Chapter 8 - Legumes

The legume family is second only to the grass family in terms of its importance to human nutrition.

Legumes are members of the bean family, Fabaceae.

Almost all members of the bean family produce legumes (fruit type).
Among the legumes, the subfamily Faboideae is the most important as a source of food crops.

Chapter 8 will deal primarily with pulses, dried legume seeds used for human food.

### TABLE 8.2 Legumes Discussed in Chapter 8

<table>
<thead>
<tr>
<th>COMMON NAME</th>
<th>SCIENTIFIC NAME</th>
<th>NATIVE REGION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bean</td>
<td>Vicia faba</td>
<td>Central Asia</td>
</tr>
<tr>
<td>Broad</td>
<td>Phaseolus vulgaris</td>
<td>Mexico, Peru</td>
</tr>
<tr>
<td>Common</td>
<td>Phaseolus lunatus</td>
<td>Mexico, Peru</td>
</tr>
<tr>
<td>Lima</td>
<td>Ceratonia siliqua</td>
<td>Arabia</td>
</tr>
<tr>
<td>Carob</td>
<td>Cicer arietinum</td>
<td>Near East</td>
</tr>
<tr>
<td>Chickpea</td>
<td>Vigna unguiculata</td>
<td>Africa</td>
</tr>
<tr>
<td>Cowpea</td>
<td>Lens culinaris</td>
<td>Near East</td>
</tr>
<tr>
<td>Lentil</td>
<td>Pisum sativum</td>
<td>Near East</td>
</tr>
<tr>
<td>Pea, common</td>
<td>Arachis hypogea</td>
<td>Central eastern South America</td>
</tr>
<tr>
<td>Peanut</td>
<td>Cajanus cajan</td>
<td>Southern Asia</td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>Glycin max</td>
<td>China</td>
</tr>
<tr>
<td>Soybean</td>
<td>Tamarind indicus</td>
<td>Tropical Africa</td>
</tr>
</tbody>
</table>

The ancestors of domesticated legumes had characteristics that attracted hunter-gatherers and led to domestication.

An important characteristic of most species of the bean subfamily, Faboideae is the ability to form root association with various bacteria.

This symbiotic relationship provides a usable source of nitrogen.

Over 93% of species from the subfamily Faboideae are associated with bacteria that fix nitrogen.

In many legumes, bacteria, more specifically Rhizobium species, infect the roots of legume species and produce swollen areas called nodules.
The bacteria live within the nodules and absorb nutrients from the host plant.

In return, the bacteria fix atmospheric nitrogen into a more usable form to the host plant.

The legume-bacteria association produces excess usable nitrogen.

Legumes provide a food crop and also fertilize the soil.

\[ N_2 \rightarrow NH_4^+ \]

Plants CANNOT use atmospheric Nitrogen \((N_2)\) and CANNOT convert it into the useable form of Ammonium \((NH_4^+)\).

However, Rhizobium, nitrogen-fixing bacteria, CAN convert atmospheric nitrogen \((N2)\) into the useable form of ammonium \((NH4+)\).

The plant and the bacteria develop a SYMBIOSIS – Where the two organisms live together for the benefit of both...
Legumes are a good source of protein and sometimes alkaloids, which contain nitrogen.

Legumes are also low in certain amino acids.

Like grasses, legumes have undergone a number of changes associated with domestication.
Soybeans, *Glycine max*

Although all the pulses are partial substitutes for animal protein, soybeans have the most protein.

### TABLE 8.1 Nutritional Composition of Edible Legumes, Based on a 100-gm, Dry, Uncooked Edible Portion

<table>
<thead>
<tr>
<th>LEGUME</th>
<th>WATER, gm</th>
<th>CALORIES, Cal</th>
<th>PROTEIN, gm</th>
<th>FAT, gm</th>
<th>CARBOHYDRATE, gm</th>
<th>TOTAL FIBER gm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beans</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finto, raw</td>
<td>11.30</td>
<td>347</td>
<td>21.4</td>
<td>1.3</td>
<td>62.5</td>
<td>15.3</td>
</tr>
<tr>
<td>White, raw</td>
<td>11.10</td>
<td>323</td>
<td>23.3</td>
<td>0.8</td>
<td>60.3</td>
<td>15.2</td>
</tr>
<tr>
<td>Broad beans</td>
<td>11.00</td>
<td>341</td>
<td>26.1</td>
<td>1.5</td>
<td>58.3</td>
<td>15.0</td>
</tr>
<tr>
<td>Carob, flour</td>
<td>3.58</td>
<td>222</td>
<td>4.6</td>
<td>0.6</td>
<td>88.9</td>
<td>17.4</td>
</tr>
<tr>
<td>Chickpeas</td>
<td>11.50</td>
<td>364</td>
<td>19.3</td>
<td>6.0</td>
<td>60.6</td>
<td>10.7</td>
</tr>
<tr>
<td>Cowpeas</td>
<td>11.10</td>
<td>343</td>
<td>23.8</td>
<td>2.1</td>
<td>59.6</td>
<td>10.7</td>
</tr>
<tr>
<td>Lentils, raw</td>
<td>10.40</td>
<td>353</td>
<td>25.8</td>
<td>1.1</td>
<td>60.8</td>
<td>15.0</td>
</tr>
<tr>
<td>Lima beans, raw</td>
<td>10.20</td>
<td>338</td>
<td>21.5</td>
<td>0.7</td>
<td>63.3</td>
<td>19.0</td>
</tr>
<tr>
<td>Peanut, raw with skins</td>
<td>6.50</td>
<td>567</td>
<td>25.8</td>
<td>49.2</td>
<td>16.1</td>
<td>8.5</td>
</tr>
<tr>
<td>Peas</td>
<td>11.50</td>
<td>341</td>
<td>24.5</td>
<td>1.2</td>
<td>62.8</td>
<td>25.5</td>
</tr>
<tr>
<td>Pigeon peas</td>
<td>10.60</td>
<td>343</td>
<td>21.7</td>
<td>1.5</td>
<td>60.4</td>
<td>15.0</td>
</tr>
<tr>
<td>Soybeans</td>
<td>8.50</td>
<td>443</td>
<td>36.5</td>
<td>9.3</td>
<td>30.2</td>
<td>9.3</td>
</tr>
<tr>
<td>Tamarind</td>
<td>31.40</td>
<td>239</td>
<td>2.8</td>
<td>0.6</td>
<td>62.5</td>
<td>5.1</td>
</tr>
</tbody>
</table>


Soybeans contain sulfur-containing amino acids, cysteine and methionine.

![cysteine](image1.png) ![methionine](image2.png)

The oldest date for domestication is about 5000 ybp from Southeastern China.

Soybeans can be used for:
Soybeans, *Glycine max*

Dried or fresh soybeans are bitter and contain trypsin, a compound that inhibits digestion.

Mature soybeans also contain lipoxidase, an enzyme that oxidizes lipids and creates off flavors.

Breeding for low lipoxidase varieties with large seeds that are harvested when immature has led to the production of edamame.

Mature seeds are used and processed to produce:

**Miso**

- paste of cooked soybeans
- mixed with barley or rice
- fermented by *Aspergillus* with *Lactobacillus*
Soybeans, *Glycine max*

**Tofu**
- soaked, rinsed and crushed in water
- the slurry is heated
- the crushed bean solids are strained from the liquid.

**Soy sauce**
- the beans are crushed forming okara
- mixed with wheat and formed into cakes
- inoculated with *Aspergillus* to initiate fermentation
- this mixture is added to salt brine with *Lactobacillus* to complete fermentation

Traditional soy sauce or tamari takes 1 to 3 years for proper color and flavor.
Soybeans, *Glycine max*

The soybean was introduced to the United States in 1765 and into the Corn Belt Region in 1851. In 1920, soybeans were grown for animal feed.

Before the 20th century, soybeans were not used for livestock because of the trypsin content. It was discovered that heating destroys trypsin.

More than half of the U.S. production is exported. The remainder is fed to animals or processed into oil, plastic, paints and adhesives.

Common beans, *Phaseolus vulgaris*

There are a wide variety of beans. Although these beans look very different, all belong to the same species, *Phaseolus vulgaris*.

The common bean was independently cultivated in 2 different regions:
Common beans, *Phaseolus vulgaris*

The independent domestications of the common bean led to two separate gene pools of cultivars:

Fossil evidence of cultivation:

- Mexico (2,500 years ago)
- Coastal valley of Peru (4,400 years ago)

In both of these areas, beans were associated with corn.

By the time Europeans arrived in the New World, common beans were an important dietary item for native people throughout North Central and South America.
Peanuts, *Arachis hypogaea*, are native to central South America.

The domestication of peanuts probably occurred first in southeastern Bolivia.

Peanuts were cultivated throughout warm regions of South America by the time Columbus reached the New World.

The Portuguese took peanuts to Africa and the Spanish introduced peanuts to the Philippines.

Peanuts are now an important part of the diet:

Like other legumes, peanuts bear a pea-like flower.

Self-pollination occurs within the flowers, but after fertilization the flower stalks curve downward and push the developing fruit into the soil.
The widespread production of peanuts in the U.S. South is because this plant was introduced to North America from Africa by slaves on Southern plantations.

Peanuts partially replace cotton as a major crop in parts of the southern U.S. after the Civil War.

George Washington Carver is credited with establishing the peanut industry in the South after the Civil War.

Most of the peanut consumption in the United States occurs in the form of peanut butter.

A substantial portion of the crop is used for pig feed.
Peanuts have many advantages:

Peanut proteins can elicit several allergic reactions.

Peanuts are susceptible to a fungus that produces aflatoxins as a by-product of metabolism.

Chickpeas, *Cicer arietinum*, are part of the domestication of several important plants in the Near East, such as barley, wheat, lentils and peas.

The first record of cultivated chickpeas is from Turkey about 9000 ybp.

The original domesticated legumes from this area germinated in the fall and fruited in the late spring.

About 5000 to 6000 ybp, there was a switch to spring sowing and summer fruiting.

The switch might have occurred to avoid fungal infections that are common during a wet spring.

Chickpeas do not grow well in cool climates.

The domestication spread to the east and the west rather than to northern parts of Europe.

By 2000 B.C., chickpeas had been introduced to India. India is now the world’s largest producer of chickpeas.

Cultivation also spread to the Mediterranean.

Today chickpeas are an important part of cuisines in Italy, Spain, Morocco and Algeria.
Peas, *Pisum sativum*, along with lentils, barley and wheat form the oldest complex of cultivated foods discovered.

Fossil seeds have been collected from excavations in the Near East and Europe between 8000 and 9000 years old.

Fossil seeds with smooth seed coats are more characteristic of domesticated peas and appeared in Middle Eastern archeological sites by 5850 to 5600 B.C.

The original domestication site was probably in an area around Turkey and Syria.

Pulses, most likely peas, are mentioned in the Biblical story of Daniel in the court of Nebuchadnezzar.

In the Middle Ages, dried peas were the mainstay of the peasant diet.

It makes you wonder what Goldilocks was really eating?

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Columbus brought peas to the New World in 1493 and planted them in the West Indies.

English settlers brought the pea to New England in the early 17th century.
Peas were not eaten as a fresh vegetable in Europe until the 17th century.

Chinese snow peas and sugar snap peas are eaten when the pod is still immature and tender.


The oldest fossil of domesticated pigeon peas are only 2000 years old.

Pigeon peas grow in poor soil and are perennial shrubs, rather than annual herbaceous plants.

This legume is an important crop in India.

In India, dried pigeon peas are used to prepare dal (or dhal), purees derived from several different types of pulses.

Lentils, *Lens culinaris*, was domesticated between 8000 and 9000 years ago in the Middle East.

The use of lentils spread around the Mediterranean and appeared in Europe by 4200 B.C.

The common name lentil and the generic name Lens refers to the flattened, ovoid shape of the seed, similar to the lens of a human eye.
Lentils are the first pulse to be mentioned in the Bible. In Genesis 25, Esau sold his birth right to his brother Jacob for a meal of red lentils. Lentils are relatively drought resistant and can grow in semi-arid regions. In the U.S., lentils are grown in dry portions of the Pacific NW as a rotational crop for wheat.

Broad or fava beans, *Vicia faba*, are associated with the Mediterranean. Broad bean fossils date to 8800 ybp. Cultivation was widespread in the Eastern Mediterranean region in prehistory. Broad beans were cultivated by the Egyptians, Greeks and Romans. The 2nd governor of Colombia brought broad beans to South America from Spain in 1543. However, the broad bean is really a cool region crop.

Today, broad beans are the least cultivated of all of the pulses. The seeds of broad beans can cause favism, a genetic disease that leads to hemolytic anemia. This illness is most common among people of Mediterranean origin. Favism is due to a sex-linked disorder on the X chromosome that results in a lack the enzyme glucose-6-phosphate dehydrogenase. Oxidative agents such as fava bean alkaloids that are ingested by individuals aggravate the anemic symptoms of the disorder.
Black-eyed peas or cow peas, *Vigna unguiculata*, originated in Africa.

Cow peas along with sorghum formed an agricultural system that developed in eastern Africa by 3000 B.C.

The cultivation of cowpeas spread west in Africa and eastward to Asia about 2000 years ago.

Slaves introduced black-eyed peas to the United States from western Africa.

Cow peas or black-eyed peas are part of regional cooking in the U.S. South.

Hoppin' John, a mixture of rice, black-eyed peas and salt-pork, is a traditional New Years Day dish.

Lima beans, *Phaseolus lunatus*, was domesticated independently:

Archeological sites on the northern coast of Peru contain fossilized beans in layers with material that is dated to 5600 years old.

The common name of the bean, lima, comes from Lima, Peru, the city where the beans were originally shipped to Europe.

In the U.S., lima beans are used in soups, but most lima beans are consumed as shelled, immature (including frozen and canned) seeds.

Some cultivars of lima beans contain compounds that release cyanide when beans are chewed or ground.

The FDA restricts the amount of these compounds that are allowed in beans sold for food in the U.S.
Tamarind, *Tamarindus indica*, belongs to a group of legumes not included in the pulses.

Tamarind plants grow wild in Africa in tropical, dry savannas, and in Southern Asia.

The plant produces long, brown pods on tall spreading trees.

The fruit pulp, or sticky mesocarp, is used in Southeast Asian cooking.

Tamarind is used to flavor steak sauce in the U.S. and Mexico.

Carob, *Ceratonia siliqua*, is another legume that produces seed pods used for their pulp.

Carob is native to the Mediterranean.

The common name is St. John’s bread, because it was the “locust” that John the Baptist ate ("locusts" may refer to carob pods, rather than to grasshoppers).

In ancient times, carob seeds were used as weights for small quantities of precious substances such as gold.

Our modern unit carat is a reflection of this former use.

Traditionally, carob pods were gathered from wild trees.

The sweet mesocarp was chewed and the seeds were used to make a coffee-like beverage.

The two most important uses of carob in the U.S.: