera, *Glycine* and *Soja*. The subgenus *Soja* includes the cultivated soybean, *G. max*, and the wild soybean, treated either as a separate species *G. soja*,[19] or as the subspecies *G. max* subsp. *soja*.[20] The cultivated and wild soybeans are annuals. The wild soybean is native to China, Japan, Korea and Russia.[19] The subgenus *Glycine* consists of at least 25 wild perennial species: for example, *G. canescens* and *G. tomentella*, both found in Australia and Papua New Guinea.[21][22] Perennial soybean (*Neonotonia wightii*) belongs to a different genus. It originated in Africa and is now a widespread pasture crop in the tropics.[23][24][25]

Like some other crops of long domestication, the relationship of the modern soybean to wild-growing species can no longer be traced with any degree of certainty.[26] It is a cultigen with a very large number of cultivars.[27]



Bean varieties

Ecology

Like many legumes, soybeans can fix atmospheric nitrogen, due to the presence of symbiotic bacteria from the Rhizobia group.[28]

Cultivation

Soybean crops in Minnesota

Soybeans are globally important agricultural crops, grown as a major source of protein and oil. It prefers fertile, well-drained soils and requires a warm temperate climate with adequate rainfall or irrigation. Soybeans are mainly grown in the United States, Brazil, and Argentina.

It is usually planted in straight rows using modern machinery, and pests and weeds must be controlled to maintain the crop. After maturity, it is harvested using mechanized harvesting machines. Soybeans are used in the production of many food and industrial products, such as tofu, oils, and feed, in addition to their role in improving soil fertility by fixing nitrogen.

Conditions

Cultivation is successful in climates with hot summers, with optimum growing conditions in mean temperatures of 20 to 30 °C (70 to 85 °F); temperatures of below 20 °C (70 °F) and over 40 °C (105 °F) stunt growth significantly. They can grow in a wide range of soils, with optimum growth in moist alluvial soils with good organic content. Soybeans, like most legumes, perform nitrogen fixation by establishing a symbiotic relationship with the bacterium *Bradyrhizobium japonicum* (syn. *Rhizobium japonicum*; Jordan 1982). This ability to fix nitrogen allows farmers to reduce nitrogen fertilizer use and increase yields when growing other crops in rotation with soy.[29] There may be some trade-offs, however, in the long-term abundance of organic material in soils where soy and other crops (for example, corn) are grown in rotation.[30] For best results, though, an inoculum of the correct strain of bacteria should be mixed with the soybean (or any legume) seed before planting. Modern crop cultivars generally reach a height of around 1 m (3 ft), and take 80–120 days from sowing to harvesting.

A cropduster sprays soy plants

Soils

Soil scientists Edson Lobato (Brazil), Andrew McClung (U.S.), and Alysson Paolinelli (Brazil) were awarded the 2006 World Food Prize for transforming the ecologically biodiverse savannah of the Cerrado region of Brazil into highly productive cropland that could grow profitable soybeans.[31][32][33][34]

Contamination concerns

Human sewage sludge can be used as fertilizer to grow soybeans. Soybeans grown in sewage sludge likely contain elevated concentrations of metals.[35][36]

Pests

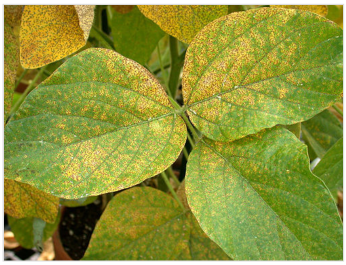
Mature row planted soy in Argentina

Soybean plants are vulnerable to a wide range of bacterial diseases, fungal diseases, viral diseases, and parasites.

The primary bacterial diseases include bacterial blight, bacterial pustule and downy mildew affecting the soybean plant.[37]

The Japanese beetle (***Popillia japonica***) poses a significant threat to agricultural crops, including soybeans, due to its voracious feeding habits. Found commonly in both urban and suburban areas, these beetles are frequently observed in agricultural landscapes where they can cause considerable damage to crops like corn, soybeans, and various fruits.[38][39]

Soybean cyst nematode (SCN) is the worst pest of soybean in the US. Losses of 30%[40] or 40%[RM 1] are common even without symptoms.



A leaf affected by Soybean rust

The corn earworm moth and bollworm (Helicoverpa zea) is a common and destructive pest of soybean growth in Virginia.[41]

Soybeans are consumed by whitetail deer which may damage soybean plants through feeding, trampling and bedding, reducing crop yields by as much as 15%.[42] Groundhogs are also a common pest in soybean fields, living in burrows underground and feeding nearby. One den of groundhogs can consume a tenth to a quarter of an acre of soybeans.[43] Chemical repellents or firearms are effective for controlling pests in soybean fields.[42][43]

Soybeans suffer from the fungus *Pythium spinosum* in Arkansas and Indiana (United States), and China.[44]

In Japan and the United States, the Soybean dwarf virus (SbDV) causes a disease in soybeans and is transmitted by aphids.[45]

Cultivars

Disease resistant cultivars

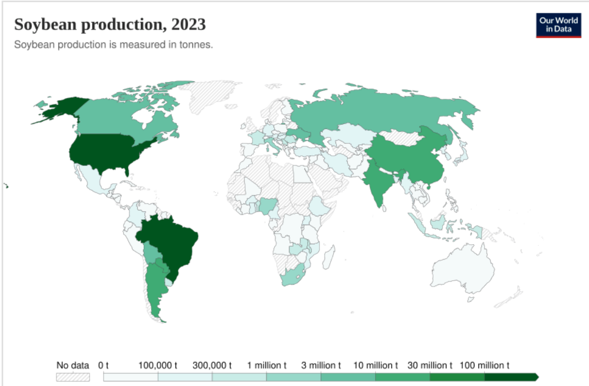
Resistant varieties are available. In Indian cultivars, Nataraj *et al.* 2020 find that anthracnose caused by *Colletotrichum truncatum* is resisted by a combination of 2 major genes.[46][47]

PI 88788

The vast majority of cultivars in the US have soybean cyst nematode resistance (SCN resistance), but rely on only one breeding line (PI 88788) as their sole source of resistance.[RM 2] (The resistance genes provided by PI 88788, Peking, and PI 90763 were characterized in 1997.)[48] As a result, for example, in 2012 only 18 cultivars out of 807 recommended by the Iowa State University Extension had any ancestry outside of PI 88788. By 2020 the situation was still about the same: Of 849 there were 810 with some ancestry from PI 88788,[49][50] 35 from Peking, and only 2 from PI 89772. (On the question of exclusively PI 88788 ancestry, that number was not available for 2020.)[50] That was speculated to be in 2012[RM 3]—and was clearly by 2020[49]—producing SCN populations that are virulent on PI 88788.

Production

In 2020, world production of soybeans was over 353 million tonnes, led by Brazil and the United States combined with 66% of the total (table). Production has dramatically increased across the globe since the 1960s, but particularly in South America after a cultivar that grew well in low latitudes was developed in the 1980s.[52] The rapid growth of the industry has been primarily fueled by large increases in worldwide demand for meat products, particularly in developing countries like China, which alone accounts for more than 60% of imports.[53] Soy is a staple crop; global soy production accounts for four times more legume production than all other legumes combined.[54]



Soybean production

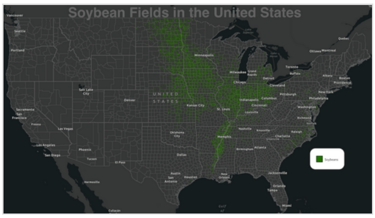
Environmental issues

In spite of the Amazon "Soy Moratorium", soy production continues to play a significant role in deforestation when its indirect impacts are taken into account, as land used to grow soy continues to increase. This land either comes from pasture land (which increasingly supplants forested areas), or areas outside the Amazon not covered by the moratorium, such as the Cerrado region. Roughly one-fifth of deforestation can be attributed to expanding land use to produce oilseeds, primarily for soy and palm oil, whereas the expansion of beef production accounts for 41%. The main driver of deforestation is the global demand for meat, which in turn requires huge tracts of land to grow feed crops for livestock.[55] Around 80% of the global soybean crop is used to feed livestock.[56]

Soybean production – 2020 (millions of tonnes)	
Brazil	122
United States	113
Argentina	49
China	20
India	11
Paraguay	11
World	**353**
Source: FAOSTAT[51]	

History

Soybeans were a crucial crop in East Asia long before written records began.[57] The origin of soy cultivation remains scientifically debated. The closest living relative of the soybean is *Glycine soja* (previously called *G. ussuriensis*), a legume native to central China.[58] Genomic data increasingly supports a single domestication event in north-central China between 6,000 and 9,000 years ago, although some evidence suggests a more complex scenario involving low-intensity pre-domestication cultivation across multiple locations in East Asia, followed by the eventual dominance of the Chinese lineage.[6]



Map of soybean fields in the United States

There is evidence for soybean domestication between 7000 and 6600 BC in China, between 5000 and 3000 BC in Japan and 1000 BC in Korea.[59] The first unambiguously domesticated, cultigen-sized soybean was discovered in Korea at the Mumun-period Daundong site.[60][61] Prior to fermented products such as fermented black soybeans (*douchi*), *jiang* (Chinese miso), soy sauce, tempeh, nattō, and miso, soy was considered sacred for its beneficial effects in crop rotation, and it was eaten by itself, and as bean curd and soy milk.

Soybeans were introduced to Java in Malay Archipelago circa 13th century or probably earlier. By the 17th century through their trade with Far East, soybeans and its products were traded by European traders (Portuguese, Spanish, and Dutch) in Asia, and reached Indian Subcontinent by this period. By the 18th century, soybeans were introduced to the Americas and Europe from China. Soy was introduced to Africa from China in the late 19th century, and is now widespread across the continent.

East Asia

Seikei Zusetsu (1804)

Soy was most likely domesticated 6,000–9,000 years ago in the region between the Yellow River and the Huai River in China.[6] The earliest documented evidence for the use of *Glycine* of any kind comes from charred plant remains of wild soybean recovered from Jiahu in Henan province, a Neolithic site occupied between 9,000 and 7,800 years ago.[60] An abundance of archaeological charred soybean specimens have been found centered around this region.[62]

Soybeans became an important crop by the Zhou dynasty (c. 1046–256 BC) in China. According to an ancient Chinese myth, in 2853 BC, the legendary Emperor Shennong of China proclaimed that five plants were sacred: soybeans, rice, wheat, barley, and millet.[63] Early Chinese records mention that soybeans were a gift from the region of the Yangtze River delta and Southeast China.[64] However, there is no archaeological evidence that soybeans were domesticated in southern China, and it appears that soy was unknown there prior to the Han dynasty.[60]

The oldest preserved soybeans resembling modern varieties in size and shape were found in archaeological sites in Korea dated about 1000 BC.[64][65] Radiocarbon dating of soybean samples recovered through flotation during excavations at the Early Mumun period Okbang site in Korea indicated soybean was cultivated as a food crop in around 1000–900 BC.[65] Soybeans from the Jōmon period in Japan from 3000 BC[60] are also significantly larger than wild varieties.[60][66] The earliest Japanese textual reference to the soybean is in the classic *Kojiki* (*Records of Ancient Matters*), which was completed in 712 CE.

Southeast Asia

Soybeans were mentioned as *kadêlê* (modern Indonesian term: *kedelai*)[67] in an old Javanese manuscript, Serat Sri Tanjung, which dates to 12th- to 13th-century Java.[68] By the 13th century, the soybean had arrived and cultivated in Indonesia; it probably arrived much earlier however, carried by traders or merchants from Southern China.[69]

The earliest known reference to it as "tempeh" appeared in 1815 in the Serat Centhini manuscript.[70] The development of tempeh fermented soybean cake probably took place earlier, circa 17th century in Java.

Indian subcontinent

By the 1600s, soy sauce spread from southern Japan across the region through the Dutch East India Company (VOC).

From a high-altitude area of Nepal

While the origins and history of Soybean cultivation in the Eastern Himalayas is debated, it was potentially introduced from southern China, more specifically Yunnan province.[71][72] Alternatively, it could have reached here through traders from Indonesia via Myanmar. Northeast India is viewed as a passive micro-centre within the soybean secondary gene centre. Central India is considered a tertiary gene centre particularly the area encompassing Madhya Pradesh which is also the country largest soybean producer.[72]

Iberia

Vocabvlario da Lingoa de Iapam, a Japanese-Portuguese dictionary, was compiled and published in 1603 by Jesuit priests in Nagasaki. It contains short but clear definitions for about 20 words related to soyfoods—the first in any European language.

Young plants in India

The Luso-Hispanic traders were familiar with soybeans and soybean product through their trade with Far East since at least the 17th century. However, it was not until the late 19th century that the first attempt to cultivate soybeans in the Iberian peninsula was undertaken. In 1880, the soybean was first cultivated in Portugal in the Botanical Gardens at Coimbra (Crespi 1935).

In about 1910 in Spain the first attempts at Soybean cultivation were made by the Count of San Bernardo, who cultivated soybeans on his estates at Almillo (in southwest Spain) about 48 miles east-northeast of Seville.[73]

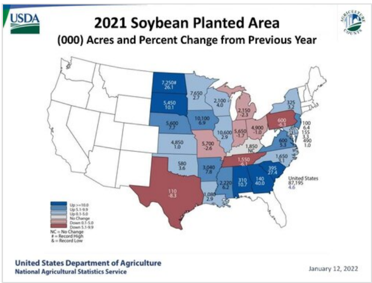
North America

Soybeans were first introduced to North America from China in 1765, by Samuel Bowen, a former East India Company sailor who had visited China in conjunction with James Flint, the first Englishman legally permitted by the Chinese authorities to learn Chinese.[74] The first "New World" soybean crop was grown on Skidaway Island, Georgia, in 1765 by Henry Yonge from seeds given him by Samuel Bowen.[75][76][77] Bowen grew soy near Savannah, Georgia, possibly using funds from Flint, and made soy sauce for sale to England.[78] Although soybean was introduced into North America in 1765, for the next 155 years, the crop was grown primarily for forage.[79]

In 1831, the first soy product "a few dozen India Soy" [sauce] arrived in Canada. Soybeans were probably first cultivated in Canada by 1855, and definitely in 1895 at Ontario Agricultural College.[80]

It was not until Lafayette Mendel and Thomas Burr Osborne showed that the nutritional value of soybean seeds could be increased by cooking, moisture or heat, that soy went from a farm animal feed to a human food.[81][82]

William Joseph Morse is considered the "father" of modern soybean agriculture in America. In 1910, he and Charles Piper began to popularize what was regarded as a relatively unknown Oriental peasant crop in America into a "golden bean", with the soybean becoming one of America's largest and most nutritious farm crops.[83][84][85]



Prior to the 1920s in the US, the soybean was mainly a forage crop, a source of oil, meal (for feed) and industrial products, with very little used as food. However, it took on an important role after World War I. During the Great Depression, the drought-stricken (Dust Bowl) regions of the United States were able to use soy to regenerate their soil because of its nitrogen-fixing properties. Farms were increasing production to meet with government demands, and Henry Ford became a promoter of soybeans.[86] In 1931, Ford hired chemists Robert Boyer and Frank Calvert to produce artificial silk. They succeeded in making a textile fiber of spun soy protein fibers, hardened or tanned in a formaldehyde bath, which was given the name Azlon. It never reached the commercial market. Soybean oil was used by Ford in paint for the automobiles,[87] as well as a fluid for shock absorbers.

During World War II, soybeans became important in both North America and Europe chiefly as substitutes for other protein foods and as a source of edible oil. During the war, the soybean was discovered as fertilizer due to nitrogen fixation by the United States Department of Agriculture.

Prior to the 1970s, Asian-Americans and Seventh-Day Adventists were essentially the only users of soy foods in the United States.[88] "The soy foods movement began in small pockets of the counterculture, notably the Tennessee commune named simply The Farm, but by the mid-1970s a vegetarian revival helped it gain momentum and even popular awareness through books such as *The Book of Tofu*."[89]

Although practically unseen in 1900, by 2000 soybean plantings covered more than 70 million acres,[90] second only to corn, and it became America's largest cash crop. In 2021, 87,195,000 acres were planted, with the largest acreage in the states of Illinois, Iowa, and Minnesota.[91]

Caribbean and West Indies

The soybean arrived in the Caribbean in the form of soy sauce made by Samuel Bowen in Savannah, Georgia, in 1767. It remains only a minor crop there, but its uses for human food are growing steadily.[92]

Mediterranean area

The soybean was first cultivated in Italy by 1760 in the Botanical Garden of Turin. During the 1780s, it was grown in at least three other botanical gardens in Italy.[93] The first soybean product, soy oil, arrived in Anatolia during 1909 under Ottoman Empire.[94] The first clear cultivation occurred in 1931.[94] This was also the first time that soybeans were cultivated in Middle East.[94] By 1939, soybeans were cultivated in Greece.[95][96]

Australia

Wild soybeans were discovered in northeastern Australia in 1770 by explorers Banks and Solander. In 1804, the first soyfood product ("Fine India Soy" [sauce]) was sold in Sydney. In 1879, the first domesticated soybeans arrived in Australia, a gift of the Minister of the Interior Department, Japan.[97]

France

The soybean was first cultivated in France by 1779 (and perhaps as early as 1740). The two key early people and organizations introducing the soybean to France were the Society of Acclimatization (starting in 1855) and Li Yu-ying (from 1910). Li started a large tofu factory, where the first commercial soyfoods in France were made.[98]

Africa

The soybean first arrived in Africa via Egypt in 1857.[99] Soya Meme (Baked Soya) is produced in the village called Bame Awudome near Ho, the capital of the Volta Region of Ghana, by the Ewe people of Southeastern Ghana and southern Togo.

Central Europe

In 1873, Professor Friedrich J. Haberlandt first became interested in soybeans when he obtained the seeds of 19 soybean varieties at the Vienna World Exposition (Wiener Weltausstellung). He cultivated these seeds in Vienna, and soon began to distribute them throughout Central and Western Europe. In 1875, he first grew the soybeans in Vienna, then in early 1876 he sent samples of seeds to seven cooperators in central Europe, who planted and tested the seeds in the spring of 1876, with good or fairly good results in each case.[100]

Most of the farmers who received seeds from him cultivated them, then reported their results. Starting in February 1876, he published these results first in various journal articles, and finally in his *magnum opus*, Die Sojabohne (The Soybean) in 1878.[100] In northern Europe, lupin (lupine) is known as the "soybean of the north".[101]

Central Asia

The soybean is first in cultivated Transcaucasia in Central Asia in 1876, by the Dungans. This region has never been important for soybean production.[102]

Central America

The first reliable reference to the soybean in this region dates from Mexico in 1877.[103]

South America

The soybean first arrived in South America in Argentina in 1882.[104]

Andrew McClung showed in the early 1950s that with soil amendments the Cerrado region of Brazil would grow soybeans.[105] In June 1973, when soybean futures markets mistakenly portended a major shortage, the Nixon administration imposed an embargo on soybean exports. It lasted only a week, but Japanese buyers felt that they could not rely on U.S. supplies, and the rival Brazilian soybean industry came into existence.[106][86] This led Brazil to become the world's largest producer of soybeans in 2020, with 131 million tons.[107]

Industrial soy production in South America is characterized by wealthy management who live far away from the production site which they manage remotely. In Brazil, these managers depend heavily on advanced technology and machinery, and agronomic practices such as zero tillage, high pesticide use, and intense fertilization. One contributing factor is the increased attention on the Brazilian Cerrado in Bahia, Brazil by US farmers in the early 2000s. This was due to rising values of scarce farmland and high production costs in the US Midwest. There were many promotions of the Brazilian Cerrado by US farm producer magazines and market consultants who portrayed it as having cheap land with ideal production conditions, with infrastructure being the only thing it was lacking. These same magazines also presented Brazilian soy as inevitably out-competing American soy. Another draw to investing was the insider information about the climate and market in Brazil. A few dozen American farmers purchased varying amounts of land by a variety of means including finding investors and selling off land holdings. Many followed the ethanol company model and formed an LLC with investments from neighboring farmers, friends, and family while some turned to investment companies. Some soy farmers either liquidated their Brazilian assets or switched to remote management from the US to return to farming there and implement new farming and business practices to make their US farms more productive. Others planned to sell their now expensive Bahia land to buy land cheaper land in the frontier regions of Piauí or Tocantins to create more soybean farms.[108]

Genetics

Chinese landraces were found to have a slightly higher genetic diversity than inbred lines by Li *et al.*, 2010.[109] Specific locus amplified fragment sequencing (SLAF-seq) has been used by Han *et al.*, 2015 to study the genetic history of the domestication process, perform genome-wide association studies (GWAS) of agronomically relevant traits, and produce high-density linkage maps.[110] An SNP array was developed by Song *et al.*, 2013 and has been used for research and breeding;[111] the same team applied their array in Song *et al.*, 2015 against the USDA Soybean Germplasm Collection and obtained mapping data that are expected to yield association mapping data for such traits.[109]

Rpp1-R1 is a resistance gene against soybean rust.[112] Rpp1-R1 is an R gene (NB-LRR) providing resistance against the rust pathogen *Phakopsora pachyrhizi*.[112] Its synthesis product includes a ULP1 protease.[112]

Qijian *et al.*, 2017 provides the SoySNP50K gene array.[113][114]

Genetic modification

Soybeans are one of the "biotech food" crops that have been genetically modified, and genetically modified soybeans are being used in an increasing number of products. In 1995, Monsanto company introduced glyphosate-tolerant soybeans that have been genetically modified to be resistant to Monsanto's glyphosate herbicides through substitution of the *Agrobacterium sp.* (strain CP4) gene EPSP (5-enolpyruvyl shikimic acid-3-phosphate) synthase. The substituted version is not sensitive to glyphosate.[115]

Different varieties of soybeans being grown together

In 1997, about 8% of all soybeans cultivated for the commercial market in the United States were genetically modified. In 2010, the figure was 93%.[116] As with other glyphosate-tolerant crops, concern is expressed over damage to biodiversity.[117] A 2003 study[118] concluded the "Roundup Ready" (RR) gene had been bred into so many different soybean cultivars, there had been little decline in genetic diversity, but "diversity was limited among elite lines from some companies".

The widespread use of such types of GM soybeans in the Americas has caused problems with exports to some regions. GM crops require extensive certification before they can be legally imported into the European Union, where there is considerable supplier and consumer reluctance to use GM products for consumer or animal use. Difficulties with coexistence and subsequent traces of cross-contamination of non-GM stocks have caused shipments to be rejected and have put a premium on non-GM soy.[119]

A 2006 United States Department of Agriculture report found the adoption of genetically engineered (GE) soy, corn and cotton reduced the amount of pesticides used overall, but did result in a slightly greater amount of herbicides used for soy specifically. The use of GE soy was also associated with greater conservation tillage, indirectly leading to better soil conservation, as well as increased income from off-farming sources due to the greater ease with which the crops can be managed. Though the overall estimated benefits of the adoption of GE soybeans in the United States was $310 million, the majority of this benefit was experienced by the companies selling the seeds (40%), followed by biotechnology firms (28%) and farmers (20%).[120] The patent on glyphosate-tolerant soybeans expired in 2014,[121] so benefits can be expected to shift.[122]

Adverse effects

Soy allergy

Allergy to soy is common, and the food is listed with other foods that commonly cause allergy, such as milk, eggs, peanuts, tree nuts, and shellfish. The problem has been reported among younger children, and the diagnosis of soy allergy is often based on symptoms reported by parents and results of skin tests or blood tests for allergy. Only a few reported studies have attempted to confirm allergy to soy by direct challenge with the food under controlled conditions.[123] It is very difficult to give a reliable estimate of the true prevalence of soy allergy in the general population. To the extent that it does exist, soy allergy may cause cases of urticaria and angioedema, usually within minutes to hours of ingestion. In rare cases, true anaphylaxis may also occur. The reason for the discrepancy is likely that soy proteins, the causative factor in allergy, are far less potent at triggering allergy symptoms than the proteins of peanut and shellfish.[124] An allergy test that is positive demonstrates that the immune system has formed IgE antibodies to soy proteins. However, this is only a factor when soy proteins reach the blood without being digested, in sufficient quantities to reach a threshold to provoke actual symptoms.

Soy can also trigger symptoms via food intolerance, a situation where no allergic mechanism can be proven. One scenario is seen in very young infants who have vomiting and diarrhoea when fed soy-based formula, which resolves when the formula is withdrawn. Older infants can suffer a more severe disorder with vomiting, diarrhoea that may be bloody, anemia, weight loss and failure to thrive. The most common cause of this unusual disorder is a sensitivity to cow's milk, but soy formulas can also be the trigger. The precise mechanism is unclear and it could be immunologic, although not through the IgE-type antibodies that have the leading role in urticaria and anaphylaxis. However, it is also self-limiting and will often disappear in the toddler years.[125]

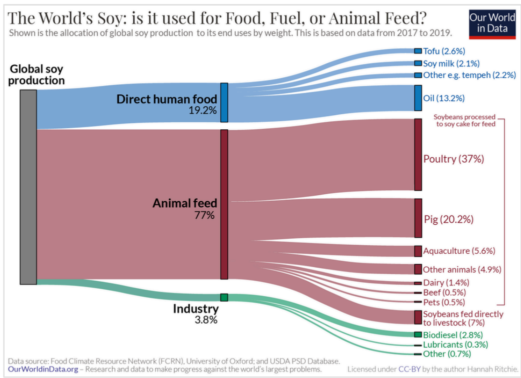
In the European Union, identifying the presence of soy either as an ingredient or unintended contaminant in packaged food is compulsory. The regulation (EC) 1169/2011 on food-labeling lists 14 allergens, including soy, in packaged food must be clearly indicated on the label as part of the list of ingredients, using a distinctive typography (such as bold type or capital letters).[126]

Thyroid function

One review noted that soy-based foods may inhibit absorption of thyroid hormone medications required for treatment of hypothyroidism.[127] A 2015 scientific review by the European Food Safety Authority concluded that intake of isoflavones from supplements did not affect thyroid hormone levels in postmenopausal women.[128]

Uses

Among the legumes, the soybean is valued for its high (38–45%) protein content as well as its high (approximately 20%) oil content. Soybeans are the most valuable agricultural export of the United States.[129] Approximately 85% of the world's soybean crop is processed into soybean meal and soybean oil, the remainder processed in other ways or eaten whole.[130]



Breakdown of what the world's soy was used for in 2018

Soybeans can be broadly classified as "vegetable" (garden) or field (oil) types. Vegetable types cook more easily, have a mild, nutty flavor, and better texture, are larger in size, higher in protein, and are lower in oil than field types. Tofu, soy milk, and soy sauce are among the top edible commodities made using soybeans. Producers prefer the higher protein cultivars bred from vegetable soybeans originally brought to the United States in the late 1930s. The "garden" cultivars are generally not suitable for mechanical combine harvesting because there is a tendency for the pods to shatter upon reaching maturity.

Nutrition

A 100-gram reference quantity of raw soybeans supplies 1,866 kilojoules (446 kilocalories) of food energy and are 9% water, 30% carbohydrates, 20% total fat and 36% protein. Peanuts are the only legumes with a higher fat content (48%) and calorie count (2,385 kJ). They contain less carbohydrates (21%), protein (25%) and dietary fiber (9%).

Soybeans are a rich source of essential nutrients, providing in a 100-gram serving (raw, for reference) high contents of the Daily Value (DV) especially for protein (36% DV), dietary fiber (37%), iron (121%), manganese (120%), phosphorus (101%) and several B vitamins, including folate (94%) (table). High contents also exist for vitamin K, magnesium, zinc and potassium.

For human consumption, soybeans must be processed prior to consumption–either by cooking, roasting, or fermenting–to destroy the trypsin inhibitors (serine protease inhibitors).[133] Raw soybeans, including the immature green form, are toxic to all monogastric animals.[134]

Tofu and soy sauce

Soybean, mature seeds, raw

Nutritional value per 100 g (3.5 oz)	
Energy	1,866 kJ (446 kcal)
Carbohydrates	30.16 g
Sugars	7.33 g
Dietary fiber	9.3 g
Fat	19.94 g
Saturated	2.884 g
Monounsaturated	4.404 g
Polyunsaturated	11.255 g
omega‑3	1.330 g
omega‑6	9.925 g
Protein	36.49 g
Amino acids	
Vitamins and minerals	
Other constituents	**Quantity**
Water	8.54 g
Cholesterol	0 mg

Link to USDA FoodData Central Entry (https://fdc.nal.usda.gov/food-details/174270/nutrients)

†Percentages estimated using US recommendations for adults,[131] except for potassium, which is estimated based on expert recommendation from the National Academies.[132]

Protein

Most soy protein is a relatively heat-stable storage protein. This heat stability enables soy food products requiring high temperature cooking, such as tofu, soy milk and textured vegetable protein (soy flour) to be made. Soy protein is essentially identical to the protein of other legume seeds and pulses.[135][136]

Soy is a good source of protein for vegetarians and vegans or for people who want to reduce the amount of meat they eat, according to the US Food and Drug Administration:[137]

> Soy protein products can be good substitutes for animal products because, unlike some other beans, soy offers a 'complete' protein profile. ... Soy protein products can replace animal-based foods—which also have complete proteins but tend to contain more fat, especially saturated fat—without requiring major adjustments elsewhere in the diet.

Although soybeans have high protein content, soybeans also contain high levels of protease inhibitors, which can prevent digestion.[138] Protease inhibitors are reduced by cooking soybeans, and are present in low levels in soy products such as tofu and soy milk.[138]

The Protein Digestibility Corrected Amino Acid Score (PDCAAS) of soy protein is the nutritional equivalent of meat, eggs, and casein for human growth and health. Soybean protein isolate has a biological value of 74, whole soybeans 96, soybean milk 91, and eggs 97.[139]

All spermatophytes, except for the family of grasses and cereals (Poaceae), contain 7S (vicilin) and 11S (legumin) soy protein-like globulin storage proteins; or only one of these globulin proteins. S denotes Svedberg, sedimentation coefficients. Oats and rice are anomalous in that they also contain a majority of soybean-like protein.[140] Cocoa, for example, contains the 7S globulin, which contributes to cocoa/chocolate taste and aroma,[141][142][143] whereas coffee beans (coffee grounds) contain the 11S globulin responsible for coffee's aroma and flavor.[144][145]

Graded seed

Vicilin and legumin proteins belong to the cupin superfamily, a large family of functionally diverse proteins that have a common origin and whose evolution can be followed from bacteria to eukaryotes including animals and higher plants.[146]

2S albumins form a major group of homologous storage proteins in many dicot species and in some monocots but not in grasses (cereals).[147] Soybeans contain a small but significant 2S storage protein.[148][149][150] 2S albumin are grouped in the prolamin superfamily.[151] Other allergenic proteins included in this 'superfamily' are the non-specific plant lipid transfer proteins, alpha amylase inhibitor, trypsin inhibitors, and prolamin storage proteins of cereals and grasses.[140]

Peanuts, for instance, contain 20% 2S albumin but only 6% 7S globulin and 74% 11S.[147] It is the high 2S albumin and low 7S globulin that is responsible for the relatively low lysine content of peanut protein compared to soy protein.

Carbohydrates

The principal soluble carbohydrates of mature soybeans are the disaccharide sucrose (range 2.5–8.2%), the trisaccharide raffinose (0.1–1.0%) composed of one sucrose molecule connected to one molecule of galactose, and the tetrasaccharide stachyose (1.4 to 4.1%) composed of one sucrose connected to two molecules of galactose. While the oligosaccharides raffinose and stachyose protect the viability of the soybean seed from desiccation (see above section on physical characteristics) they are not digestible sugars, so contribute to flatulence and abdominal discomfort in humans and other monogastric animals, comparable to the disaccharide trehalose. Undigested oligosaccharides are broken down in the intestine by native microbes, producing gases such as carbon dioxide, hydrogen, and methane.

Since soluble soy carbohydrates are found in the whey and are broken down during fermentation, soy concentrate, soy protein isolates, tofu, soy sauce, and sprouted soybeans are without flatus activity. On the other hand, there may be some beneficial effects to ingesting oligosaccharides such as raffinose and stachyose, namely, encouraging indigenous bifidobacteria in the colon against putrefactive bacteria.

The insoluble carbohydrates in soybeans consist of the complex polysaccharides cellulose, hemicellulose, and pectin. The majority of soybean carbohydrates can be classed as belonging to dietary fiber.

Fats

Raw soybeans are 20% fat, including saturated fat (3%), monounsaturated fat (4%) and polyunsaturated fat, mainly as linoleic acid (table).

Within soybean oil or the lipid portion of the seed is contained four phytosterols: stigmasterol, sitosterol, campesterol, and brassicasterol accounting for about 2.5% of the lipid fraction; and which can be converted into steroid hormones. Additionally soybeans are a rich source of sphingolipids.[152]

Other constituents

Soy contains isoflavones—polyphenolic compounds, produced by legumes including peanuts and chickpeas. Isoflavones are closely related to flavonoids found in other plants, vegetables and flowers.[153]

Soy contains the phytoestrogen coumestans, also are found in beans and split-peas, with the best sources being alfalfa, clover, and soybean sprouts. Coumestrol, an isoflavone coumarin derivative, is the only coumestan in foods.[154][155]

Saponins, a class of natural surfactants (soaps), are sterols that are present in small amounts in various plant foods, including soybeans, other legumes, and cereals, such as oats.[156][157]

Comparison to other major staple foods

The following table shows the nutrient content of green soybean and other major staple foods, each in respective raw form on a dry weight basis to account for their different water contents. Raw soybeans, however, are not edible and cannot be digested. These must be sprouted, or prepared and cooked for human consumption. In sprouted and cooked form, the relative nutritional and anti-nutritional contents of each of these grains is remarkably different from that of raw form of these grains reported in this table. The nutritional value of soybean and each cooked staple depends on the processing and the method of cooking: boiling, frying, roasting, baking, etc.

Nutrient content of 10 major staple foods per 100 g dry weight[158]

Staple	Maize (corn) [A]	Rice, white[B]	Wheat[C]	Potatoes[D]	Cassava[E]	Soybeans, green[F]	Sweet potatoes[G]	Yams[Y]	Sorghum[H]	Plantain[Z]	RDA
Water content (%)	10	12	13	**79**	60	68	77	70	9	65	
Raw grams per 100 g dry weight	111	114	115	**476**	250	313	435	333	110	286	
Nutrient											
Energy (kJ)	1698	1736	1574	1533	1675	**1922**	1565	1647	1559	1460	8,368–10,460
Protein (g)	10.4	8.1	14.5	9.5	3.5	**40.6**	7.0	5.0	12.4	3.7	50
Fat (g)	5.3	0.8	1.8	0.4	0.7	**21.6**	0.2	0.6	3.6	1.1	44–77
Carbohydrates (g)	82	91	82	81	**95**	34	87	93	82	91	130
Fiber (g)	8.1	1.5	**14.0**	10.5	4.5	13.1	13.0	13.7	6.9	6.6	30
Sugar (g)	0.7	0.1	0.5	3.7	4.3	0.0	18.2	1.7	0.0	**42.9**	minimal
Minerals	[A]	[B]	[C]	[D]	[E]	[F]	[G]	[Y]	[H]	[Z]	**RDA**
Calcium (mg)	8	32	33	57	40	**616**	130	57	31	9	1,000
Iron (mg)	3.01	0.91	3.67	3.71	0.68	**11.09**	2.65	1.80	4.84	1.71	8
Magnesium (mg)	141	28	145	110	53	**203**	109	70	0	106	400
Phosphorus (mg)	233	131	331	271	68	**606**	204	183	315	97	700
Potassium (mg)	319	131	417	2005	678	1938	1465	**2720**	385	1426	4700
Sodium (mg)	39	6	2	29	35	47	**239**	30	7	11	1,500
Zinc (mg)	2.46	1.24	3.05	1.38	0.85	**3.09**	1.30	0.80	0.00	0.40	11
Copper (mg)	0.34	0.25	0.49	0.52	0.25	0.41	**0.65**	0.60	-	0.23	0.9
Manganese (mg)	0.54	1.24	**4.59**	0.71	0.95	1.72	1.13	1.33	-	-	2.3
Selenium (μg)	17.2	17.2	**81.3**	1.4	1.8	4.7	2.6	2.3	0.0	4.3	55
Vitamins	[A]	[B]	[C]	[D]	[E]	[F]	[G]	[Y]	[H]	[Z]	**RDA**
Vitamin C (mg)	0.0	0.0	0.0	**93.8**	51.5	90.6	10.4	57.0	0.0	52.6	90
Thiamin (B1) (mg)	0.43	0.08	0.34	0.38	0.23	**1.38**	0.35	0.37	0.26	0.14	1.2
Riboflavin (B2) (mg)	0.22	0.06	0.14	0.14	0.13	**0.56**	0.26	0.10	0.15	0.14	1.3
Niacin (B3) (mg)	4.03	1.82	**6.28**	5.00	2.13	5.16	2.43	1.83	3.22	1.97	16
Pantothenic acid (B5) (mg)	0.47	1.15	1.09	1.43	0.28	0.47	**3.48**	1.03	-	0.74	5
Vitamin B6 (mg)	0.69	0.18	0.34	**1.43**	0.23	0.22	0.91	0.97	-	0.86	1.3
Folate Total (B9) (μg)	21	9	44	76	68	**516**	48	77	0	63	400
Vitamin A (IU)	238	0	10	10	33	563	**4178**	460	0	3220	5000
Vitamin E, alpha-tocopherol (mg)	0.54	0.13	1.16	0.05	0.48	0.00	1.13	**1.30**	0.00	0.40	15
Vitamin K1 (μg)	0.3	0.1	2.2	**9.0**	4.8	0.0	7.8	8.7	0.0	2.0	120
Beta-carotene (μg)	108	0	6	5	20	0	**36996**	277	0	1306	10500
Lutein+zeaxanthin (μg)	**1506**	0	253	38	0	0	0	0	0	86	6000
Fats	[A]	[B]	[C]	[D]	[E]	[F]	[G]	[Y]	[H]	[Z]	**RDA**
Saturated fatty acids (g)	0.74	0.20	0.30	0.14	0.18	**2.47**	0.09	0.13	0.51	0.40	minimal
Monounsaturated fatty acids (g)	1.39	0.24	0.23	0.00	0.20	**4.00**	0.00	0.03	1.09	0.09	22–55
Polyunsaturated fatty acids (g)	2.40	0.20	0.72	0.19	0.13	**10.00**	0.04	0.27	1.51	0.20	13–19
	[A]	[B]	[C]	[D]	[E]	[F]	[G]	[Y]	[H]	[Z]	**RDA**

A raw yellow dent corn
B raw unenriched long-grain white rice
C raw hard red winter wheat
D raw potato with flesh and skin
E raw cassava
F raw green soybeans
G raw sweet potato
H raw sorghum
Y raw yam
Z raw plantains
/* unofficial

Soybean oil

Soybean seed contains 18–19% oil.[159] To extract soybean oil from seed, the soybeans are cracked, adjusted for moisture content, rolled into flakes, and solvent-extracted with commercial hexane.[160] The oil is then refined, blended for different applications, and sometimes hydrogenated. Soybean oils, both liquid and partially hydrogenated, are exported abroad, sold as "vegetable oil," or end up in a wide variety of processed foods.

Soybean meal

Soybean meal, or soymeal, is the material remaining after solvent extraction of oil from soybean flakes, with a 50% soy protein content. The meal is 'toasted' (a misnomer because the heat treatment is with moist steam) and ground in a hammer mill. Ninety-seven percent of soybean meal production globally is used as livestock feed.[159] Soybean meal is also used in some dog foods.[161]

Livestock feed

One of the major uses of soybeans globally is as livestock feed, predominantly in the form of soybean meal. In the European Union, for example, though it does not make up most of the weight of livestock feed, soybean meal provides around 60% of the protein fed to livestock.[162] In the United States, 70 percent of soybean production is used for animal feed, with poultry being the number one livestock sector of soybean consumption.[163] Spring grasses are rich in omega-3 fatty acids, whereas soy is predominantly omega-6. The soybean hulls, which mainly consist of the outer coats of the beans removed before oil extraction, can also be fed to livestock and whole soybean seeds after processing.[164][165]

Food for human consumption


Tempeh


Soy chunks

In addition to their use in livestock feed, soybean products are widely used for human consumption. Common soybean products include soy sauce, soy milk, tofu, soy meal, soy flour, textured vegetable protein (TVP), soy curls, tempeh, soy lecithin and soybean oil. Soybeans may also be eaten with minimal processing, for example, in the Japanese food *edamame* (枝豆, *edamame*), in which immature soybeans are boiled whole in their pods and served with salt.

In China, Japan, Vietnam and Korea, soybean and soybean products are a standard part of the diet.[166] Tofu (豆腐 *dòufu*) is thought to have originated in China, along with soy sauce and several varieties of soybean paste used as seasonings. Japanese foods made from soya include *miso* (味噌), *nattō* (納豆), *kinako* (黄粉) and *edamame* (枝豆), as well as products made with tofu such as atsuage and aburaage. In China, whole dried soybeans are sold in supermarkets and used to cook various dishes, usually after rehydration by soaking in water; they find their use in soup or as a savory dish. In Korean cuisine, soybean sprouts (콩나물 *kongnamul*) are used in a variety of dishes, and soybeans are the base ingredient in *doenjang*, *cheonggukjang* and *ganjang*. In Vietnam, soybeans are used to make soybean paste (*tương*) in the North with the most popular products are *tương Bần*, *tương Nam Đàn*, *tương Cự Đà* as a garnish for *phở* and *gỏi cuốn* dishes, as well as tofu (*đậu hũ* or *đậu phụ* or *tàu hũ*), soy sauce (*nước tương*), soy milk (*nước đậu* in the North or *sữa đậu nành* in the South), and *đậu hũ nước đường* (tofu sweet soup).

Flour


Beans for sale at a supermarket in China

Soy flour refers to soybeans ground finely enough to pass through a 100-mesh or smaller screen where special care was taken during desolventizing (not toasted) to minimize denaturation of the protein to retain a high protein dispersibility index, for uses such as food extrusion of textured vegetable protein.[167] It is the starting material for soy concentrate and protein isolate production.

Soy flour can also be made by roasting the soybean, removing the coat (hull), and grinding it into flour. Soy flour is manufactured with different fat levels.[168] Alternatively, raw soy flour omits the roasting step.

- Defatted soy flour is obtained from solvent extracted flakes and contains less than 1% oil.[168]
- "Natural or full-fat soy flour is made from unextracted, dehulled beans and contains about 18% to 20% oil."[168] Its high oil content requires the use of a specialized Alpine Fine Impact Mill to grind rather than the usual hammer mill. Full-fat soy flour has a lower protein concentration than defatted flour. Extruded full-fat soy flour, ground in an Alpine mill, can replace/extend eggs in baking and cooking.[169][170] Full-fat soy flour is a component of Cornell bread.[171][172][173]
- Low-fat soy flour is made by adding some oil back into defatted soy flour. Fat levels range from 4.5% to 9%.[168]
- High-fat soy flour can also be produced by adding back soybean oil to defatted flour, usually at 15%.[174]

Soy lecithin can be added (up to 15%) to soy flour to make lecithinated soy flour. It increases dispersibility and gives it emulsifying properties.[168]

Soy flour has 50% protein and 5% fiber. It has higher levels of protein, thiamine, riboflavin, phosphorus, calcium, and iron than wheat flour. It does not contain gluten.[168] As a result, yeast-raised breads made with soy flour are dense in texture. Among many uses, soy flour thickens sauces, prevents staling in baked food, and reduces oil absorption during frying. Baking food with soy flour gives it tenderness, moistness, a rich color, and a fine texture.[168]

Bhatmaas – Nepali fried soybeans

Soy grits are similar to soy flour, except the soybeans have been toasted and cracked into coarse pieces.

Kinako is a soy flour used in Japanese cuisine.

Section reference: Circle & Smith (1972, p. 442)

Soy-based infant formula

Soy-based infant formula (SBIF) is sometimes given to infants who are not being strictly breastfed; it can be useful for infants who are either allergic to pasteurized cow milk proteins or who are being fed a vegan diet. It is sold in powdered, ready-to-feed, and concentrated liquid forms.

Some reviews have expressed the opinion that more research is needed to determine what effect the phytoestrogens in soybeans may have on infants.[175] Diverse studies have concluded there are no adverse effects in human growth, development, or reproduction as a result of the consumption of soy-based infant formula.[176][177][178] One of these studies, published in the *Journal of Nutrition*,[178] concludes that there are:

> ... no clinical concerns with respect to nutritional adequacy, sexual development, neurobehavioral development, immune development, or thyroid disease. SBIFs provide complete nutrition that adequately supports normal infant growth and development. FDA has accepted SBIFs as safe for use as the sole source of nutrition.

Meat and dairy alternatives and extenders

Japanese soybean meat

Soybeans can be processed to produce a texture and appearance similar to many other foods. For example, soybeans are the primary ingredient in many dairy product substitutes (e.g., soy milk, margarine, soy ice cream, soy yogurt, soy cheese, and soy cream cheese) and meat alternatives (e.g. veggie burgers). These substitutes are readily available in most supermarkets. Soy milk does not naturally contain significant amounts of digestible calcium. Many manufacturers of soy milk sell calcium-enriched products, as well.

Soy products also are used as a low-cost substitute for meat and poultry products.[179][180] Food service, retail and institutional (primarily school lunch and correctional) facilities regularly use such "extended" products. The extension may result in diminished flavor, but fat and cholesterol are reduced. Vitamin and mineral fortification can be used to make soy products nutritionally equivalent to animal protein; the protein quality is already roughly equivalent. The soy-based meat substitute textured vegetable protein has been used for more than 50 years as a way of inexpensively extending ground beef without reducing its nutritional value.[5][181][182]

Cream cheese alternative with chives

Soy nut butter

The soybean is used to make a product called soy nut butter which is similar in texture to peanut butter.[183]

Sweetened soybean

Sweet-boiled beans are popular in Japan and Korea, and the sweet-boiled soybeans are called "Daizu no Nimame" in Japan and Kongjorim (Korean: 콩조림) in Korea. Sweet-boiled beans are even used in sweetened buns, especially in Mame Pan.

The boiled and pasted edamame, called Zunda, is used as one of the Sweet bean pastes in Japanese confections.

Coffee substitute

Roasted and ground soybeans can be a caffeine-free substitute for coffee. After the soybeans are roasted and ground, they look similar to regular coffee beans or can be used as a powder similar to instant coffee, with the aroma and flavor of roasted soybeans.[184]

Other products

Soybeans with black hulls are used in Chinese fermented black beans, *douchi*, not to be confused with black turtle beans.

Soybeans are also used in industrial products, including oils, soap, cosmetics, resins, plastics, inks, crayons, solvents, and clothing. Soybean oil is the primary source of biodiesel in the United States, accounting for 80% of domestic biodiesel production.[185] Soybeans have also been used since 2001 as fermenting stock in the manufacture of a brand of vodka.[186] In 1936, Ford Motor Company developed a method where soybeans and fibers were rolled together producing a soup which was then pressed into various parts for their cars, from the distributor cap to knobs on the dashboard. Ford also informed in public relation releases that in 1935 over five million acres (20,000 km^2) was dedicated to growing soybeans in the United States.[187]

Soy candles for sale in Texas

Potential health benefits

Reducing risk of cancer

According to the American Cancer Society, "There is growing evidence that eating traditional soy foods such as tofu may lower the risk of cancers of the breast, prostate, or endometrium (lining of the uterus), and there is some evidence it may lower the risk of certain other cancers." There is insufficient research to indicate whether taking soy dietary supplements (e.g., as a pill or capsule) has any effect on health or cancer risk.[188]

As of 2018, rigorous dietary clinical research in people with cancer has proved inconclusive.[153][189][190][191][192]

Breast cancer

Although considerable research has examined the potential for soy consumption to lower the risk of breast cancer in women, as of 2016 there is insufficient evidence to reach a conclusion about a relationship between soy consumption and any effects on breast cancer.[153] A 2011 meta-analysis stated: "Our study suggests soy isoflavones intake is associated with a significant reduced risk of breast cancer incidence in Asian populations, but not in Western populations."[193]

Gastrointestinal and colorectal cancer

Reviews of preliminary clinical trials on people with colorectal or gastrointestinal cancer suggest that soy isoflavones may have a slight protective effect against such cancers.[189][190]

Prostate cancer

A 2016 review concluded that "current evidence from observational studies and small clinical trials is not robust enough to understand whether soy protein or isoflavone supplements may help prevent or inhibit the progression of prostate cancer."[153] A 2010 review showed that neither soy foods nor isoflavone supplements alter measures of bioavailable testosterone or estrogen concentrations in men.[194] Soy consumption has been shown to have no effect on the levels and quality of sperm.[195] Meta-analyses on the association between soy consumption and prostate cancer risk in men concluded that dietary soy may lower the risk of prostate cancer.[196][192]

Cardiovascular health

The Food and Drug Administration (FDA) granted the following health claim for soy: "25 grams of soy protein a day, as part of a diet low in saturated fat and cholesterol, may reduce the risk of heart disease."[137] One serving, (1 cup or 240 mL) of soy milk, for instance, contains 6 or 7 grams of soy protein.

An American Heart Association (AHA) review of a decade long study of soy protein benefits did not recommend isoflavone supplementation. The review panel also found that soy isoflavones have not been shown to reduce post-menopausal "hot flashes" and the efficacy and safety of isoflavones to help prevent cancers of the breast, uterus or prostate is in question. AHA concluded that "many soy products should be beneficial to cardiovascular and overall health because of their high content of polyunsaturated fats, fiber, vitamins, and minerals and low content of saturated fat".[197] Other studies found that soy protein consumption could lower the concentration of low-density lipoproteins (LDL) transporting fats in the extracellular water to cells.[198][199]

Research by constituent

Lignans

Plant lignans are associated with high fiber foods such as cereal brans and beans are the principal precursor to mammalian lignans which have an ability to bind to human estrogen sites. Soybeans are a significant source of mammalian lignan precursor secoisolariciresinol containing 13–273 µg/100 g dry weight.[200]

Phytochemicals

Soybeans and processed soy foods are among the richest foods in total phytoestrogens (wet basis per 100 g), which are present primarily in the form of the isoflavones, daidzein and genistein.[153][201] Because most naturally occurring phytoestrogens act as selective estrogen receptor modulators, or SERMs, which do not necessarily act as direct agonists of estrogen receptors, normal consumption of foods that contain these phytoestrogens should not provide sufficient amounts to elicit a physiological response in humans.[202][203] The major product of daidzein microbial metabolism is equol.[204] Only 33% of Western Europeans have a microbiome that produces equol, compared to 50–55% of Asians.[204]

Soy isoflavones—polyphenolic compounds that are also produced by other legumes like peanuts and chickpeas[153]—are under preliminary research. As of 2016, no cause-and-effect relationship has been shown in clinical research to indicate that soy isoflavones lower the risk of cardiovascular diseases.[153][197][205]

Phytic acid

Soybeans contain phytic acid, which may act as a chelating agent and inhibit mineral absorption, especially for diets already low in minerals.[206]

In culture

Although observations of soy consumption inducing gynecomastia on men[207] are not conclusive,[208] a pejorative term, "soy boy", has emerged to describe perceived emasculated young men with feminine traits.[209]

Futures

Soybean futures are traded on the Chicago Board of Trade and have delivery dates in January (F), March (H), May (K), July (N), August (Q), September (U), November (X).

They are also traded on other commodity futures exchanges under different contract specifications:

- SAFEX: The South African Futures Exchange[210]
- DC: Dalian Commodity Exchange[211]
- ODE: Osaka Dojima Commodity Exchange (formerly Kansai Commodities Exchange, KEX) in Japan[212]
- NCDEX: National Commodity and Derivatives Exchange, India.
- ROFEX: Rosario Grain Exchange in Argentina

See also

- Alternative fodders
- Cash crop
- List of soy-based foods
- Organic infant formula
- Soy molasses
- Soybean in Paraguay
- Soybean management practices
- Soybean agglutinin, a lectin

Food portal

Further reading

- da Silva, Claiton Marcio; de Majo, Claudio, eds. *The Age of the Soybean: An Environmental History of Soy during the Great Acceleration* (White Horse Press, 2022) online review (http://www.h-net.org/reviews/showrev.php?id=58897)

References

1. "*Glycine max*" (http://eol.org/pages/641527/overview). Encyclopedia of Life (EoL). Retrieved February 16, 2012.
2. Generally written in *katakana*, not *kanji*.
3. "*Glycine max*" (http://www.plantnames.unimelb.edu.au/Sorting/Glycine.html#max). Multilingual Multiscript Plant Name Database. Retrieved February 16, 2012.
4. Rotundo JL, Marshall R, McCormick R, et al. (March 2024). "European soybean to benefit people and the environment" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10982307). *Scientific Reports*. **14** (1) 7612. Bibcode:2024NatSR..14.7612R (https://ui.adsabs.harvard.edu/abs/2024NatSR..14.7612R). doi:10.1038/s41598-024-57522-z (https://doi.org/10.1038%2Fs41598-024-57522-z). PMC 10982307 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10982307). PMID 38556523 (https://pubmed.ncbi.nlm.nih.gov/38556523).
5. Riaz MN (2006). *Soy Applications in Food*. Boca Raton, FL: CRC Press. ISBN 978-0-8493-2981-4.
6. Sedivy EJ, Wu F, Hanzawa Y (2017). "Soybean domestication: the origin, genetic architecture and molecular bases" (https://onlinelibrary.wiley.com/doi/abs/10.1111/nph.14418). *New Phytologist*. **214** (2): 539–553. doi:10.1111/nph.14418 (https://doi.org/10.1111%2Fnph.14418). ISSN 1469-8137 (https://search.worldcat.org/issn/1469-8137). PMID 28134435 (https://pubmed.ncbi.nlm.nih.gov/28134435).
7. "Pocket K No. 16: Global Status of Commercialized Biotech/GM Crops in 2014" (http://www.isaaa.org/resources/publications/pocketk/16/). *isaaa.org*. International Service for the Acquisition of Agri-biotech Applications. Retrieved February 23, 2016.
8. Reynolds G (October 25, 2019). "Why do people hate vegans?" (https://www.theguardian.com/lifeandstyle/2019/oct/25/why-do-people-hate-vegans). *The Guardian*. ISSN 0261-3077 (https://search.worldcat.org/issn/0261-3077). Retrieved June 11, 2025.
9. "soy" (https://doi.org/10.1093/OED/6140796016). *Oxford English Dictionary* (Online ed.). Oxford University Press. doi:10.1093/OED/6140796016 (https://doi.org/10.1093%2FOED%2F6140796016). (Subscription or participating institution membership (https://www.oed.com/public/login/loggingin#withyourlibrary) required.)
10. Hymowitz T, Newell C (July 1, 1981). "Taxonomy of the genus *Glycine*, domestication and uses of soybeans". *Economic Botany*. **35** (3): 272–88. Bibcode:1981EcBot..35..272H (https://ui.adsabs.harvard.edu/abs/1981EcBot..35..272H). doi:10.1007/BF02859119 (https://doi.org/10.1007%2FBF02859119). S2CID 21509807 (https://api.semanticscholar.org/CorpusID:21509807).

11. Purcell LC, Salmeron M, Ashlock L (2014). "Chapter 2" (https://web.archive.org/web/20160304011452/http://www.uaex.edu/publications/mp-197.aspx). *Arkansas Soybean Production Handbook – MP197* (http://www.uaex.edu/publications/mp-197.aspx). Little Rock: University of Arkansas Cooperative Extension Service. pp. 1–8. Archived from the original (http://www.uaex.edu/publications/pdf/mp197/chapter2.pdf) (PDF) on March 4, 2016. Retrieved February 21, 2016.
12. Purcell LC, Salmeron M, Ashlock L (2000). "Chapter 19: Soybean Facts" (https://web.archive.org/web/20160304011452/http://www.uaex.edu/publications/mp-197.aspx). *Arkansas Soybean Production Handbook – MP197* (http://www.uaex.edu/publications/mp-197.aspx). Little Rock, AR: University of Arkansas Cooperative Extension Service. p. 1. Archived from the original (http://www.uaex.edu/publications/pdf/mp197/chapter19.pdf) (PDF) on March 4, 2016. Retrieved September 5, 2016.
13. Bennett JM, Rhetoric E, Hicks DR, et al. (2014). *The Minnesota Soybean Field Book* (https://web.archive.org/web/20130930151502/http://www1.extension.umn.edu/agriculture/soybean/docs/minnesota-soybean-field-book.pdf) (PDF). St Paul, MN: University of Minnesota Extension. p. 33. Archived from the original (http://www.extension.umn.edu/agriculture/soybean/docs/minnesota-soybean-field-book.pdf) (PDF) on September 30, 2013. Retrieved September 16, 2016.
14. Shurtleff W, Aoyagi A (2015). *History of Soybeans and Soyfoods in Sweden, Norway, Denmark and Finland (1735–2015): Extensively Annotated Bibliography and Sourcebook* (https://books.google.com/books?id=0gtpCgAAQBAJ&pg=PA490). Lafayette: Soyinfo Center. p. 490. ISBN 978-1-928914-80-8.
15. Reisig D. "Soybean flowering, pollination, and bees" (https://web.archive.org/web/20210628160525/http://www.ncagr.gov/pollinators/documents/DominicReisig-NCPollinatorProtectionSoybeans.pdf) (PDF). *North Carolina Department of Agriculture & Consumer Services*. Archived from the original (http://www.ncagr.gov/pollinators/documents/DominicReisig-NCPollinatorProtectionSoybeans.pdf) (PDF) on June 28, 2021. Retrieved July 15, 2021.
16. Blackman S, Obendorf R, Leopold A (1992). "Maturation Proteins and Sugars in Desiccation Tolerance of Developing Soybean Seeds" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1075542). *Plant Physiology*. **100** (1): 225–30. doi:10.1104/pp.100.1.225 (https://doi.org/10.1104%2Fpp.100.1.225). PMC 1075542 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1075542). PMID 16652951 (https://pubmed.ncbi.nlm.nih.gov/16652951).
17. See *Nutrition* table
18. Corke, Walker and Wrigley (2004). *Encyclopedia of Grain Science*. Academic Press. ISBN 978-0-12-765490-4.
19. Singh RJ, Nelson RL, Chung G (November 2, 2006). *Genetic Resources, Chromosome Engineering, and Crop Improvement: Oilseed Crops, Volume 4* (https://books.google.com/books?id=lQ9bcjETlrIC&pg=PA15). London: Taylor & Francis. p. 15. ISBN 978-0-8493-3639-3.
20. "*Glycine max subsp. soja* (Siebold & Zucc.) H.Ohashi" (https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:920989-1). *Plants of the World Online*. Royal Botanic Gardens, Kew. Retrieved January 28, 2023.
21. Hymowitz T (August 9, 1995). "Evaluation of Wild Perennial *Glycine* Species and Crosses For Resistance to Phakopsora". In Sinclair J, Hartman G (eds.). *Proceedings of the Soybean Rust Workshop*. Urbana, IL, US: National Soybean Research Laboratory. pp. 33–37.
22. Newell C, Hymowitz T (March 1983). "Hybridization in the Genus *Glycine* Subgenus *Glycine* Willd. (Leguminosae, Papilionoideae)". *American Journal of Botany*. **70** (3): 334–48. doi:10.2307/2443241 (https://doi.org/10.2307%2F2443241). JSTOR 2443241 (https://www.jstor.org/stable/2443241).
23. Heuzé V., Tran G., Giger-Reverdin S., Lebas F., 2015. Perennial soybean (*Neonotonia wightii*). Feedipedia, a programme by INRA, CIRAD, Association Française de Zootechnie and FAO. https://www.feedipedia.org/node/293 Last updated on September 30, 2015, 15:09
24. "*Neonotonia wightii* in Global Plants on JSTOR" (https://plants.jstor.org/compilation/Neonotonia.wightii). *Global Plants on JSTOR*.
25. "Factsheet – *Neonotonia wightii*" (https://web.archive.org/web/20170601233037/http://tropicalforages.info/key/Forages/Media/Html/Neonotonia_wightii.htm). *tropicalforages.info*. Archived from the original (http://www.tropicalforages.info/key/Forages/Media/Html/Neonotonia_wightii.htm) on June 1, 2017. Retrieved January 19, 2014.
26. Shekhar, Hossain, Uddin, Howlader, Zakir Hossain, et al. (July 22, 2016). *Exploring the Nutrition and Health Benefits of Functional Foods* (https://books.google.com/books?id=H2m_DAAAQBAJ&q=the+relationship+of+the+modern+soybean+to+wild-growing+species+can+no+longer+be+traced+with+any+degree+of+certainty&pg=PA223). IGI Global. p. 223. ISBN 978-1-5225-0592-1. Retrieved November 22, 2017.
27. Ghulam Raza, Mohan B. Singh, Prem L. Bhalla (June 11, 2017). Atanassov A (ed.). "In Vitro Plant Regeneration from Commercial Cultivars of Soybean" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5485301). *BioMed Research International*. **2017** 7379693. doi:10.1155/2017/7379693 (https://doi.org/10.1155%2F2017%2F7379693). PMC 5485301 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5485301). PMID 28691031 (https://pubmed.ncbi.nlm.nih.gov/28691031).
28. Jim Deacon (April 5, 2023). "The Nitrogen cycle and Nitrogen fixation" (https://web.archive.org/web/20130116214211/http://www.biology.ed.ac.uk/archive/jdeacon/microbes/nitrogen.htm). Institute of Cell and Molecular Biology, The University of Edinburgh. Archived from the original (http://www.biology.ed.ac.uk/archive/jdeacon/microbes/nitrogen.htm) on January 16, 2013. Retrieved November 6, 2012.
29. "The Corn and Soybean Rotation Effect - Wisconsin Corn Agronomy" (https://web.archive.org/web/20200807071753/http://corn.agronomy.wisc.edu/AA/A014.aspx). *corn.agronomy.wisc.edu*. Archived from the original (http://corn.agronomy.wisc.edu/AA/A014.aspx) on August 7, 2020. Retrieved May 17, 2020.
30. "Corn and soybean rotation could pose long-term tradeoffs for soil health" (https://phys.org/news/2019-10-corn-soybean-rotation-pose-long-term.html). *phys.org*. Retrieved May 17, 2020.
31. "2006: Lobato, McClung, Paolinelli" (https://www.worldfoodprize.org/en/laureates/20002009_laureates/2006_lobato_mcclung_paolinelli/). *World Food Prize*.
32. Lang S (June 21, 2006). "Cornell Alumnus Andrew Colin McClung Reaps 2006 World Food Prize" (https://www.news.cornell.edu/stories/June06/World.Food.prize.ssl.html). *Chronicle Online*. Cornell University. Retrieved February 18, 2012.
33. Pearce F (April 14, 2011). "The Cerrado: Brazil's Other Biodiverse Region Loses Ground" (https://web.archive.org/web/20160913030125/http://e360.yale.edu/feature/the_cerrado_brazils_other_biodiversity_hotspot_loses_ground/2393/). Yale University. Archived from the original (http://e360.yale.edu/feature/the_cerrado_brazils_other_biodiversity_hotspot_loses_ground/2393/) on September 13, 2016. Retrieved February 18, 2012.
34. Alves BJ, Boddey RM, Urquiaga S (2003). "The success of BNF in soybean in Brazil". *Plant and Soil*. **252** (1): 1–9. Bibcode:2003PlSoi.252....1A (https://ui.adsabs.harvard.edu/abs/2003PlSoi.252....1A). doi:10.1023/A:1024191913296 (https://doi.org/10.1023%2FA%3A1024191913296). S2CID 10143668 (https://api.semanticscholar.org/CorpusID:10143668).
35. McBride M, Richards B, Steenhuis T, et al. (May–June 2000). "Molybdenum Uptake by Forage Crops Grown on Sewage Sludge-Amended Soils in the Field and Greenhouse" (https://soilandwater.bee.cornell.edu/publications/McBrideJEQ00.pdf) (PDF). *Journal of Environmental Quality*. **29** (3): 848–54. Bibcode:2000JEnvQ..29..848M (https://ui.adsabs.harvard.edu/abs/2000JEnvQ..29..848M). doi:10.2134/jeq2000.00472425002900030021x (https://doi.org/10.2134%2Fjeq2000.00472425002900030021x).
36. Heckman J, Angle J, Chaney R (December 9, 1985). "Residual Effects of Sewage Sludge on Soybean: II. Accumulation of Soil and Symbiotically Fixed Nitrogen". *Journal of Environmental Quality*. **16** (2): 118–24. doi:10.2134/jeq1987.00472425001600020005x (https://doi.org/10.2134%2Fjeq1987.00472425001600020005x).

37. "Soybean plant - How to grow, care, pest control and uses of soybeans" (https://gardenandme.com/soybean/). *Garden And Me*. June 5, 2020.
38. "Japanese beetle - Popillia japonica" (https://entnemdept.ufl.edu/creatures/orn/beetles/japanese_beetle.htm). *entnemdept.ufl.edu*. Retrieved April 25, 2024.
39. "EENY350/IN630: Japanese Beetle, Popillia japonica Newman (Insecta: Coleoptera: Scarabaeidae)" (https://edis.ifas.ufl.edu/publication/IN630). *Ask IFAS - Powered by EDIS*. Retrieved April 25, 2024.
40. "Soybean Cyst Nematode: Diagnosis and Management" (https://extension.missouri.edu/publications/g4450). *extension.missouri.edu*. August 2010.
41. Herbert, Ames, Cathy Hull, and Eric Day. "Corn Earworm Biology and Management in Soybeans." Virginia Cooperative Extension, Virginia State University (2009).
42. "Controlling white-tailed deer in soybeans" (https://www.morningagclips.com/controlling-white-tailed-deer-in-soybeans). Morning AgClips – Michigan. January 16, 2018. Retrieved May 9, 2019.
43. Brant, Jesse D (September 9, 2016). "Soybean Farmers Warranted in Waging War on Groundhogs" (https://www.lancasterfarming.com/news/columnists/soybean-farmers-warranted-in-waging-war-on-groundhogs/article_f6e6a210-2995-521f-8655-aa19efe373c3.html). Lancaster Farming. Retrieved May 9, 2019.
44. "U.S. National Fungus Collections Database results" (https://nt.ars-grin.gov/fungaldatabases/new_allViewGenBank.cfm?thisName=Pythium%20spinosum&organismtype=Fungus). *Fungal Databases, U.S. National Fungus Collections*. December 8, 2020. Retrieved December 8, 2020.
45. Harrison B, Steinlage TA, Domier LL, et al. (January 2005). "Incidence of Soybean dwarf virus and Identification of Potential Vectors in Illinois" (https://doi.org/10.1094%2FPD-89-0028). *Plant Disease*. **89** (1): 28–32. Bibcode:2005PlDis..89...28H (https://ui.adsabs.harvard.edu/abs/2005PlDis..89...28H). doi:10.1094/PD-89-0028 (https://doi.org/10.1094%2FPD-89-0028). ISSN 0191-2917 (https://search.worldcat.org/issn/0191-2917). PMID 30795280 (https://pubmed.ncbi.nlm.nih.gov/30795280).
46. Boufleur TR, Ciampi-Guillardi M, Tikami Í, et al. (2021). "Soybean anthracnose caused by *Colletotrichum* species: Current status and future prospects" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7938629). *Molecular Plant Pathology*. **22** (4): 393–409. Bibcode:2021MolPP..22..393B (https://ui.adsabs.harvard.edu/abs/2021MolPP..22..393B). doi:10.1111/mpp.13036 (https://doi.org/10.1111%2Fmpp.13036). PMC 7938629 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7938629). PMID 33609073 (https://pubmed.ncbi.nlm.nih.gov/33609073). S2CID 231969160 (https://api.semanticscholar.org/CorpusID:231969160).
47. Nataraj V, Maranna S, Kumawat G, et al. (2020). "Genetic inheritance and identification of germplasm sources for anthracnose resistance in soybean [*Glycine max* (L.) Merr.]". *Genetic Resources and Crop Evolution*. **67** (6): 1449–1456. Bibcode:2020GRCEv..67.1449N (https://ui.adsabs.harvard.edu/abs/2020GRCEv..67.1449N). doi:10.1007/s10722-020-00917-4 (https://doi.org/10.1007%2Fs10722-020-00917-4). S2CID 211730576 (https://api.semanticscholar.org/CorpusID:211730576).
48. Concibido VC, Lange DA, Denny RL, et al. (1997). "Genome Mapping of Soybean Cyst Nematode Resistance Genes in 'Peking', PI 90763, and PI 88788 Using DNA Markers". *Crop Science*. **37** (1): 258–264. doi:10.2135/cropsci1997.0011183x003700010046x (https://doi.org/10.2135%2Fcropsci1997.0011183x003700010046x).
49. "Soybean varieties with SCN resistance other than PI 88788" (http://crops.extension.iastate.edu/cropnews/2020/12/soybean-varieties-scn-resistance-other-pi-88788). *Integrated Crop Management*. Iowa State University Extension. Retrieved March 12, 2021.
50. "SCN-resistant Soybean Varieties for Iowa - By the Numbers" (http://crops.extension.iastate.edu/cropnews/2020/11/scn-resistant-soybean-varieties-iowa-numbers). *Integrated Crop Management*. Iowa State University Extension. Retrieved March 12, 2021.
51. "Soybean production in 2019, Crops/World regions/Production quantity (from pick lists)" (http://www.fao.org/faostat/en/#data/QC/). United Nations, Food and Agriculture Organization, Statistics Division, FAOSTAT. 2019. Retrieved February 8, 2021.
52. Cattelan AJ, Dall'Agnol A (January 1, 2018). "The rapid soybean growth in Brazil" (https://www.ocl-journal.org/articles/ocl/abs/2018/01/ocl170039/ocl170039.html). *OCL*. **25** (1): D102. doi:10.1051/ocl/2017058 (https://doi.org/10.1051%2Focl%2F2017058).
53. "OEC - Soybeans (HS92: 1201) Product Trade, Exporters and Importers" (https://web.archive.org/web/20200404122328/https://oec.world/en/profile/hs92/1201/). *oec.world*. Archived from the original (https://oec.world/en/profile/hs92/1201/) on April 4, 2020. Retrieved May 17, 2020.
54. "U.S. Grown Soy | Soy Nutrition Institute" (https://sniglobal.org/us-grown-soy/). *SNI Global*. Retrieved June 11, 2025.
55. Ritchie H (February 9, 2021). "Drivers of Deforestation" (https://ourworldindata.org/drivers-of-deforestation). *Our World in Data*. Retrieved March 20, 2021.
56. Liotta E (August 23, 2019). "Feeling Sad About the Amazon Fires? Stop Eating Meat" (https://www.vice.com/en/article/feeling-sad-about-the-amazon-fires-stop-eating-meat/). *Vice*. Retrieved August 25, 2019. "Soy is the most important protein in animal feed, with 80 percent of the world's soybean crop fed to livestock."
57. Shurtleff, William; Aoyagi, Akiko. 2013. History of Whole Dry Soybeans, Used as Beans, or Ground, Mashed or Flaked (240 BCE to 2013). Lafayette, California. 950 pp.
58. "Soybean" (https://www.britannica.com/plant/soybean). *Encyclopædia Britannica*. June 19, 2025. Retrieved July 5, 2025.
59. Lee GA, Crawford GW, Liu L, et al. (November 4, 2011). "Archaeological Soybean (*Glycine max*) in East Asia: Does Size Matter?" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3208558). *PLOS ONE*. **6** (11) e26720. Bibcode:2011PLoSO...626720L (https://ui.adsabs.harvard.edu/abs/2011PLoSO...626720L). doi:10.1371/journal.pone.0026720 (https://doi.org/10.1371%2Fjournal.pone.0026720). PMC 3208558 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3208558). PMID 22073186 (https://pubmed.ncbi.nlm.nih.gov/22073186).
60. Lee GA, Crawford GW, Liu L, et al. (November 4, 2011). "Archaeological Soybean (*Glycine max*) in East Asia: Does Size Matter?" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3208558). *PLOS ONE*. **6** (11) e26720. Bibcode:2011PLoSO...626720L (https://ui.adsabs.harvard.edu/abs/2011PLoSO...626720L). doi:10.1371/journal.pone.0026720 (https://doi.org/10.1371%2Fjournal.pone.0026720). PMC 3208558 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3208558). PMID 22073186 (https://pubmed.ncbi.nlm.nih.gov/22073186).
61. Stark MT (April 15, 2008). *Archaeology of Asia* (https://books.google.com/books?id=z4_bT2SJ-HUC&pg=PA81). John Wiley & Sons. p. 81. ISBN 978-1-4051-5303-4. Retrieved April 18, 2017.
62. Zhao Z. 2004. "Floatation: a paleobotanic method in field archaeology". Archaeology 3: 80–87.
63. "History of Soybeans" (http://www.soya.be/history-of-soybeans.php). Soya – Information about Soy and Soya Products. Retrieved February 18, 2012.
64. The History of Agriculture By Britannica Educational Publishing, p. 48
65. Stark MT (2005). *Archaeology of Asia (Blackwell Studies in Global Archaeology)* (https://books.google.com/books?id=PoDFdOstSNwC&pg=PA81). Hoboken, NJ: Wiley-Blackwell. p. 81. ISBN 978-1-4051-0213-1. Retrieved February 18, 2012.
66. Shurtleff, William; Aoyagi, Akiko. 2012. *History of Soybeans and Soyfoods in Japan*. Lafayette, California.
67. "kedelai translate Indonesian to English: Cambridge Dictionary" (https://dictionary.cambridge.org/dictionary/indonesian-english/kedelai). *dictionary.cambridge.org*. Retrieved January 21, 2018.

68. Hendri F. Isnaeni (July 9, 2014). "Sejarah Tempe" (https://web.archive.org/web/20180327002807/http://historia.id/kuliner/sejarah-tempe) (in Indonesian). Historia. Archived from the original (http://historia.id/kuliner/sejarah-tempe) on March 27, 2018. Retrieved January 21, 2018.
69. Shurtleff W, Aoyagi A (2010). *History of Soybeans and Soyfoods in Southeast Asia (1770–2010)* (http://www.soyinfocenter.com/books/139). Soy Info Center. ISBN 978-1-928914-30-3. Retrieved February 18, 2012.
70. *The Book of Tempeh*, 2nd ed., by W. Shurtleff and A. Aoyagi (2001, Ten Speed Press, p. 145)
71. Shurtleff W, Aoyagi A (2010). *History of Soybeans and Soyfoods in South Asia / Indian Subcontinent (1656–2010)* (http://www.soyinfocenter.com/books/140). Soy Info Center. ISBN 978-1-928914-31-0. Retrieved February 18, 2012.
72. Tamang JP (September 2024). "Unveiling kinema: blending tradition and science in the Himalayan fermented soya delicacy" (https://doi.org/10.1186%2Fs42779-024-00247-1). *Journal of Ethnic Foods*. **11** (1) 29. doi:10.1186/s42779-024-00247-1 (https://doi.org/10.1186%2Fs42779-024-00247-1). ISSN 2352-619X (https://search.worldcat.org/issn/2352-619X).
73. Shurtleff, W.; Aoyagi, A. 2015. "History of Soybeans and Soyfoods in Spain and Portugal (1603–2015)." Lafayette, California: Soyinfo Center. (624 references; 23 photos and illustrations. Free online.)
74. Chaplin J (1996). *An Anxious Pursuit: Agricultural Innovation and Modernity in the Lower South, 1730–1815* (https://books.google.com/books?id=_I0_gkKKMM8C&pg=PA147). University of North Carolina Press. p. 147. ISBN 978-0-8078-4613-1.
75. Hymowitz T (October 1, 1970). "On the domestication of the soybean" (http://elartu.tntu.edu.ua/handle/lib/43629). *Economic Botany*. **24** (4): 408–21. Bibcode:1970EcBot..24..408H (https://ui.adsabs.harvard.edu/abs/1970EcBot..24..408H). doi:10.1007/BF02860745 (https://doi.org/10.1007%2FBF02860745). S2CID 26735964 (https://api.semanticscholar.org/CorpusID:26735964).
76. Roger Boerma. "Another First for Georgia Agriculture" (https://web.archive.org/web/20150923195804/http://www.caes.uga.edu/extension/irwin/anr/Vol29.1.pdf.pdf) (PDF). *caes.uga.edu*. Georgia Soybean News. p. 5. Archived from the original (http://www.caes.uga.edu/extension/irwin/anr/Vol29.1.pdf.pdf) (PDF) on September 23, 2015.
77. "Soybeans planted first in Georgia" (https://news.google.com/newspapers?nid=360&dat=19940831&id=9eMyAAAAIBAJ&pg=6901,2669493&hl=en). *Google News Archive*. The Rockmart Journal. August 21, 1994.
78. *Eat Your Food! Gastronomical Glory from Garden to Gut: A Coastalfields Cookbook, Nutrition Textbook, Farming Manual and Sports Manual* (https://books.google.com/books?id=BtZ2oNGyv6AC&pg=PR2). Coastalfields Press. April 2007. ISBN 978-0-9785944-8-0. Retrieved May 4, 2013.
79. "About Soy - Soybeans: The Success Story - p.4" (https://web.archive.org/web/20031122134643/http://www.nsrl.uiuc.edu/aboutsoy/history4.html). *National Soybean Research Laboratory - University of Illinois Urbana-Champaign*. November 22, 2003. Archived from the original (http://www.nsrl.uiuc.edu/aboutsoy/history4.html) on November 22, 2003.
80. Shurtleff W, Aoyagi A (2010). *History of Soybeans and Soyfoods in Canada (1831–2010)* (http://www.soyinfocenter.com/books/137). Soy Info Center. ISBN 978-1-928914-28-0. Retrieved February 18, 2012.
81. Hymowitz T (February 20, 2018). "The Kunitz Soybean Variety" (https://web.archive.org/web/20180220194714/http://www.aces.uiuc.edu/vista/html_pubs/irspsm91/kunitz.html). *uiuc.edu*. Archived from the original (http://www.aces.uiuc.edu/vista/html_pubs/irspsm91/kunitz.html) on February 20, 2018. Retrieved June 8, 2015.
82. "Scientists create new low-allergen soybean" (https://web.archive.org/web/20150605195117/http://cropsci.illinois.edu/news/scientists-create-new-low-allergen-soybean). *illinois.edu*. Archived from the original (http://cropsci.illinois.edu/news/scientists-create-new-low-allergen-soybean) on June 5, 2015.
83. Shurtleff W, Aoyagi A (2004). "William J. Morse and Charles V. Piper" (http://www.soyinfocenter.com/HSS/morse_and_piper.php). *soyinfocenter.com*.
84. "William J. Morse – History of His Work with Soybeans and Soyfoods (1884–1959) – SoyInfo Center" (http://www.soyinfocenter.com/books/147). soyinfocenter.com.
85. Piper CV, Morse WJ (1923). *The Soybean* (https://books.google.com/books?id=6hRCAAAAYAAJ). Agricultural and Biological Publications. New York: McGraw-Hill Book Company. OCLC 252589754 (https://search.worldcat.org/oclc/252589754) – via Google Books.
86. "How Soybeans Became Ubiquitous" (https://www.bloomberg.com/opinion/articles/2019-12-07/history-of-soybeans-in-u-s-could-take-turn-in-trump-s-trade-war?srnd=premium). *Bloomberg.com*. Bloomberg News. December 7, 2019. Retrieved December 7, 2019.
87. Joe Schwarcz (2004). *The Fly in the Ointment: 63 Fascinating Commentaries on the Science of Everyday Life* (https://books.google.com/books?id=rmIbClRzfeoC&pg=PA193). ECW Press. p. 193. ISBN 978-1-55022-621-8. Retrieved May 4, 2013.
88. Roth M (2018). *Magic Bean: The Rise of Soy in America*. Lawrence, KS: University Press of Kansas. p. 109. ISBN 978-0-7006-2633-5. OCLC 1012618664 (https://search.worldcat.org/oclc/1012618664).
89. Roth M (2018). *Magic Bean: The Rise of Soy in America*. Lawrence, KS: University Press of Kansas. p. 201. ISBN 978-0-7006-2633-5. OCLC 1012618664 (https://search.worldcat.org/oclc/1012618664).
90. Roth M (2018). *Magic Bean: The Rise of Soy in America*. Lawrence, KS: University Press of Kansas. p. 8. ISBN 978-0-7006-2633-5. OCLC 1012618664 (https://search.worldcat.org/oclc/1012618664).
91. "2021 Soybean Planted Area (000) Acres and Percent Change from Previous Year" (https://www.nass.usda.gov/Charts_and_Maps/graphics/soyacm.pdf) (PDF). *USDA-National Agricultural Statistics Service*. USDA. January 12, 2022. Retrieved February 4, 2022.
92. Shurtleff W, Aoyagi A. *History of Soybeans and Soyfoods in the Caribbean / West Indies (1767–2008)* (http://www.soyinfocenter.com/books/126). Soy Info Center. Retrieved February 18, 2012.
93. Shurtleff, W.; Aoyagi, A. (2015). *History of Soybeans and Soyfoods in Italy (1597–2015)*. Lafayette, California: Soyinfo Center. 618 pp. (1,381 references; 93 photos and illustrations. Free online.)
94. Shurtleff W, Aoyagi A (2008). *History of Soybeans and Soyfoods in the Middle East: Extensively Annotated Bibliography and Sourcebook* (https://books.google.com/books?id=urb6IPmxwU8C&q=soybean+turkey&pg=PA7). Soyinfo Center. ISBN 978-1-928914-15-0.
95. Matagrin. 1939. "Le Soja et les Industries du Soja," p. 47–48
96. Shurtleff, W.; Aoyagi, A. 2015. "History of Soybeans and Soyfoods in Greece, the European Union and Small Western European Countries (1939–2015)." Lafayette, California: Soyinfo Center. 243 pp. (462 references; 20 photos and illustrations. Free online. ISBN 978-1-928914-81-5).
97. Shurtleff W, Aoyagi A (2010). *History of Soybeans and Soyfoods in Australia, New Zealand and Oceania (1770–2010)* (http://www.soyinfocenter.com/books/138). Soy Info Center. ISBN 978-1-928914-29-7. Retrieved February 18, 2012.
98. Shurtleff, W.; Aoyagi, A.; 2015. "History of Soybeans and Soyfood in France (1665–2015)". Lafayette, California; Soyinfo Center. 1,202 pp. (3,405 references; 145 photos and illustrations. Free online).
99. Shurtleff W, Aoyagi A (2009). *History of Soybeans and Soyfoods in Africa (1857–2009)* (http://www.soyinfocenter.com/books/134). Soy Info Center. ISBN 978-1-928914-25-9. Retrieved February 18, 2012.
100. Shurtleff, W.; Aoyagi, A. 2015. "History of Soybeans and Soyfoods in Austria and Switzerland (1781–2015)." Lafayette, California: Soyinfo Center. 705 pp. (1444 references; 128 photos and illustrations). Free online. ISBN 978-1-928914-77-8.
101. Ross K (November 16, 2011). "Soy Substitute Edges Its Way Into European Meals" (https://www.nytimes.com/2011/11/17/business/energy-environment/soy-substitute-edges-its-way-into-european-meals.html?pagewanted=all&_r=0). *New York Times*. Retrieved February 28, 2015.

102. Shurtleff W, Aoyagi A. *History of Soybeans and Soyfoods in Central Asia (1876–2008)* (http://www.soyinfocenter.com/books/123). Soy Info Center. Retrieved February 18, 2012.
103. Shurtleff W, Aoyagi A. "History of Soybeans and Soyfoods in Mexico and Central America (1877–2009)" (http://www.soyinfocenter.com/books/128). Soy Info Center. Retrieved February 18, 2012.
104. Shurtleff W, Aoyagi A (2009). *History of Soybeans and Soyfoods in South America (1882–2009)* (http://www.soyinfocenter.com/books/132). Soy Info Center. ISBN 978-1-928914-23-5. Retrieved February 18, 2012.
105. "Cornell alumnus Andrew Colin McClung reaps 2006 World Food Prize" (https://www.news.cornell.edu/stories/2006/06/cornellian-reaps-2006-world-food-prize). news.cornell.edu – Cornell Chronicle.
106. "Policy Pennings, by Daryll E. Ray, Agricultural Policy Analysis Center" (https://www.agpolicy.org/weekcol/217.html). *www.agpolicy.org*. Retrieved December 7, 2019.
107. Brasil deve colher 131 milhões de toneladas de soja na safra 2020/21, aponta USDA (https://revistagloborural.globo.com/Noticias/Agricultura/noticia/2020/06/brasil-deve-colher-131-milhoes-de-toneladas-de-soja-na-safra-202021-aponta-usda.html)
108. Ofstehage AL (May 10, 2018). "Financialization of work, value, and social organization among transnational soy farmers in the Brazilian Cerrado". *Economic Anthropology*. **5** (2): 274–285. doi:10.1002/sea2.12123 (https://doi.org/10.1002%2Fsea2.12123). ISSN 2330-4847 (https://search.worldcat.org/issn/2330-4847).
109. Hinze LL, Hulse-Kemp AM, Wilson IW, et al. (February 3, 2017). "Diversity analysis of cotton (*Gossypium hirsutum* L.) germplasm using the CottonSNP63K Array" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5291959). *BMC Plant Biology*. **17** (1): 37. Bibcode:2017BMCPB..17...37H (https://ui.adsabs.harvard.edu/abs/2017BMCPB..17...37H). doi:10.1186/s12870-017-0981-y (https://doi.org/10.1186%2Fs12870-017-0981-y). PMC 5291959 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5291959). PMID 28158969 (https://pubmed.ncbi.nlm.nih.gov/28158969). S2CID 3969205 (https://api.semanticscholar.org/CorpusID:3969205).
110. Rasheed A, Hao Y, Xia X, et al. (2017). "Crop Breeding Chips and Genotyping Platforms: Progress, Challenges, and Perspectives" (https://doi.org/10.1016%2Fj.molp.2017.06.008). *Molecular Plant*. **10** (8): 1047–1064. Bibcode:2017MPlan..10.1047R (https://ui.adsabs.harvard.edu/abs/2017MPlan..10.1047R). doi:10.1016/j.molp.2017.06.008 (https://doi.org/10.1016%2Fj.molp.2017.06.008). PMID 28669791 (https://pubmed.ncbi.nlm.nih.gov/28669791). S2CID 33780984 (https://api.semanticscholar.org/CorpusID:33780984).
111. Hulse-Kemp AM, Lemm J, Plieske J, et al. (June 1, 2015). "Development of a 63K SNP Array for Cotton and High-Density Mapping of Intraspecific and Interspecific Populations of *Gossypium* spp" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4478548). *G3: Genes, Genomes, Genetics*. **5** (6): 1187–1209. doi:10.1534/g3.115.018416 (https://doi.org/10.1534%2Fg3.115.018416). PMC 4478548 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4478548). PMID 25908569 (https://pubmed.ncbi.nlm.nih.gov/25908569). S2CID 11590488 (https://api.semanticscholar.org/CorpusID:11590488).
112. Marchal C, Michalopoulou VA, Zou Z, et al. (2022). "Show me your ID: NLR immune receptors with integrated domains in plants" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9528084). *Essays in Biochemistry*. **66** (5): 527–539. doi:10.1042/ebc20210084 (https://doi.org/10.1042%2Febc20210084). PMC 9528084 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9528084). PMID 35635051 (https://pubmed.ncbi.nlm.nih.gov/35635051).
113. Rasheed A, Hao Y, Xia X, et al. (2017). "Crop Breeding Chips and Genotyping Platforms: Progress, Challenges, and Perspectives" (https://doi.org/10.1016%2Fj.molp.2017.06.008). *Molecular Plant*. **10** (8): 1047–1064. Bibcode:2017MPlan..10.1047R (https://ui.adsabs.harvard.edu/abs/2017MPlan..10.1047R). doi:10.1016/j.molp.2017.06.008 (https://doi.org/10.1016%2Fj.molp.2017.06.008). PMID 28669791 (https://pubmed.ncbi.nlm.nih.gov/28669791). S2CID 33780984 (https://api.semanticscholar.org/CorpusID:33780984).
114. Song Q, Hyten D, Jia G, et al. (2013). "Development and Evaluation of SoySNP50K, a High-Density Genotyping Array for Soybean" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3555945). *PLoS ONE*. **8** (1) e54985. Bibcode:2013PLoSO...854985S (https://ui.adsabs.harvard.edu/abs/2013PLoSO...854985S). doi:10.1371/journal.pone.0054985 (https://doi.org/10.1371%2Fjournal.pone.0054985). PMC 3555945 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3555945). PMID 23372807 (https://pubmed.ncbi.nlm.nih.gov/23372807). S2CID 1850673 (https://api.semanticscholar.org/CorpusID:1850673).
115. Padgette S, Kolacz K, Delannay X, et al. (1995). "Development, Identification, and Characterization of a Glyphosate-Tolerant Soybean Line". *Crop Science*. **35** (5): 1451–61. doi:10.2135/cropsci1995.0011183X003500050032x (https://doi.org/10.2135%2Fcropsci1995.0011183X003500050032x).
116. National Agricultural Statistics Board annual report, June 30, 2010. Retrieved July 23, 2010.
117. Liu K (1997). *Soybeans: Chemistry, Technology, and Utilization* (https://archive.org/details/soybeanschemistr00liuk). Berlin: Springer. p. 532 (https://archive.org/details/soybeanschemistr00liuk/page/n555). ISBN 978-0-8342-1299-2.
118. Sneller CH (2003). "Impact of Transgenic Genotypes and Subdivision on Diversity Within Elite North American Soybean Germplasm". *Crop Science*. **43**: 409–14. doi:10.2135/cropsci2003.0409 (https://doi.org/10.2135%2Fcropsci2003.0409).
119. "EU Caught in Quandary Over GMO Animal Feed Imports". *The Guardian*. December 7, 2007.
120. Fernandez-Cornejo J, Caswell, Margriet (April 1, 2006). "The First Decade of Genetically Engineered Crops in the United States" (https://web.archive.org/web/20100614154639/http://www.ers.usda.gov/publications/eib11/eib11.pdf) (PDF). United States Department of Agriculture. Archived from the original (https://www.ers.usda.gov/publications/eib11/eib11.pdf) (PDF) on June 14, 2010. Retrieved February 18, 2012.
121. Pollack A (December 18, 2009). "As Patent Ends, a Seed's Use Will Survive" (https://www.nytimes.com/2009/12/18/business/18seed.html). *The New York Times*.
122. "Cooperative Extension ‹ Log In" (https://archive.today/20150408022806/http://extension.udel.edu/kentagextension/2008/11/18/soybean-seed-decisions-2009/). Archived from the original (http://extension.udel.edu/kentagextension/2008/11/18/soybean-seed-decisions-2009/) on April 8, 2015.
123. Cantani A, Lucenti P. (August 1997). "Natural History of Soy Allergy and/or Intolerance in Children, and Clinical Use of Soy-protein Formulas". *Pediatric Journal of Allergy and Clinical Immunology*. **8** (2): 59–74. doi:10.1111/j.1399-3038.1997.tb00146.x (https://doi.org/10.1111%2Fj.1399-3038.1997.tb00146.x). PMID 9617775 (https://pubmed.ncbi.nlm.nih.gov/9617775). S2CID 35264190 (https://api.semanticscholar.org/CorpusID:35264190).
124. Cordle C (May 2004). "Soy Protein Allergy: Incidence and Relative Severity" (https://doi.org/10.1093%2Fjn%2F134.5.1213S). *Journal of Nutrition*. **134** (5): 1213S – 19S. doi:10.1093/jn/134.5.1213S (https://doi.org/10.1093%2Fjn%2F134.5.1213S). PMID 15113974 (https://pubmed.ncbi.nlm.nih.gov/15113974).
125. Sampson H (May 1999). "Food Allergy, Part 1: Immunopathogenesis and Clinical Disorders" (http://www.jacionline.org/article/S0091674999704112/pdf). *The Journal of Allergy and Clinical Immunology*. **103** (5): 717–728. doi:10.1016/S0091-6749(99)70411-2 (https://doi.org/10.1016%2FS0091-6749%2899%2970411-2). PMID 10329801 (https://pubmed.ncbi.nlm.nih.gov/10329801).
126. "Regulation (EG) 1169/2011" (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32011R1169). Eur-Lex - European Union Law, European Union. October 25, 2011. Retrieved October 7, 2020.
127. Messina M, Redmond G (2006). "Effects of soy protein and soybean isoflavones on thyroid function in healthy adults and hypothyroid patients: A review of the relevant literature". *Thyroid*. **16** (3): 249–58. doi:10.1089/thy.2006.16.249 (https://doi.org/10.1089%2Fthy.2006.16.249). PMID 16571087 (https://pubmed.ncbi.nlm.nih.gov/16571087).

28. "Risk assessment for peri- and postmenopausal women taking food supplements containing isolated isoflavones" (https://www.efsa.europa.eu/en/efsajournal/pub/4246). *EFSA Journal*. **13** (10): 4246. 2015. doi:10.2903/j.efsa.2015.4246 (https://doi.org/10.2903%2Fj.efsa.2015.4246).
29. "Top U.S. Agricultural Exports in 2017" (https://web.archive.org/web/20190501071813/https://www.fas.usda.gov/data/top-us-agricultural-exports-2017). *US Foreign Agricultural Service*. March 23, 2018. Archived from the original (https://www.fas.usda.gov/data/top-us-agricultural-exports-2017) on May 1, 2019. Retrieved May 1, 2019.
30. "Soy Facts" (https://web.archive.org/web/20170112075924/http://www.soyatech.com/soy_facts.htm). Soyatech. Archived from the original (http://www.soyatech.com/soy_facts.htm) on January 12, 2017. Retrieved January 24, 2017.
31. United States Food and Drug Administration (2024). "Daily Value on the Nutrition and Supplement Facts Labels" (https://www.fda.gov/food/nutrition-facts-label/daily-value-nutrition-and-supplement-facts-labels). *FDA*. Archived (https://web.archive.org/web/20240327175201/https://www.fda.gov/food/nutrition-facts-label/daily-value-nutrition-and-supplement-facts-labels) from the original on March 27, 2024. Retrieved March 28, 2024.
32. "TABLE 4-7 Comparison of Potassium Adequate Intakes Established in This Report to Potassium Adequate Intakes Established in the 2005 DRI Report" (https://www.ncbi.nlm.nih.gov/books/NBK545428/table/tab_4_7/). p. 120. In: Stallings VA, Harrison M, Oria M, eds. (2019). "Potassium: Dietary Reference Intakes for Adequacy". *Dietary Reference Intakes for Sodium and Potassium*. pp. 101–124. doi:10.17226/25353 (https://doi.org/10.17226%2F25353). ISBN 978-0-309-48834-1. PMID 30844154 (https://pubmed.ncbi.nlm.nih.gov/30844154). NCBI NBK545428 (https://www.ncbi.nlm.nih.gov/books/NBK545428).
33. Adeyemo S, Onilude A (2013). "Enzymatic Reduction of Anti-nutritional Factors in Fermenting Soybeans by Lactobacillus plantarum Isolates from Fermenting Cereals" (https://doi.org/10.1016%2FS0189-7241%2815%2930080-1). *Nigerian Food Journal*. **31** (2). Elsevier: 84–90. doi:10.1016/S0189-7241(15)30080-1 (https://doi.org/10.1016%2FS0189-7241%2815%2930080-1).
34. Circle & Smith 1972, pp. 104, 163.
35. Derbyshire E, Wright D, Boulter D (1976). "Legumin and Vicilin, Storage Proteins of Legume Seeds". *Phytochemistry*. **15** (1): 3–24. Bibcode:1976PChem..15....3D (https://ui.adsabs.harvard.edu/abs/1976PChem..15....3D). doi:10.1016/S0031-9422(00)89046-9 (https://doi.org/10.1016%2FS0031-9422%2800%2989046-9).
36. Danielsson C (1949). "Seed Globulins of the Gramineae and Leguminosae" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1274878). *The Biochemical Journal*. **44** (4): 387–400. doi:10.1042/bj0440387 (https://doi.org/10.1042%2Fbj0440387). PMC 1274878 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1274878). PMID 16748534 (https://pubmed.ncbi.nlm.nih.gov/16748534).
37. "Food Labeling: Health Claims; Soy Protein and Coronary Heart Disease; Docket No. 98P–0683" (https://www.gpo.gov/fdsys/pkg/FR-1999-10-26/pdf/99-27693.pdf) (PDF). Washington, DC: US Food and Drug Administration; Federal Register, Vol. 64, No. 206. October 26, 1999.
38. Gilani GS, Cockell KA, Sepehr E (2005). "Effects of antinutritional factors on protein digestibility and amino acid availability in foods" (https://www.researchgate.net/publication/7742226). *Journal of AOAC International*. **88** (3): 967–987. doi:10.1093/jaoac/88.3.967 (https://doi.org/10.1093%2Fjaoac%2F88.3.967). PMID 16001874 (https://pubmed.ncbi.nlm.nih.gov/16001874).
39. *Protein Quality Evaluation: Report of the Joint FAO/WHO Expert Consultation*. Bethesda, MD: Food and Agriculture Organization of the United Nations (Food and Nutrition Paper No. 51). 1989. ISBN 978-92-5-103097-4.
40. Seed Proteins; Peter R. Shewery and Rod Casey (Eds) 1999. Kluwer Academic Publishers, Dordrecht, The Netherlands
141. "Subunit structure of the vicilin-like globular storage..." (https://web.archive.org/web/20150707233616/http://openagricola.nal.usda.gov/Record/IND44131228) *usda.gov*. Archived from the original (https://openagricola.nal.usda.gov/Record/IND44131228) on July 7, 2015.
142. "Cocoa-specific aroma precursors are generated by proteolytic..." (https://web.archive.org/web/20150707234934/http://openagricola.nal.usda.gov/Record/IND20412524) *usda.gov*. Archived from the original (https://openagricola.nal.usda.gov/Record/IND20412524) on July 7, 2015.
143. Barringer S (February 3, 2010). "The Chemistry of Chocolate Flavor" (https://web.archive.org/web/20120324131437/http://library.osu.edu/assets/Uploads/ScienceCafe/Barringer020310.pdf) (PDF). *Ohio State University*. Archived from the original (http://library.osu.edu/assets/Uploads/ScienceCafe/Barringer020310.pdf) (PDF) on March 24, 2012. Retrieved August 24, 2013. "Two proteases: aspartic endopeptidase and serine carboxy-(exo)peptidase on vicilin (7S)-class globulin storage proteins."
144. Koshino LL, Gomes CP, Silva LP, et al. (November 26, 2008). "Comparative Proteomical Analysis of Zygotic Embryo and Endosperm from *Coffea arabica* Seeds" (http://www.alice.cnptia.embrapa.br/alice/handle/doc/190361). *J. Agric. Food Chem.* **56** (22): 10922–26. Bibcode:2008JAFC...5610922K (https://ui.adsabs.harvard.edu/abs/2008JAFC...5610922K). doi:10.1021/jf801734m (https://doi.org/10.1021%2Fjf801734m). PMID 18959416 (https://pubmed.ncbi.nlm.nih.gov/18959416).
145. Koshino LL, Gomes CP, Silva LP, et al. (November 26, 2008). "Comparative Proteomical Analysis of Zygotic Embryo and Endosperm from Coffea arabica Seeds" (https://web.archive.org/web/20131203144038/http://www.alice.cnptia.embrapa.br/bitstream/doc/880533/1/Comparativeproteomical.pdf) (PDF). *Journal of Agricultural and Food Chemistry*. **56** (22): 10922–10926. Bibcode:2008JAFC...5610922K (https://ui.adsabs.harvard.edu/abs/2008JAFC...5610922K). doi:10.1021/jf801734m (https://doi.org/10.1021%2Fjf801734m). PMID 18959416 (https://pubmed.ncbi.nlm.nih.gov/18959416). Archived from the original (http://www.alice.cnptia.embrapa.br/bitstream/doc/880533/1/Comparativeproteomical.pdf) (PDF) on December 3, 2013. Retrieved August 24, 2013.
146. Shutov A (2011). "Evolution of seed storage globulins and cupin superfamily". *Molecular Biology*. **45** (4): 529–35. doi:10.1134/S0026893311030162 (https://doi.org/10.1134%2FS0026893311030162). PMID 21954589 (https://pubmed.ncbi.nlm.nih.gov/21954589). S2CID 26111362 (https://api.semanticscholar.org/CorpusID:26111362).
147. Youle RJ, Huang A (1981). "Occurrence of low molecular weight and high cysteine containing albumin storage proteins in oilseed of diverse species". *American Journal of Botany*. **68** (1): 44–48. doi:10.2307/2442990 (https://doi.org/10.2307%2F2442990). JSTOR 2442990 (https://www.jstor.org/stable/2442990).
148. Moreno FJ, Clemente A (2008). "2S Albumin Storage Proteins: What Makes them Food Allergens?" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2570561). *Open Biochemistry Journal*. **2**: 16–28. doi:10.2174/1874091X00802010016 (https://doi.org/10.2174%2F1874091X00802010016). PMC 2570561 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2570561). PMID 18949071 (https://pubmed.ncbi.nlm.nih.gov/18949071).
149. Seber LE, Barnett BW, McConnell EJ (2012). "Scalable purification and characterization of the anticancer lunasin peptide from soybean" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3326064). *PLOS ONE*. **7** (4) e35409. Bibcode:2012PLoSO...735409S (https://ui.adsabs.harvard.edu/abs/2012PLoSO...735409S). doi:10.1371/journal.pone.0035409 (https://doi.org/10.1371%2Fjournal.pone.0035409). PMC 3326064 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3326064). PMID 22514740 (https://pubmed.ncbi.nlm.nih.gov/22514740).
150. "Soy peptide lunasin has anti-cancer, anti-inflammatory properties" (https://www.sciencedaily.com/releases/2009/12/091202153946.htm). *ScienceDaily*.
151. "AllFam – AllFam Allergen Family Factsheet" (https://web.archive.org/web/20160304045912/http://www.meduniwien.ac.at/allergens/allfam/factsheet.php?allfam_id=AF050). *meduniwien.ac.at*. Archived from the original (http://www.meduniwien.ac.at/allergens/allfam/factsheet.php?allfam_id=AF050) on March 4, 2016.

52. Vesper H, Schmelz EM, Nikolova-Karakashian MN, et al. (July 1, 1999). "Sphingolipids in Food and the Emerging Importance of Sphingolipids to Nutrition" (https://doi.org/10.1093%2Fjn%2F129.7.1239). *Journal of Nutrition*. **129** (7): 1239–50. doi:10.1093/jn/129.7.1239 (https://doi.org/10.1093%2Fjn%2F129.7.1239). PMID 10395583 (https://pubmed.ncbi.nlm.nih.gov/10395583).
53. "Soy isoflavones" (http://lpi.oregonstate.edu/mic/dietary-factors/phytochemicals/soy-isoflavones). Micronutrient Information Center, Linus Pauling Institute, Oregon State University, Corvallis. 2016. Retrieved March 4, 2021.
54. De Kleijn M, Van Der Schouw Y, Wilson P, et al. (February 2002). "Dietary Intake of Phytoestrogens is Associated With a Favorable Metabolic Cardiovascular Risk Profile in Postmenopausal U.S. Women: The Framingham Study" (https://doi.org/10.1093%2Fjn%2F132.2.276). *The Journal of Nutrition*. **132** (2): 276–82. doi:10.1093/jn/132.2.276 (https://doi.org/10.1093%2Fjn%2F132.2.276). PMID 11823590 (https://pubmed.ncbi.nlm.nih.gov/11823590).
55. Valsta L, Kilkkinen A, Mazur W, et al. (June 2003). "Phyto-oestrogen Database of Foods and Average Intake in Finland" (https://doi.org/10.1079%2FBJN2002794). *British Journal of Nutrition*. **89** (5): S31 – S38. doi:10.1079/BJN2002794 (https://doi.org/10.1079%2FBJN2002794). PMID 12725654 (https://pubmed.ncbi.nlm.nih.gov/12725654). S2CID 14175754 (https://api.semanticscholar.org/CorpusID:14175754).
56. Hu C, Wong WT, Wu R, et al. (July 5, 2019). "Biochemistry and use of soybean isoflavones in functional food development". *Critical Reviews in Food Science and Nutrition*. **60** (12): 2098–2112. doi:10.1080/10408398.2019.1630598 (https://doi.org/10.1080%2F10408398.2019.1630598). hdl:10397/101521 (https://hdl.handle.net/10397%2F101521). PMID 31272191 (https://pubmed.ncbi.nlm.nih.gov/31272191). S2CID 195806006 (https://api.semanticscholar.org/CorpusID:195806006).
57. Moses T, Papadopoulou K, Osbourn A (2014). "Metabolic and functional diversity of saponins, biosynthetic intermediates and semi-synthetic derivatives" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4266039). *Critical Reviews in Biochemistry and Molecular Biology*. **49** (6): 439–62. doi:10.3109/10409238.2014.953628 (https://doi.org/10.3109%2F10409238.2014.953628). PMC 4266039 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4266039). PMID 25286183 (https://pubmed.ncbi.nlm.nih.gov/25286183).
58. "Nutrient data laboratory" (https://fdc.nal.usda.gov/fdc-app.html#/). United States Department of Agriculture. Retrieved August 10, 2016.
59. "Livestock's long shadow: environmental issues and options" (http://www.fao.org/docrep/010/a0701e/a0701e00.HTM). *www.fao.org*. Retrieved January 15, 2016.
60. Friedrich J, Gary R (1982). "Characterization of soybean oil extracted by supercritical carbon dioxide and hexane" (https://pubs.acs.org/doi/10.1021/jf00109a044). *Journal of Agricultural and Food Chemistry*. **30** (1): 192–193. Bibcode:1982JAFC...30..192F (https://ui.adsabs.harvard.edu/abs/1982JAFC...30..192F). doi:10.1021/jf00109a044 (https://doi.org/10.1021%2Fjf00109a044).
61. Lusas EW, Riaz MN (1995). "Soy Protein Products: Processing and Use" (https://web.archive.org/web/20121207023240/http://jn.nutrition.org/content/125/3_Suppl/573S.full.pdf) (PDF). *Journal of Nutrition*. **125** (125): 573S – 80S. doi:10.1093/jn/125.3_Suppl.573S (https://doi.org/10.1093%2Fjn%2F125.3_Suppl.573S). PMID 7884536 (https://pubmed.ncbi.nlm.nih.gov/7884536). Archived from the original (http://jn.nutrition.org/content/125/3_Suppl/573S.full.pdf) (PDF) on December 7, 2012. Retrieved January 20, 2013.
62. "Soybean meal | Feedipedia" (https://www.feedipedia.org/node/674). *www.feedipedia.org*. Retrieved May 17, 2020.
63. "USDA Coexistence Fact Sheet Soybeans" (https://web.archive.org/web/20230217112456/https://www.usda.gov/sites/default/files/documents/coexistence-soybeans-factsheet.pdf) (PDF). *www.usda.gov*. February 12, 2015. Archived from the original (https://www.usda.gov/sites/default/files/documents/coexistence-soybeans-factsheet.pdf) (PDF) on February 17, 2023. Retrieved January 11, 2023.
164. Heuzé V., Thiollet H., Tran G., Lessire M., Lebas F., 2017. Soybean hulls. Feedipedia, a program by INRA, CIRAD, AFZ, and FAO. https://www.feedipedia.org/node/719
165. Heuzé V., Tran G., Nozière P., Lessire M., Lebas F., 2017. Soybean seeds. Feedipedia, a program by INRA, CIRAD, AFZ, and FAO. https://www.feedipedia.org/node/42 Last updated on July 4, 2017, 10:37
166. Lindsay S, Lora G (1998). "Considering soy" (https://www.nwhjournal.org/article/S1091-5923(15)30123-0/abstract). *Nursing for Women's Health*. **2** (1): 41–44. doi:10.1111/j.1552-6356.1998.tb00990.x (https://doi.org/10.1111%2Fj.1552-6356.1998.tb00990.x). PMID 9526302 (https://pubmed.ncbi.nlm.nih.gov/9526302).
167. Shao S (2009). "Tracking isoflavones: From soybean to soy flour, soy protein isolates to functional soy bread" (https://doi.org/10.1016%2Fj.jff.2008.09.013). *Journal of Functional Foods*. **1** (1): 119–127. doi:10.1016/j.jff.2008.09.013 (https://doi.org/10.1016%2Fj.jff.2008.09.013).
168. Lim 2012, p. 637.
169. Mustakas G (1964). "Production and nutritional evaluation of extrusion-cooked full-fat soybean flour". *Journal of the American Oil Chemists' Society*. **41** (9): 607–14. doi:10.1007/BF02664977 (https://doi.org/10.1007%2FBF02664977). S2CID 84967811 (https://api.semanticscholar.org/CorpusID:84967811).
170. Mustakas GC, Griffin EL, Sohns VE (1966). "Full-Fat Soybean Flours by Continuous Extrusion Cooking". *World Protein Resources*. Advances in Chemistry. Vol. 57. pp. 101–11. doi:10.1021/ba-1966-0057.ch008 (https://doi.org/10.1021%2Fba-1966-0057.ch008). ISBN 978-0-8412-0058-6.
171. "Cornell Bread" (https://web.archive.org/web/20150509122617/http://cornell-classic.univcomm.cornell.edu/search/?tab=facts&id=188). *Cornell University*. May 9, 2015. Archived from the original (https://cornell-classic.univcomm.cornell.edu/search/?tab=facts&id=188) on May 9, 2015.
172. "Whole Wheat Bread Recipe: McCay's Miracle Loaf – Real Food" (http://www.motherearthnews.com/real-food/whole-wheat-bread-mccays-miracle-loaf-zmaz81sozhun.aspx). Mother Earth News. September 1981.
173. "Cornell Bread A Heavyweight When It Comes To Nutrition And Fiber" (https://www.chicagotribune.com/1987/05/21/cornell-bread-a-heavyweight-when-it-comes-to-nutrition-and-fiber/). *Chicago Tribune*. May 21, 1987.
174. "Technology of production of edible flours and protein products from soybeans. Chapter 4" (https://www.fao.org/3/t0532e/t0532e05.htm). *www.fao.org*.
175. Miniello VL, Moro GE, Tarantino M, et al. (2003). "Soy-based Formulas and Phyto-oestrogens: A Safety Profile". *Acta Paediatrica*. **91** (441): 93–100. doi:10.1111/j.1651-2227.2003.tb00655.x (https://doi.org/10.1111%2Fj.1651-2227.2003.tb00655.x). PMID 14599051 (https://pubmed.ncbi.nlm.nih.gov/14599051). S2CID 25762109 (https://api.semanticscholar.org/CorpusID:25762109).
176. Giampietro P, Bruno G, Furcolo G, et al. (2004). "Soy Protein Formulas in Children: No Hormonal Effects in Long-term Feeding". *Journal of Pediatric Endocrinology and Metabolism*. **17** (2): 191–96. doi:10.1515/JPEM.2004.17.2.191 (https://doi.org/10.1515%2FJPEM.2004.17.2.191). PMID 15055353 (https://pubmed.ncbi.nlm.nih.gov/15055353). S2CID 43304969 (https://api.semanticscholar.org/CorpusID:43304969).
177. Strom B, Schinnar R, Ziegler EE, et al. (2001). "Exposure to Soy-Based Formula in Infancy and Endocrinological and Reproductive Outcomes in Young Adulthood" (https://doi.org/10.1001%2Fjama.286.7.807). *JAMA: The Journal of the American Medical Association*. **286** (7): 807–14. doi:10.1001/jama.286.7.807 (https://doi.org/10.1001%2Fjama.286.7.807). PMID 11497534 (https://pubmed.ncbi.nlm.nih.gov/11497534).
178. Merritt RJ, Jenks BH (2004). "Safety of Soy-Based Infant Formulas Containing Isoflavones: The Clinical Evidence" (https://doi.org/10.1093%2Fjn%2F134.5.1220S). *The Journal of Nutrition*. **134** (5): 1220S – 24S. doi:10.1093/jn/134.5.1220S (https://doi.org/10.1093%2Fjn%2F134.5.1220S). PMID 15113975 (https://pubmed.ncbi.nlm.nih.gov/15113975).

79. Hoogenkamp, Henk W. (2005). *Soy Protein and Formulated Meat Products* (https://books.google.com/books?id=IRIRBOd_oTcC&q=soy+protein). Wallingford, Oxon: CABI Publishing. p. 14. ISBN 978-0-85199-864-0. Retrieved February 18, 2012.
80. Endres JG (2001). *Soy Protein Products* (https://books.google.com/books?id=3RNa1vS0sZYC&q=Soy+Protein+Products++endres&pg=PA15). Champaign-Urbana, IL: AOCS Publishing. pp. 43–44. ISBN 978-1-893997-27-1. Retrieved February 18, 2012.
81. Circle SJ, Smith AH (1972). *Soybeans: Chemistry and Technology* (https://books.google.com/books?id=A3NRAAAAMAAJ). Westport, CT: Avi Publishing. pp. 7, 350. ISBN 978-0-87055-111-6. Retrieved February 18, 2012.
82. Liu K (1997). *Soybeans: Chemistry, Technology, and Utilization* (https://books.google.com/books?id=Plmi4WfHos4C&q=reducing+nutritional+value). Gaithersburg, MD: Aspen Publishers. p. 69. ISBN 978-0-8342-1299-2. Retrieved February 18, 2012.
83. "Soy fact sheets: soy nut butter" (https://web.archive.org/web/20180131081150/http://www.soyfoods.org/soy-products/soy-fact-sheets/soy-nut-butter-fact-sheet). Soyfoods Association of North America, Washington, DC. 2016. Archived from the original (http://www.soyfoods.org/soy-products/soy-fact-sheets/soy-nut-butter-fact-sheet) on January 31, 2018. Retrieved November 1, 2016.
84. William Shurtleff, Akiko Aoyagi (2013). *History of Whole Dry Soybeans, Used as Beans, or Ground, Mashed or Flaked (240 BCE to 2013); see page 254* (https://books.google.com/books?id=YIP-szICnhIC). Soyinfo Center. ISBN 978-1-928914-57-0.
85. "Sustainability Fact Sheet" (https://wayback.archive-it.org/all/20080528055311/http://biodiesel.org/resources/sustainability/pdfs/SustainabilityFactSheet.pdf) (PDF). National Biodiesel Board. April 2008. Archived from the original (http://biodiesel.org/resources/sustainability/pdfs/SustainabilityFactSheet.pdf) (PDF) on May 28, 2008. Retrieved February 18, 2012.
86. "How Vodka is Made" (http://www.martinimuse.com/vodka_brands_and_types.shtml). Martini Muse. Retrieved February 18, 2012.
87. "Soy Bean Soup is Pressed into Auto Parts" (https://books.google.com/books?id=lNsDAAAAMBAJ&pg=PA513). *Popular Mechanics*. **64** (4): 513. April 1936.
88. "How Your Diet May Affect Your Risk of Breast Cancer" (http://blogs.cancer.org/expertvoices/2012/08/02/the-bottom-line-on-soy-and-breast-cancer-risk/). American Cancer Society. October 1, 2018. Retrieved March 16, 2019.
89. Yu Y, Jing X, Li H, et al. (2016). "Soy isoflavone consumption and colorectal cancer risk: a systematic review and meta-analysis" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4864327). *Scientific Reports*. **6** (1) 25939. Bibcode:2016NatSR...625939Y (https://ui.adsabs.harvard.edu/abs/2016NatSR...625939Y). doi:10.1038/srep25939 (https://doi.org/10.1038%2Fsrep25939). PMC 4864327 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4864327). PMID 27170217 (https://pubmed.ncbi.nlm.nih.gov/27170217).
90. Tse G, Eslick GD (December 30, 2014). "Soy and isoflavone consumption and risk of gastrointestinal cancer: a systematic review and meta-analysis". *European Journal of Nutrition*. **55** (1): 63–73. doi:10.1007/s00394-014-0824-7 (https://doi.org/10.1007%2Fs00394-014-0824-7). PMID 25547973 (https://pubmed.ncbi.nlm.nih.gov/25547973). S2CID 32112249 (https://api.semanticscholar.org/CorpusID:32112249).
91. "Soy: How Your Diet May Affect Your Risk of Breast Cancer" (https://www.cancer.org/latest-news/how-your-diet-may-affect-your-risk-of-breast-cancer.html). American Cancer Society. October 1, 2018. Retrieved May 9, 2019.
92. van Die MD, Bone KM, Williams SG, et al. (2014). "Soy and soy isoflavones in prostate cancer: a systematic review and meta-analysis of randomized controlled trials". *BJU International*. **113** (5b): E119–30. doi:10.1111/bju.12435 (https://doi.org/10.1111%2Fbju.12435). PMID 24053483 (https://pubmed.ncbi.nlm.nih.gov/24053483). S2CID 39315041 (https://api.semanticscholar.org/CorpusID:39315041).
193. Dong JY, Qin LQ (January 2011). "Soy Isoflavones Consumption and Risk of Breast Cancer Incidence or Recurrence: A Meta-analysis of Prospective Studies". *Breast Cancer Research and Treatment*. **125** (2): 315–323. doi:10.1007/s10549-010-1270-8 (https://doi.org/10.1007%2Fs10549-010-1270-8). PMID 21113655 (https://pubmed.ncbi.nlm.nih.gov/21113655). S2CID 13647788 (https://api.semanticscholar.org/CorpusID:13647788).
194. Hamilton-Reeves JM, Vazquez G, Duval SJ, et al. (2010). "Clinical studies show no effects of soy protein or isoflavones on reproductive hormones in men: Results of a meta-analysis" (https://doi.org/10.1016%2Fj.fertnstert.2009.04.038). *Fertility and Sterility*. **94** (3): 997–1007. doi:10.1016/j.fertnstert.2009.04.038 (https://doi.org/10.1016%2Fj.fertnstert.2009.04.038). PMID 19524224 (https://pubmed.ncbi.nlm.nih.gov/19524224).
195. Messina M (2010). "Soybean isoflavone exposure does not have feminizing effects on men: A critical examination of the clinical evidence" (https://doi.org/10.1016%2Fj.fertnstert.2010.03.002). *Fertility and Sterility*. **93** (7): 2095–2104. doi:10.1016/j.fertnstert.2010.03.002 (https://doi.org/10.1016%2Fj.fertnstert.2010.03.002). PMID 20378106 (https://pubmed.ncbi.nlm.nih.gov/20378106).
196. Yan L, Spitznagel EL (2009). "Soy consumption and prostate cancer risk in men: a revisit of a meta-analysis" (https://doi.org/10.3945%2Fajcn.2008.27029). *The American Journal of Clinical Nutrition*. **89** (4): 1155–63. doi:10.3945/ajcn.2008.27029 (https://doi.org/10.3945%2Fajcn.2008.27029). PMID 19211820 (https://pubmed.ncbi.nlm.nih.gov/19211820).
197. Sacks F, Lichtenstein A, Van Horn L, et al. (February 21, 2006). "Soy Protein, Isoflavones, and Cardiovascular Health: An American Heart Association Science Advisory for Professionals from the Nutrition Committee" (https://doi.org/10.1161%2FCIRCULATIONAHA.106.171052). *Circulation*. **113** (7): 1034–44. doi:10.1161/CIRCULATIONAHA.106.171052 (https://doi.org/10.1161%2FCIRCULATIONAHA.106.171052). PMID 16418439 (https://pubmed.ncbi.nlm.nih.gov/16418439).
198. Jenkins DJ, Mirrahimi A, Srichaikul K, et al. (December 2010). "Soy Protein Reduces Serum Cholesterol by Both Intrinsic and Food Displacement Mechanisms" (https://doi.org/10.3945%2Fjn.110.124958). *The Journal of Nutrition*. **140** (12): 2302S – 11S. doi:10.3945/jn.110.124958 (https://doi.org/10.3945%2Fjn.110.124958). PMID 20943954 (https://pubmed.ncbi.nlm.nih.gov/20943954).
199. Harland J, Haffner T (September 2008). "Systematic Review, Meta-analysis and Regression of Randomised Controlled Trials Reporting an Association Between an Intake of Circa 25 g Soya Protein Per Day and Blood Cholesterol". *Atherosclerosis*. **200** (1): 13–27. doi:10.1016/j.atherosclerosis.2008.04.006 (https://doi.org/10.1016%2Fj.atherosclerosis.2008.04.006). PMID 18534601 (https://pubmed.ncbi.nlm.nih.gov/18534601).
200. Adlercreutz H, Mazur W, Bartels P, et al. (March 2000). "Phytoestrogens and Prostate Disease" (https://doi.org/10.1093%2Fjn%2F130.3.658S). *The Journal of Nutrition*. **130** (3): 658S – 59S. doi:10.1093/jn/130.3.658S (https://doi.org/10.1093%2Fjn%2F130.3.658S). PMID 10702603 (https://pubmed.ncbi.nlm.nih.gov/10702603).
201. Thompson LU, Boucher BA, Liu Z, et al. (2006). "Phytoestrogen Content of Foods Consumed in Canada, Including Isoflavones, Lignans, and Coumestan". *Nutrition and Cancer*. **54** (2): 184–201. doi:10.1207/s15327914nc5402_5 (https://doi.org/10.1207%2Fs15327914nc5402_5). PMID 16898863 (https://pubmed.ncbi.nlm.nih.gov/16898863). S2CID 60328 (https://api.semanticscholar.org/CorpusID:60328).
202. Mitchell JH, Cawood E, Kinniburgh D, et al. (June 2001). "Effect of a Phytoestrogen Food Supplement on Reproductive Health in Normal Males". *Clinical Science*. **100** (6): 613–18. doi:10.1042/CS20000212 (https://doi.org/10.1042%2FCS20000212). PMID 11352776 (https://pubmed.ncbi.nlm.nih.gov/11352776).

203. Oseni T, Patel R, Pyle J, et al. (2008). "Selective Estrogen Receptor Modulators and Phytoestrogens" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2587438). *Planta Med*. **74** (13): 1656–65. Bibcode:2008PlMed..74.1656O (https://ui.adsabs.harvard.edu/abs/2008PlMed..74.1656O). doi:10.1055/s-0028-1088304 (https://doi.org/10.1055%2Fs-0028-1088304). PMC 2587438 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2587438). PMID 18843590 (https://pubmed.ncbi.nlm.nih.gov/18843590).
204. Luca SV, Macovei I, Bujor A, et al. (2020). "Bioactivity of dietary polyphenols: The role of metabolites". *Critical Reviews in Food Science and Nutrition*. **60** (4): 626–659. doi:10.1080/10408398.2018.1546669 (https://doi.org/10.1080%2F10408398.2018.1546669). PMID 30614249 (https://pubmed.ncbi.nlm.nih.gov/30614249). S2CID 58651581 (https://api.semanticscholar.org/CorpusID:58651581).
205. Qin Y, Niu K, Zeng Y, et al. (2013). "Isoflavones for hypercholesterolaemia in adults" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10163823). *Cochrane Database of Systematic Reviews*. **2013** (6) CD009518. doi:10.1002/14651858.CD009518.pub2 (https://doi.org/10.1002%2F14651858.CD009518.pub2). PMC 10163823 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10163823). PMID 23744562 (https://pubmed.ncbi.nlm.nih.gov/23744562).
206. Committee on Food Protection, Food and Nutrition Board, National Research Council (1973). "Phytates" (https://books.google.com/books?id=IIsrAAAAYAAJ&pg=PA363). *Toxicants Occurring Naturally in Foods* (https://archive.org/details/toxicantsoccurri0000unse/page/363). Washington, DC: National Academy of Sciences. pp. 363–71 (https://archive.org/details/toxicantsoccurri0000unse/page/363). ISBN 978-0-309-02117-3.
207. Jorge Martinez, Jack E Lewi (2008). "An unusual case of gynecomastia associated with soy product consumption". *Endocrine Practice*. **14** (4): 415–418. doi:10.4158/EP.14.4.415 (https://doi.org/10.4158%2FEP.14.4.415). PMID 18558591 (https://pubmed.ncbi.nlm.nih.gov/18558591).
208. Glenn D. Braunstein, James R. Klinenberg (May 1, 2008). "Environmental Gynecomastia" (https://www.endocrinepractice.org/article/S1530-891X(20)43301-4/fulltext). *Endocrine Practice*. **14** (4): 409–411. doi:10.4158/EP.14.4.409 (https://doi.org/10.4158%2FEP.14.4.409). PMID 18558589 (https://pubmed.ncbi.nlm.nih.gov/18558589).
209. Hosie R (September 30, 2020). "Soy Boy: What is this new online insult used by the far right?" (https://www.independent.co.uk/life-style/soy-boy-insult-what-is-definition-far-right-men-masculinity-women-a8027816.html). *The Independent*. Archived (https://ghostarchive.org/archive/20220524/https://www.independent.co.uk/life-style/soy-boy-insult-what-is-definition-far-right-men-masculinity-women-a8027816.html) from the original on May 24, 2022.
210. "SAFEX Commodity Derivatives Market" (https://web.archive.org/web/20120309211057/http://www.jse.co.za/Markets/Commodity-Derivatives-Market.aspx). Johannesburg Stock Exchange. Archived from the original (http://www.jse.co.za/Markets/Commodity-Derivatives-Market.aspx) on March 9, 2012. Retrieved February 19, 2012.
211. "交易所动态" (https://web.archive.org/web/20120220091624/http://www.dce.com.cn/). Dalian Commodity Exchange. Archived from the original (http://www.dce.com.cn/) on February 20, 2012. Retrieved February 19, 2012.
212. "Exchange Introduction" (https://web.archive.org/web/20210303074858/http://ode.or.jp/english/index.html). *Osaka Dojima Commodity Exchange*. Archived from the original (http://ode.or.jp/english/index.html) on March 3, 2021. Retrieved November 18, 2020.

1. "You can literally have 40% yield loss with no symptoms," says Greg Tylka, Iowa State University (ISU) Extension nematologist.
2. Reliance on the main genetic source of SCN resistance (PI 88788)may be helping SCN to overcome SCN-resistant varieties. Out of 807 resistant varieties listed by ISU this year, just 18 had a genetic background outside of PI 88788. "We have lots of varieties to pick from, but the genetic background is not as diverse as we would like it to be," says Tylka.
3. There have been cases where SCN has clipped yields of SCN-resistant varieties. Reliance on the main genetic source of SCN resistance (PI 88788)may be helping SCN to overcome SCN-resistant varieties.

Works cited

- Lim TK (2012). "Glycine max". *Edible Medicinal and Non-Medicinal Plants*. Dordrecht, NL: Springer. pp. 634–714. doi:10.1007/978-94-007-1764-0_79 (https://doi.org/10.1007%2F978-94-007-1764-0_79). ISBN 978-94-007-1763-3.