Chickpeas

The chickpea was originally cultivated on the lands bordering Mesopotamia and the eastern Mediterranean and has been grown in India, the Middle East, and parts of Africa for many years. Chickpeas are estimated to be at least 7,500 years old.

Between 80 and 90 percent of the world’s chickpea supply comes from India, while most acreage in the U.S. is in California, eastern Washington, Idaho, and Montana. Acreage continues to grow to make up for supplies that formerly came from Mexico, which has in recent years cut back chickpea production in favor of pinto beans.

Like lentils, chickpeas take their name from their shape, which resembles the beak of a baby chick. Some may also know chickpeas by their other name, garbanzo beans.

General Properties of Dry Peas, Lentils & Chickpeas
Legumes belong to the botanical family **Papilionaceae** within the order **Fabaceae** (also called **Leguminosae**). The **Fabaceae** family includes about 600 genera and 13,000 species, making it the third largest family within the plant kingdom. Familiar legumes aside from dry peas, lentils, and chickpeas include soybeans, fava beans, peanuts, lupins, beans, lucerne (alfalfa), clovers, and vetches.

Legumes are distinguished by three principal characteristics:

- A butterfly-shaped, or papilionaceous, flower
- Production of pods that contain seeds
- An ability to use atmospheric nitrogen to produce their own protein compounds (this is true for nearly all legumes and is made possible by the symbiotic relationship between nitrogen-fixing bacteria in the soil and the nodules in the legumes’ roots)

Legumes fall into the following two general categories:

**Grain Legumes**

Grain legumes are cultivated primarily for their seeds, or grains, which are harvested at maturity and marketed as dry products rich in protein. More than 40 species and myriad varieties of grain legumes are cultivated throughout the world. The major grain legumes grown in the U.S. include dry peas, lentils, chickpeas, soybeans, fava beans, lupins, vetches, and dry beans.

**Forage Legumes**

Forage legumes (mostly with small grains) are grown and used as feedstock for animals, either via grazing the crop or through the production of silage or hay, and for industrial purposes. Popular forage legumes include lucerne and clover.

**What Is a Pulse?**

The edible seed of a legume is known as a pulse, a name taken from the Latin word *puls*, meaning a thick soup. Familiar pulses include peas, beans, lentils, and chickpeas. They are most commonly cultivated as a food for human consumption, in large part because of their rich protein and starch content. A percentage is also grown for animal feed.

Considered environmentally friendly crops, pulses are less dependent on fossil fuels and reduce the need for fertilizer applications thanks to their ability to obtain much of their nitrogen from the atmosphere. Pulses also offer low crop residues and low carbon-to-nitrogen ratios. This eliminates the need for burning and makes it very easy to
Pulse crops have a hypogeal type of germination, which means that the plant's seed leaves (cotyledons) remain below ground. This makes pulse crops more frost-tolerant than soybeans or dry beans. Pulse crops are also more tolerant of having the soil disturbed, such as tillage, operations like harrowing, culi-packing, or rotary hoeing.

Dry Pea Varieties

Dry peas, like their lentil cousins, have been around for thousands of years. The earliest evidence dates from Neolithic times in Syria, Turkey, and Jordan. Finds were made in present-day Thailand that date from 11,000 years ago. Discoveries have also been made in Egypt and what is today Georgia, Pakistan, Afghanistan, and India.

Cultivated peas have been classified into two types: (1) garden peas (Pisum sativum ssp. hortense), which are identified by the wrinkled nature of their seed and cotyledon, and (2) field peas (Pisum sativum ssp. arvense), also known as dry peas. This second type is distinguished by its smooth seed surface. The two types are genetically different and produce starches with different granular morphologies and characteristics.

Within the dry pea family, two main varieties are grown throughout the world: the dry green cotyledon and the dry yellow cotyledon. Split peas are simply dry peas (green, yellow, or red) that have been split. Most people are familiar with green split peas, which have a bright green color due to chlorophyll and boast a stronger taste than yellow split peas.

As an annual herbaceous plant the dry pea can be indeterminate (climbing) or determinate (bush or dwarf). One has normal leaves and a vine length of 3 feet to 6 feet. The other is semi-leafless with modified pale-green leaflets reduced to tendrils resulting in shorter vine lengths of 2 feet to 4 feet. They usually have a single stem, but can branch from nodes below the first flower.

Depending on the variety, dry peas start flowering after a specific number of nodes (i.e., the part of the plant's stem that bears a leaf) are reached. All varieties, except for the Austrian Winter Peas, which are reddish-purple, the self-pollinating blossoms are white, with flowering occurring normally two to four weeks out, depending on the variety and weather. Flowering continues until drought or nitrogen deficiency brings it to an end. Dry pea varieties are distinguished by determinate or indeterminate flowering. Determinate varieties mature in 80 to 90 days, indeterminate varieties in 90 to 100 days.

The pods of the dry pea are about three inches long and contain four to nine seeds, which can have a green, yellow, or cream-colored seed coat. By the time some pea varieties reach maturity, the plant becomes a prostrate vine.

Peas are a cool season crop with planting taking place from winter through early summer depending on location. The seeds may be planted as soon as the soil temperature reaches 50 degrees F (10 degrees C), with the plants growing best at temperatures of 55 degrees F to 65 degrees F (13 degrees C to 18 degrees C), and outside versus in greenhouses.

Dry pea seedlings can withstand considerable frost exposure without damage. If damage does occur and the main shoot is killed, new shoots will originate from nodes below the soil surface. Dry peas also prefer slightly acidic, well-drained soils.

Planting is typically done in the spring. Where frost is not an issue, planting can occur in the fall and early winter. Once planted, it takes dry peas about 60 days to bloom and 100 days to mature the dry seed. Because high temperature during blossoming results in reduced seed set, production of dry pea as a summer annual in the United States is limited to the northern states.

The moisture requirement for the dry pea is similar to that of cereal grains. The ideal includes good rains and/or early irrigation, and no rain during pod fill and ripening. Dry peas can be grown in a wide range of soil types, from light sandy loams to heavy clays. But in each case, there must be good drainage as dry peas don’t tolerate soggy or water-soaked conditions.

Dry peas grow best when planted into a seedbed with a minimum amount of residue on the soil surface. Good soil contact with the seed is also important, so seedbeds that are firm and well worked tend to be favored. Such features of the soil environment can impact the percentage of seedlings that emerge. Seed and soil-borne pathogens may have a major effect on emergence.

Another factor is the pea seed germination rate, which increases as the temperature increases. But if temperatures reach 64 degrees F (18 degrees C) or higher, the percentage of germinating seeds decreases.

Temperature is also critical during flowering. Being a cool season crop, dry peas cannot tolerate hot weather or drought stress during this period. This makes seeding early very important. As early in the spring as feasible is best, provided the soil temperature in the upper inch is over 40 degrees F (4 degrees C). Unless erosion is an issue, fall plowing is recommended as a good way to help enable early spring planting.

Among harvested seeds, color variability within a particular variety is usually related to the seed's maturity and the storage conditions. If irregular pigmentation is evident in a given lot of seeds from a single-stage harvest it may be due to the differing ripeness of the seeds.
Use of Dry Peas

Peas were originally grown mostly for their seeds. Dry peas can be hydrated by soaking and either canned or frozen and then served as a vegetable. Applications for canned or frozen peas include stir-fry dishes, pot pies, salads, and casseroles. Most dry peas are put through a splitting process and the split peas are then used in the popular North American dish, split pea soup.

In many Asian countries, peas are roasted, salted, and consumed as snacks. In parts of the Mediterranean, they are added to meat and potatoes to make a hearty stew. Dry yellow split peas are used in the UK to make the traditional pease pudding or porridge, while dried, rehydrated, and mashed marrowfat peas, known in England as “mushy peas,” are a common accompaniment to fish and chips and meat pie.

Dry pea flour also figures in many uses worldwide. It is valued not only as a vegetable protein source, but also, in part, for its unique functional properties. In keeping with the increasingly popular use of vegetable proteins as functional ingredients in the food industry, dry peas have been especially sought after due to their wide acceptance as part of the human diet. For example, slurred pea flour offers a viscosity that makes it uniquely useful as a thickening agent in certain food products.

Dry peas can also be used as a green manure crop, which is plowed back into the soil to restore nutrients, and provide large amounts of fixed nitrogen to the soil. Dry peas may also be grown as a forage crop for hay, pasture, or silage, while pea starch can be used for industrial purposes such as adhesives.

The Health Benefits of Dry Peas

As with other legumes, dry peas are rich in nutrients. A good source of protein, one-quarter cup of dry split peas also provides 13 grams of dietary fiber or 52 percent of the daily recommended 25 grams (based on a 2000-calorie diet). Peas offer more than one-third of the recommended daily value for folate, a nutrient that plays a critical role in the prevention of birth defects. Dry peas also have little or no fat and no cholesterol, making them a smart addition to almost any diet.

The many nutrients in dry peas may help lower the risk of heart disease, stroke, and various cancers, while enhancing quality of life by helping manage weight and prevent hemorrhoids and diverticulitis. The soluble fiber in dry peas and low glycemic index may help stabilize blood sugar levels, which is especially important for people with diabetes. In addition, the presence of phytochemicals in dry peas is another reason why they, like other legumes, should be consumed regularly. The body uses phytochemicals to fight disease.

Lentil Varieties

The lentil (Lens culinaris) is a feathery legume with lens-shaped seeds, which typically grow two to a pod. The plant originated and was among the first crops to be domesticated in the Near East. It has been a part of the human diet since Neolithic times.

A similarity in shape to the lentil, which is Latin for “lens,” also led to the eye’s borrowing the name for its optical lens. This same lens-lentil association appears in myriad languages, from Arabic to Vietnamese.

Lentil types comprise a wide variety, with colors that include yellow, red-orange, green, brown, and black. Red, white, and yellow lentils have their skins removed in a process called *decortication*. Many lentils types come in large and small varieties and are sold in many forms, with or without the skins, whole or split.

Lentil plants are herbaceous, with thin stems and branches. Plant height ranges from 12 inches to 15 inches for most varieties, but can vary from 8 inches to 30 inches depending on variety and environment.

The plants have a slender taproot with fibrous lateral roots. Rooting patterns range from a many-branched, shallow root system to types that are less branched and more deeply rooted. The taproot and lateral roots at the surface layers of soil have nodules that vary in shape from round to elongated. The stems are square and ribbed and usually thin and weak, while the branches sprout directly from the main stem and may emerge from the cotyledon node below ground or from nodes above ground.

The leaves of the lentil are relatively small compared to those of other large-seeded...
USA Lentil Varieties

USA Pardin lentils
The Pardin lentil, sometimes called the Spanish brown lentil, is favored for its excellent taste (slightly nutty) and its cooking characteristics. These lentils maintain their shape and texture very well when cooked and do not fall apart even if slightly overcooked. Although the Pardin lentil is originally from Spain, over 90 percent of the world’s production is now grown in Washington and Idaho.

USA Richlea Lentils
The medium-sized Richlea lentil is greenish-tan and often mistaken for the Regular lentil because of its similar size and color. The Richlea lentil is distinguished from the Regular lentil by its general lack of mottling.

USA Red Chief Lentils
These red lentils are quick cooking because the brown outer skin is typically removed. Simply boil for six to eight minutes for a great visual and nutritional addition to any meal. Try adding to soups as a thickener or to salads for something different.

USA Regular Lentils
Also known as the Brewer lentil, this greenish-tan lentil is the most common lentil type available in the U.S. The mottled appearance of the Regular lentil is a natural genetic trait that was inherited from its Chilean lentil parents.

USA Crimson Lentils
These colorful, small-sized lentils have a pinkish-brown skin that covers a red seed. The lentil is thought to originally derive from Turkish red lentils.

USA Beulga Lentils
This small, black lentil gets its name from its similar appearance to Beluga caviar. Look for this attractive variety to grow in popularity in years to come.

USA French Green Lentils
This is the same type of lentil as the du Puy lentil from the du Puy region of France, though it is not generally called du Puy when grown in the U.S. It is a great visual and nutritional addition to any meal.

USA Large Green Lentils
These red lentils are quick cooking because the brown outer skin is typically removed. Simply boil for six to eight minutes for a great visual and nutritional addition to any meal. Try adding to soups as a thickener or to salads for something different.

USA Estoni Lentils
These small green or tan lentils are most often exported. To avoid cooking problems from hard seeds, make sure that the Estons you purchase are from the U.S.

USA Eston Lentils
This is the lentil of choice among many South American countries.

USA Lentils in particular offer a high level of protein that is well-suited to this diet, which recommends eating an abundance of foods from plant-based sources.

Use of Lentils

Lentils are most well known for their namesake soup, which is popular across North and South America and Europe. In India and elsewhere, lentils are often combined with rice, which has a similar cooking time. Typically, lentils are consumed as a soup or joined with vegetables and boiled to a stew-like consistency before being seasoned with a mixture of spices to make a variety of side dishes, including the Indian dhal. These are then served over rice and roti.

In the Jewish tradition, the round shape of the lentil symbolizes the life cycle, and for this reason they have become traditional food for mourning.

The Health Benefits of Lentils

The Superfoods Rx Diet, released in 2008, included lentils for their nutritional attributes. In addition, lentils and legumes are highlighted as key daily ingredients in the Mediterranean Diet.

The product of more than 50 years of scientific research into the eating habits of those living along the Mediterranean Sea, the diet is today considered by many to be the “gold standard” for healthful eating.

Lentils are an excellent source of:
- Fiber
- Folic Acid (Folate)
- Iron
- Manganese
- Phosphorus
- Thiamin

Lentils are a good source of:
- Copper
- Magnesium
- Panthenic Acid
- Potassium
- Vitamin B6
- Zinc

Food legumes. The pods are oblong, compressed, 6 mm to 20 mm long and 3 mm to 10 mm wide, and usually contain one to two lens-shaped seeds. Seed diameter ranges from 2 mm to 9 mm, while colors can vary from light green or greenish red to gray, tan, brown, or black. The seeds of some varieties can have purple and black mottling and speckling.

Lentils are usually sown in late April or early May, when soil temperatures are above 40 degrees F (4 degrees C). The North American lentil crop is planted in early spring and harvested in late summer. Early seeding will increase the height and size of the plant at first bloom, while planting after April can result in lower quality and diminished seed yield.
In fact, among plant-based foods, lentils boast the highest amount of protein after
couscous, barley, and beans. They have
been and remain a critical part of the diet
in many parts of the world, especially on
the Indian subcontinent. Mixing lentils
with grains, such as rice, creates a complete
protein dish.

In addition to the high protein content, len-
tils are high in dietary fiber, folate, manga-
nese, phosphorous and thiamin. Lentils
one of the best vegetable sources of iron,
also boast a high tannins content. As a
phytochemical in plants, tannins have an-
timicrobial properties. In the body, tannins
can act as an antioxidant and may reduce
blood pressure, lower cholesterol, and help
regulate the immune response

Chickpea Varieties

Chickpeas (Cicer arietinum), like all le-
gumes, are members of the subfamily
Fabioideae of the family Fabaceae. Thought
to have been first grown in Mesopotamia
up to 7,500 years ago, chickpeas are con-
sidered one of the earliest cultivated veget-
tables on earth.

Chickpeas are divided into two types: Desi
and Kabuli. The classification is based on
seed size, color, and the thickness and
shape of the seed coat. Desi types tend to
be smaller, angular seeds with thick seed
coats that range in color from light tan and
speckled to solid black.

If intended for human food, they require
a specialized seed-coat removal process.
Decortication requires adjusting the mois-
ture level of the seeds to facilitate the me-
chanical removal of the thick seed coat,
after which the seeds resemble a small
yellow pea.

Kabuli types, also known as garbanzo
beans in the U.S., have larger seeds with
paper-thin seed coats that range in color
from white to pale cream to tan.

Chickpea plants stand erect and resemble
a bush with primary, secondary, and ter-
tyary branching. They flower profusely and
have an indeterminate growth habit, con-
tinuing to flower and set pods as long as
conditions support it. Pods appear on the
primary and secondary branches and on
the main stem, with each of the individual
round pods generally containing one seed
in Kabuli types and often two seeds in Desi
types.

Chickpeas can be seeded into standing
or tilled stubble and fallow. To reduce soil-
borne diseases, Kabuli chickpea types are
planted when soil temperature at a depth
of 2 inches to 3 inches reaches at least 50
degrees C) or above.

Chickpeas tend to grow best in fertile san-
loam soils with good internal drainage.

Mature chickpeas can be cooked and eat-
en cold in salads, cooked in stews, ground
into flour, ground and shaped into balls
and fried (falafel), stirred into a batter and
baked (farinata), cooked and ground into a
paste (hummus), or roasted, spiced, and
eaten as a snack. Unripe chickpeas are of-
ten picked out of the pod and eaten raw,
they can even be fermented into an alcohol-
colic drink similar to sake or ground, roasted,
and brewed as a coffee substitute.

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eaten as a snack. Unripe chickpeas are of-
ten picked out of the pod and eaten raw,
while the leaves are used as a green veg-
etable in salads. In the Philippines, chick-
peas are preserved in syrup and enjoyed
as sweets and in desserts. They can even
be fermented into an alcoholic drink similar
to sake or ground, roasted, and brewed as
a coffee substitute.
In North America, most Kabuli chickpeas are marketed as canned chickpeas for salads at home or in restaurant salad bars. They are also marketed as dry chickpeas and ground flour for baking purposes. Other common uses in the U.S. include as an ingredient in soups and stews and as part of vegetable combinations. Hummus, a dip or spread made from cooked, mashed chickpeas, has also become a major product in the U.S. in recent years.

Chickpeas are a good source of:
- Fiber
- Folic Acid (Folate)
- Iron
- Manganese
- Copper

Chickpeas are an excellent source of:
- Protein
- Phosphorus
- Iron
- Copper
- Manganese
- Iron
- Copper

About 90 percent of chickpeas, the majority of which are Desi types, are consumed in India. Decorticated Desi chickpeas are commonly processed into South Asian food products.

The Health Benefits of Chickpeas

As well as being good to eat, chickpeas are also good for you. Some ancient cultures associated them with Venus, thinking them an effective medicinal for increasing sperm and milk, bringing about menstruation and urine, and even helping to treat kidney stones.

Today, we know that chickpeas, like other legumes, provide a valuable source of fat, iron, manganese, and protein. They are also a healthy source of complex carbohydrates and are low in fat. Most notably, chickpeas are high in dietary fiber—one-half cup of canned chickpeas provides 24 percent of the daily recommendation of 25 grams of fiber (based on a 2000-calorie diet).

The benefit of a high fiber diet goes beyond regularity and prevention of hemorrhoids and diverticulitis. It reduces the risk of cardiovascular disease by lowering blood cholesterol levels, helps control blood sugar levels in people with diabetes, and may even help protect against several cancers.

See Appendix C for a collection of sample formulations using dry peas, chickpeas, and/or lentils.

Chemical Composition

Pulses (dry peas, lentils, and chickpeas) are some of the most widely available, inexpensive, and nutritionally complete staple foods in the world. Offering a balanced proportion of proteins, starches, fiber, and minerals, they are a valuable feature of a healthy human diet. Health benefits have been ascribed to three main components found in legumes: non-nutritional factors, proteins, and carbohydrates.

There is an extensive amount of literature on the nutritional aspects of grain legumes, including the digestibility of main nutrients (mainly proteins, starch, and dietary fiber), colonic fermentation, post-prandial glycemia and insulinemia, and some data on lipid metabolism. Their high fiber content means that legumes help to protect against diabetes, cardiovascular disease, and maybe even some cancers.

Because pulses are low in fat and rich in protein, fiber, minerals, and vitamins, they have a low glycemic index (i.e., small rise of glucose after a meal) and can contribute to improved blood glucose control. It is thought that regular consumption of pulses can help lower blood cholesterol concentration.

At the same time, legumes provide the amino acids necessary to build and repair muscles and assure proper muscle development. They also nourish muscles with a range of other nutrients, including folacin and minerals. They boast a low allergenic capacity compared with some other sources of protein.

Over the previous two decades, non-nutritional factors, such as phytates, tannins, alkaloids, saponins, oligosaccharides, etc., have been linked with health-promoting properties. These elements are increasingly considered natural bioactive substances and are credited with playing an important role in the prevention of heart disease and some types of cancer.

The amount of protein, starch, fiber, oil, vitamins, and minerals vary in proportion and importance depending on the legume. For example, numerous studies have demonstrated significant genetic variability in seed protein composition, which offers the possibility of breeding for improved protein nutritional value.

A better understanding of the fundamental aspects of assimilate uptake, transport, partitioning, and metabolism in legume seeds, and the genetic factors that regulate all of these processes, will help contribute to the successful breeding of improved legume seed quality over time.

Chickpeas have one of the highest nutritional compositions of any dry edible legume. The chickpea’s average nutritional content is 22 percent protein, 67 percent total carbohydrates, 47 percent starch, 5 percent fat, 8 percent crude fiber, and 3.6 percent ash. The fat (lipid) fraction is high in unsaturated fatty acids, primarily linoleic and oleic acids.

Chickpea protein digestibility is also the highest among the dry edible legumes. The content of the amino acid lysine is adequate, while the sulphur-containing amino acids, methionine and cystine, are the first limiting amino acids. Chickpeas are con-
sidered a cholesterol reducer due to their unsaturated fatty acid and fiber content, and they are also unique in their ability to moderate the rise in plasma glucose after meals.

In addition, the chickpea mineral component includes generous amounts of potassium, phosphorous, iron, and magnesium. Apart from being eaten as a vegetable, grain legumes are also a source of raw material for the processing industry. Fractions isolated from grain legumes can be used as simple ingredients or as additives. Legume starch and fiber both have useful functional properties and can be readily used in food products.

Moisture Content

Seeding, Growth, and Harvesting

Dry peas are adapted to grow during the cool season when evapotranspiration (i.e., the sum of evaporation and plant transpiration into the atmosphere) is minimal and rely on stored soil moisture for a large part of their growth cycle. In years of warm, wet springs and cool, wet summers, desiccant herbicides are important tools for promoting faster drying to avoid threats like pod shattering and sprouting, and seed coat slough and bleaching.

Despite having moisture requirements similar to those of cereal grains, dry peas have a lower tolerance to saline and waterlogged soil conditions. Peas commonly die after 24 to 48 hours in a water-logged condition, making poorly drained or saline alkaline soils a hazard when growing peas. Maintaining firm seed-to-soil moisture contact is critical. So seeding peas well into moisture is important, with a half inch being the minimum and one to three inches the preferred depth.

Excessive tillage in the spring is also to be avoided to prevent drying out the seedbed. By comparison to cereal grains pea seed

requires considerably higher amounts of moisture for germination. It is their relatively shallow root system and high water use efficiency that make them an excellent rotational crop with small grains, especially in arid areas where soil moisture conservation is key.

Dry peas can be harvested when seed moisture is less than 15 percent. Harvesting at very low moisture levels will cause losses from cracking and splitting, which can result in the crop being downgraded for the seed and food markets. Harvesting at too high a moisture content will require immediate aeration or drying.

Ideal threshing and separation occurs when the crop is below 13 percent seed moisture, while the harvest starts in late July when pods are dry and seed moisture is less than 13.5 percent.

Like dry peas, lentils have been adapted to grow during the cool season when evapotranspiration is minimal. They usually rely on stored soil moisture for a large part of their growth cycle. Proper packing after seeding is also very important to prevent moisture loss, and to make the ground smooth and even for harvest.

Also similar to dry peas, as long as moisture is available, lentils will continue to flower and set pods. If growers wait for the crop to dry naturally under such high-moisture conditions, they risk compromising the integrity and value of the crop. Weeds can also mechanically impair the harvest of the crop. Swathing improves the moisture uniformity of the lentil seed and reduces the amount of seed discoloration, helping protect seed quality and value.

In each case, the level of moisture can also impact herbicide effectiveness and pest control. The density and injury wrought by the wireworm, the larvae of the click beetle that feeds on plant roots, are directly related to soil moisture. Wireworms are generally low in years of average or below-average precipitation, and high and more destructive in years of above-average precipitation.

Due to a deep tap-root, the chickpea can use water from greater depths than other pulse crops. But because of its indeterminate nature, and the fact that it continues growing into the fall, the chickpea can deplete a field’s subsoil moisture. If it is a dry fall and there is limited winter precipitation, this can undermine the cereal crop yields the following year.

Chickpeas are seeded at a depth of one inch below moisture for the Desi type and up to two inches below moisture for the Kabuli type. Kabulis may be planted to a depth of four inches to use available soil moisture for germination. To protect this necessary level of moisture, it is often recommended with chickpeas to minimize soil tillage to reduce moisture loss. This is especially important for the large-seeded Kabuli chickpeas. Chickpeas can be harvested at 18 percent moisture.
Desi chickpeas require a specialized seed coat removal process if used for human food. The process, called decortication, involves adjusting the moisture level of the seeds to facilitate the mechanical removal of the thick seed coat. If moisture levels are too high, grain dryers are often used, though always with extreme caution as they can cause mechanical and thermal damage to pulse crops. Aeration is used to cool and dry the seed and to avoid storage complications.

Managing storage moisture levels for chickpeas can be especially challenging. When a chickpea seed is harvested, the outside seed coat normally has a lower moisture level than the inside of the seed. As it sits in the bin, the moisture level tempers, which can cause the overall moisture level to rise. The result is that a crop that was harvested at a safe moisture level can, just a week later, have a moisture level higher than the recommended 14 percent. For this reason, chickpeas, like lentils, tend to be stored in a hopper-bottomed bin that has aeration, which, when left on, can bring the moisture down to prescribed levels.

Protein Content

The history of legumes is intertwined with that of human civilization. During times when meat was not available, legumes became an important staple by providing essential supplementing protein, as well as key vitamins and minerals. Protein was the major reason for the development of pulses, especially in Europe. It remains a signature feature of the diet of many millions of people around the world, often combined with a cereal crop to provide energy.

The protein values of legumes tend to range from 18.5 grams to 21.9 grams/100 grams for raw grains and from 21.3 grams to 23.7 grams/100 grams for freeze-dried cooked legumes. Pulses are also an important part of vegetarian diets because they are rich in the amino acid lysine, and when combined with a source of the amino acid methionine, such as cereals, provide the balanced protein necessary for growth.

The higher protein of the legume seed and foliage is thought to be due in part to the additional nitrogen that legumes receive through nitrogen-fixation symbiosis. In round-seeded peas, high protein content is also often associated with increased legumin (i.e., a globulin found in legume seeds) content. The amount of protein varies in proportion and importance, depending on the species.

Studies conducted in the late 1990s suggest that the effect of the environment is the first source of variation for seed protein content. Among the variables contributing to the environmental influence on protein content is the efficiency of plant nitrogen nutrition.

The impact of legume variety on protein content is also usually significant, with a difference of 2 percent versus 3 percent when comparing the varieties with the lowest and highest protein content. Among U.S. pea cultivars, the Nitouche and Majoret varieties offer the highest protein content.

Yield does not appear to influence legume protein content. When the yield is low, it is possible to have low protein content if the nitrogen nutrition is deficient at flowering time and after. It is also possible to have a high yield and a high protein content at the same time. Similarly, no connection has been made between protein content and crop height at harvest (i.e., the standing ability).

In the search of new food protein resources, commercial facilities have begun focusing on extracting protein concentrates from pulses by air classification or wet milling techniques. Legume seeds can be fractionated (i.e., the separation out of component ingredients) to obtain the desired protein concentrates and isolates.

Numerous studies have demonstrated significant genetic variability in seed protein composition and this offers the possibility of breeding for improved protein nutritional value. Before this can be done, the link between protein content, protein composition, and nutrient supply to the seeds will need to be further explored.

Also required will be a better understanding of the environmental interactions, the complex relationships between crop yield potential, plant carbon costs, and protein content. Additional investigation is similarly necessary into the various sources of instability, including drought stress, high temperatures, and symbiosis mechanisms.

Legumes provide both energy and protein for humans and animals. Increasing legume protein content and yield at the same time via genetic improvement through breeding is a goal currently being worked on by researchers. It is hoped that the results of these efforts will help point producers to the best strategies for improving their crops, while highlighting the existing potential for genetic progress in grain legumes.
Starch Content

Starch is the main carbohydrate reserve found in plants, accounting for 22 percent to 45 percent in the pea seed. It is also a major source of nutrition for humans and animals, and an important raw material for industry.

Starch content varies between genera, from negligible amounts to half the dry seed weight in a wild-type, round-seeded pea. Mutations that affect the activities of enzymes of the starch can dramatically affect not only the starch content but also its composition. Most starches from grain legumes also have a relatively high amylose (i.e., the inner portion of a starch granule) content compared to most starches.

Cooking legumes can significantly increase the rapidly digestible starch and decreases the resistant starch. Known as a prebiotic, resistant starch passes through the stomach and small intestine undigested. In the colon, it is digested along with dietary fiber to stimulate the growth of “good bacteria” and produce fatty acids that researchers have determined have anti-cancer properties.

It is thought that certain legume genes that affect starch synthesis might enable legume starch to be used for a wide range of food and non-food applications. Part of the interest is due to the beneficial health effects offered by legume starch. Their low glycemic index is, for example, credited with contributing to the prevention of diseases related to insulin resistance.

Legume starch has unique properties, including a good stability at high temperature and high point viscosity compared with cereal or tuber starches. These properties can be further improved by starch processing, including using chemical and biotechnological methods.

As with protein, legume seeds can be fractionated to capture the desired starch concentrates and isolates. Pea starch, for example, is usually made available as a byproduct of protein extraction. This makes it a relatively cheap source of starch compared to corn, wheat, and potato. Among dry pea varieties, the Miami and Nitouche have the highest starch content at 45 percent and 44 percent, respectively, while Majoret has the lowest at 41 percent.

Pea starch is used in some industrial applications like the paper and board industries, among detergent manufacturers, in the water-treatment industry, and for production of textiles, plastics, and pharmaceuticals. It is also an integral part of noodle manufacturing in China.

To date, starch from peas is used in deep-frozen dishes, dressings, extruded bakery products, cookies, crackers, sauces, instant soups, and puddings. They are often incorporated to modify food texture, which is important both for processing and consumer acceptance.

Fiber Content

Legumes have more dietary fiber than any major food group. One-half cup of cooked split peas provides 10 grams of dietary fiber or 40 percent of the daily recommended 25 grams (based on a 2000-calorie diet). Servings of the most commonly consumed grains, fruits, and vegetables contain 1 to 3 grams of dietary fiber.

Some fibers are soluble and others insoluble. Most plant foods contain some of each kind. Soluble fiber can slow the absorption of lipids and lower blood cholesterol. It can also slow the increase of fecal bile excretion, promoting reduced intestinal absorption of fat and cholesterol. Insoluble fiber assists in maintaining regularity and helps prevent gastrointestinal problems.

When legumes are part of a diet low in saturated fat and cholesterol, dietary soluble fiber may actually reduce the risk of coronary heart disease. The exact mechanism by which this happens remains unknown, but scientists theorize that insoluble fiber adds bulk to stool, which in turn dilutes carcinogens and expedites their passage through the lower intestines and out the body.

The typical American eats only about 11 grams of fiber a day, according to the American Dietetic Association. Health experts recommend a minimum of 20 grams per day, or 40 percent of the daily recommended 25 grams of fiber for adults.

The production of legume starches remains small when compared to the 6 million tons of starch produced each year. However, thanks to the characteristics of legume starches, especially their amylose content, food producers and others see a large potential for new applications targeted at industrial uses and human nutrition.
The cell walls of the cotyledons contain a range of polysaccharides, including pectic substances (about 55 percent), cellulose (about 9 percent), and non-starchy non-cellulosic glucans (i.e., a polysaccharide that is a polymer of glucose) (6 percent to 12 percent). The seed coat contains large quantities of cellulose (35 percent to 57 percent) and lower amounts of hemicelluloses (i.e., polysaccharides that are more complex than a sugar and less complex than cellulose) and pectins (i.e., a water-soluble carbohydrate).

In terms of its use, inner fibers are generally employed in texturing or bulking of products. In many cases, they can replace food additives, offering the benefit of more favorable labeling of the product. The fiber is most commonly used in baked goods, particularly biscuits, and to enrich mousses, jellies, drinks, and desserts.

The outer fiber is used primarily to enrich the fiber content of food, but without changing its technical properties. It is found mostly in bakery and extruded products, snacks, and cereals.

Processing can be applied to improve the functional characteristics of fiber. For example, a mixture of cellulose and appropriate enzymes has been used to enhance important characteristics like mouthfeel and smoothness. Success in this regard is influenced by the fiber dimensions, porosity, hydration, and rheological and fat-binding properties.

The dietary fiber is captured as a byproduct of the process of fractionation in which protein and starch concentrates are obtained from legume seeds. Preparations are generally richer in dietary fiber when obtained from hulls. Cotyledons contain variable amounts of starch and protein, while the inner-fiber exhibits higher water-retention capacity than outer fibers.

**Micronutrient Profile**

Lentils, dry peas, and chickpeas are good sources of important minerals like iron, magnesium, phosphorous, and manganese. They also contain significant amounts of phosphorous, and the B vitamins, which play a key role in cellular metabolism. Lentils and chickpeas provide zinc as well.

While the iron aids in the prevention of anemia, zinc is one of several nutrients necessary for fending off infections. What’s more, eating the recommended portion of legumes helps avoid the low magnesium that can come from a diet too heavily weighted with refined grains and cereals. Lentils and chickpeas also boast among the highest concentrations of folate (or folic acid as it is called when used in supplements), a single cup providing 37 percent of the recommended daily allowance.

**Quick Facts**

**Legumes contain:**

- 3 times as much iron as meat
- 2 times as much magnesium as rice
- 4 to 5 times as much potassium as meat
- 2 times as much phosphorous as 2 pounds of eggs, 3 times as much as a two pounds of meat

processing of the legume. In most legumes consumed by humans, the content ranges from 6 percent to nearly 28 percent, with soluble fiber in the range 3.3 percent to 13.8 percent. Dietary fiber content in the cotyledon of legume seeds is generally low compared to that of the testa, or outer seed coat.

The fiber from legume seeds boasts excellent water hydration properties that can be utilized in food products to replace fat in items including confectionery products, dressings, and meat. Such fiber provides a broad range of positive effects, both physiological and metabolic, related to the source of the fiber (from cotyledon or hull), with the nature of that benefit being dependent on the form in which the fiber is ingested.

The composition of the dietary fiber depends very much on its location in the seed coat (outer fiber) or in the cotyledons (inner fiber). A major difference between the inner and outer dietary fiber is the amount of cellulosic and non-cellulosic polysaccharides present.

A form of the water-soluble vitamin B9, folate is essential for growth and good health. But because it is not made by the body, it must be obtained from foods and supplements. For this reason the Food and Drug Administration (FDA) instituted rules in January 1, 1998, that grain products such as breads, macaroni, rice, corn meal, and enriched flours are required to be fortified with folic acid.

Among its many health benefits, folate is necessary for the formation and development of new and normal tissue. Because new tissue forms at a rapid pace during pregnancy, the body’s need for the important nutrient nearly doubles at that time, helping prevent anemia and the risk of neural tube defects such as spina bifida.

Folate also helps break down homocysteine (i.e., an amino acid associated with heart disease) in the body, improves metabolism functions as well as the immune and nervous systems, and promotes cell growth and division. New research suggests that folate may reduce asthma and allergy suffering as well.

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