Chickpea

Annual leguminous plant (see legume), grown for food in India and the Middle East. Its short hairy pods contain edible seeds similar to peas. (*Cicer arietinum*, family **Leguminosae**).

**Abstract**

Chickpea was one of the first legume crops domesticated. Today, it is a key component of cropping systems in many parts of Asia and Africa, providing families of resource-poor farmers with a valuable source of dietary protein. Chickpea has become established in some agriculturally advanced nations in response to a growing world demand. This article describes the species, its uses, and role in farming systems around the world.

**Keywords**

Besan, Break crop, *Cicer*, Desi, Dhal, Diploid, Grain, Kabuli, Legume, Protein

**Topic Highlights**

- Chickpea is an annual legume belonging to the *Cicer* genus.
- Seed shape separates the species into three main groups: desi, kabuli, and pea.
- Chickpea is a key dietary component in many countries where vegetarian diets dominate or animal protein is too expensive.
- Chickpea is grown mainly as a sole crop in a range of rotations.
- World production averages 10 Mha annually.
- India produces more than 67% of the world's annual production.

**Learning Objective**

- To achieve understanding of the agriculturally important species in both farming systems and its end uses

**Introduction**

Chickpea (*Cicer arietinum* L.) is a herbaceous, annual legume. Plants are typically short (20–50 cm) with a semierect to erect growth habit and a variable number of primary and secondary branches. An imparipinnate leaf type, producing 11–18 small leaflets, gives the foliage its distinct fernlike appearance (Figure 1). Chickpea is a long day plant; however, time to flowering is accelerated by increasing temperature. Flowering is indeterminate with single (rarely double), small purple or white flowers produced on racemes arising from the leaf axil. Pods have a characteristic oval to rhomboid shape and inflate rapidly after (self-) fertilization (Figure 1). All aerial plant parts excepting flowers have a dense covering of fine hairs, which secrete a mixture of organic acids. Roots are colonized by *Mesorhizobium*...
ciceri, a nitrogen-fixing bacterium specific to the genus Cicer. Nodules formed by these bacteria vary in size, the largest approaching 3 cm in diameter. The seed is highly variable in appearance but invariably possesses the characteristic chickpea ‘beak’ protruding over the embryo. Seed shape, color, and, to a lesser extent, size separate the species into three main groups: ‘desi,’ ‘kabuli,’ and ‘pea’ (Figure 2).

Figure 1 Chickpea branch showing typical leaf and pod shape. (Chickpea normally produces single, axillary flowers; the ‘double-podded’ variant shown here may confer some yield advantage in low-productivity environments.)

Figure 2 Seed type in chickpea showing, clockwise from top of picture: kabuli, desi, and pea (intermediate) forms.

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Desi (derived from the Hindi and Urdu word for ‘native’ or ‘local’) seeds have an angular shape and thick, colored (mostly brown) seed coat. In contrast, kabuli seeds have a more rounded shape and thin, white to cream-beige seed coat. There is considerable overlap between these two seed types in seed size; however, desi seeds are generally smaller (weighing 80–350 mg) than kabuli seeds (100–750 mg). The pea-type seed has little commercial significance.

**Origin and Spread**

The genus *Cicer* contains 43 species, 34 perennial and 9 annual. All annual species are diploids and have 16 chromosomes (*2N* = 16). Among these, *C. reticulatum* is the most closely related to the cultivated chickpea and the presumed progenitor. Domestication occurred about 10,000 years ago in the region of southeastern Turkey, part of the ‘Fertile Crescent.’ Recent evidence suggests this occurred as a single event due to the limited geographic distribution of the wild species populations and the very low genetic variation of the cultigen. About 4000–5000 years ago, the domesticated forms, initially desi types, commenced a westward movement along established trade routes toward the Mediterranean. Subsequent spread to southern Europe and North Africa, including Ethiopia, occurred by land and/or sea routes. Differentiation of the kabuli type is thought to have occurred in the Mediterranean region in comparatively recent times. The eastward movement of desi types to India commenced about 4000 years ago, whereas kabuli types did not arrive there until about 300 years ago. (The prominence of Kabul on the ‘Silk Road’ suggests both an overland introduction and the origin of the word ‘kabuli.’) In the sixteenth century, Spanish and Portuguese travelers carried kabuli types to South and Central America where they came to be known by their Spanish name ‘garbanzo.’ Chickpea industries have comparatively recent histories in the United States (1950s), Australia (1970s), and Canada (1990s).

**Production**

During the 1990s, world chickpea production has averaged 8 million tonnes (Mt) from 10.5 million hectares (Mha). In the 2000s, this increased to 8.5 Mt from a similar area, with the increased production coming from increased yield. Crop area for the past 3 years (2011–2013) has averaged 13 Mha, which is the highest 3-year average production (Figure 3). Historically, Asia has been the major chickpea producer. For years 2009–2013, it accounted for 85.1% of all production, followed by Australia (5.3%), Africa (5.0%), Americas (3.8%), and Europe (0.9%). Desi types contribute ~70% of production worldwide. Chickpea is cropped in approximately 80 countries. India produces two-thirds of the world crop (Table 1), and after a steady decline in the 1990s, production has been increasing in recent years. A similar trend has occurred in Pakistan, the world’s second largest producer. In European countries, chickpea production has fallen dramatically, by 60–97% since the 1960s. On the other hand, production has risen significantly in some countries. In Australia, the world’s fourth largest producer, chickpea area increased rapidly during the 2000s as the demand increased for cereal break crops and alternatives were sought for nitrogen fertilizer. Expanded chickpea areas in African countries such as Ethiopia, Malawi, and Tanzania have also helped stabilize or even increase world production in recent years. Average world yield over the period 2009–2013 was 925 kg ha⁻¹. Central and North America had the highest yields (1772 kg ha⁻¹) followed by Europe (1529 kg ha⁻¹), Australia (1222 kg ha⁻¹), Africa (1076 kg ha⁻¹), and Asia (883 kg ha⁻¹). Yields were generally highest in countries where all or most of the crop was irrigated, such as Israel (4723 kg ha⁻¹), Lebanon (2592 kg ha⁻¹), and Egypt (2071 kg ha⁻¹).

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Table 1 Mean area, production, and yield of chickpea in major chickpea-producing countries (2009–2013)

<table>
<thead>
<tr>
<th>Country</th>
<th>Area (ha)</th>
<th>Production (tonne)</th>
<th>Yield (kg ha&lt;sup&gt;−1&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>8 634 000</td>
<td>7 858 400 (67.8)</td>
<td>910</td>
</tr>
<tr>
<td>Pakistan</td>
<td>1 049 660</td>
<td>568 000 (4.9)</td>
<td>543</td>
</tr>
<tr>
<td>Iran (Islamic Republic of)</td>
<td>549 175</td>
<td>275 385 (2.4)</td>
<td>502</td>
</tr>
<tr>
<td>Australia</td>
<td>509 162</td>
<td>609 402 (5.3)</td>
<td>1222</td>
</tr>
<tr>
<td>Turkey</td>
<td>437 471</td>
<td>520 935 (4.5)</td>
<td>1191</td>
</tr>
<tr>
<td>Myanmar</td>
<td>326 106</td>
<td>461 708 (4.0)</td>
<td>1414</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>202 927</td>
<td>333 377 (2.9)</td>
<td>1673</td>
</tr>
<tr>
<td>Malawi</td>
<td>115 545</td>
<td>61 075 (0.5)</td>
<td>526</td>
</tr>
<tr>
<td>Mexico</td>
<td>92 938</td>
<td>163 674 (1.4)</td>
<td>1705</td>
</tr>
<tr>
<td>United Republic of Tanzania</td>
<td>77 083</td>
<td>74 425 (0.6)</td>
<td>938</td>
</tr>
<tr>
<td>Syrian Arab Republic</td>
<td>76 944</td>
<td>52 749 (0.5)</td>
<td>685</td>
</tr>
</tbody>
</table>

* Percentage of world production in brackets.

Data from FAO.

Figure 3 World area, production and yield of chickpea, 1961–2013. Each datum is the mean for a 3-year period.

Source: FAO.

Consumption and Trade

Chickpea is an important part of the diet in most producing countries and is gaining in popularity.
elsewhere. Per capita consumption is generally much higher in producing countries, such as India (5.1 kg pc) and Pakistan (4.4 kg pc), than in developed, nonproducing countries such as the United Kingdom (0.2 kg pc). Consumption is also comparatively high in some wealthier, producing countries such as Turkey (6.3 kg pc) and Spain (2.3 kg pc). Historically, most chickpeas were consumed in their country of origin. Until the late 1970s, international trade accounted for only 2% of world production. This percentage rose to 9% in the following three decades as demand exceeded supply in major producing countries, especially in east Asia. During the period 2008–2011, India was the largest importer (183,000 tonnes) followed by Pakistan (177,000 tonnes) and Bangladesh (129,000 tonnes). For the same period, Australia was the largest exporter (414,000 tonnes), followed by India (154,000 tonnes) and Mexico (104,000 tonnes). India's position as the second largest exporter of chickpea is driven by a rapid increase in the production of large kabuli types. Globally, the volumes of desi and kabuli types now traded are similar. Prices fluctuate according to supply and demand; however, there is generally a premium for kabuli types and particularly for those with large seed (diameter 9–11 mm).

Role in Farming Systems
Chickpea is grown in a range of environments encompassing extensive variation in latitude (53° N to 39° S), altitude, soil type, photoperiod, temperature, and rainfall. Seven broadly different regions can be distinguished.

Indian Subcontinent (India, Pakistan, Nepal, Bangladesh, and Myanmar)
Desi types predominate in this region; however, the production of kabuli has expanded rapidly in recent years. Chickpea is typically grown as a ‘winter’ crop with sowing from October to December and harvest from February to April. The crop is mostly rainfed, relying essentially on soil moisture conserved from monsoon rains; there is little effective growing season rainfall. Soil types vary from the heavy, black ‘cotton’ soils of central and southern India to the alluvial soils of the Indo-Gangetic Plain and the much lighter textured sands of Rajasthan in India and the Thal area of Pakistan. There has been a large shift in chickpea area from north to south over the past four decades.

Chickpea is grown mainly as a sole crop in a range of rotations. Where sufficient rainfall or irrigation allows, for example, in northwestern India or in the rice-based systems of northeastern India, Bangladesh, and Myanmar, chickpea follows rainy season crops such as rice, millet, sorghum, maize, sugarcane, cotton, guar, and sesame. However, in lower rainfall zones where only one crop per year is possible, chickpea is grown as a fallow crop. Less frequently, it is intercropped in varying proportions with Brassica spp., linseed, safflower, or sorghum or sown as a mixed crop with wheat, barley, linseed, or sorghum.

Fertilizer and pesticide use is generally low and there is minimal mechanization of sowing, harvest, or weed, insect, and disease control. Traditionally, these operations are performed by hand or with the assistance of animal drawn implements, although some regions are introducing mechanized processes.

West Asia, North Africa, and Southern Europe
Production in this region is almost exclusively of kabuli types. The crop is grown at high altitudes in west Asia (Afghanistan, Iran, and Turkey) but at comparatively lower altitudes in the Middle East (Syria, Yemen, Jordan, Israel, and Iraq), North Africa (Egypt, Sudan, Algeria, Tunisia, and Morocco), and southern Europe (Greece, Italy, Spain, and Portugal). It is grown as a ‘spring’ crop in this Mediterranean-type environment, relying mainly on growing season rainfall. Winter sowing occurs in Egypt and Sudan. Sowing is usually delayed until late February to May to minimize losses from cold and/or ascochyta blight.
Rapidly increasing temperatures and moisture stress in summer hasten maturity and limit crop duration to 90–120 days.

Chickpea is generally confined to areas having an annual rainfall above 400 mm. It is grown as a sole crop in rotation with wheat (bread or durum) or barley; a fallow phase or summer or forage crop may be included in drier areas. There is some mechanization of production, particularly sowing and weeding, but harvest is still largely manual. High labor costs have contributed to the decline in chickpea production in parts of the region, especially in Europe.

East Africa (Ethiopia, Eritrea, Kenya, Tanzania, Malawi, and Uganda)

Mostly desi and some kabuli chickpeas are grown in this region, usually at high altitudes (up to 2400 m). The area of kabuli is increasing in some countries with the introduction of improved varieties and is up to one-third of the crop in Ethiopia. Crops are mainly sown as pure stands in rotation with wheat, barley, and teff, but to a lesser extent as mixtures with sorghum, safflower, and maize. Crop growth relies mainly on residual soil moisture. Sowing follows the wet season, from July to early September in Ethiopia and from February to April further south. Inputs of fertilizers and pesticides are minimal, and although there is some use of tractors in sowing, harvest and threshing remain manual operations.

Central and Southern America (Mexico and Argentina)

In Mexico, desi chickpeas are produced under rainfed conditions in the west-central parts of the country and kabuli types under irrigation in the drier northwest. Chickpea is grown as a ‘winter’ crop following maize in the west-central region and following soybean or sesame in the northwest. Sowing is from October to December and harvest from March to May. There has been some recent transition to mechanized production, particularly for kabuli types. Production in Argentina has recently increased to 40 000 ha of kabuli type. It is sown from April to July.

North America (Canada and the United States)

The North American chickpea industry began in coastal districts of California where spring-sown kabuli crops were grown on residual soil moisture. Later, winter crops were grown under irrigation in the drier San Joaquin Valley. During the 1980s, both desi and kabuli chickpeas were introduced to the Palouse region of northwestern United States and, in the following decade, to the brown and dark brown soil zones of Saskatchewan and Alberta in Canada. Current production areas are the Pacific Northwest in the United States and the province of Saskatchewan in Canada. The threat of cold and ascochyta blight forces chickpeas to be grown as a ‘spring crop’ in both these regions. Sowing commences in May and harvest, particularly in Canada, needs to be completed by September to avoid freezing injury to immature seeds. In the United States and Canada, all stages of chickpea production, including seed inoculation; sowing; weed, disease, and insect control; harvest; and seed drying, are highly mechanized. In most cases, the machinery and processes have been modified from those used in cereal production.

Australia

National production (≈ 90%) is mainly desi type and this predominantly occurs in the summer rainfall-dominant regions in the northeast of Australia. In the winter rainfall-dominant Mediterranean-type environments in the southeast and southwest, production in the southeast region is mainly kabuli type. Chickpea is grown as a ‘winter’ crop, sown from May to July and harvested from October to January. Most crops are produced under rainfed conditions; incrop rainfall is a major yield determinant in most regions, especially in the southeast and southwest. As in North America, production is highly mechanized. Control of ascochyta blight, the major industry problem in most regions, relies heavily on
ground rig application of foliar fungicides. In northeast Australia, *Phytophthora* root rot is a common biotic constraint, particularly in seasons conducive to the disease.

**Production Constraints**

There is a large discrepancy between the yield in farmers’ fields and that commonly obtained under experimental conditions. The low yields generally obtained by farmers reflect a plethora of problems that beset the crop. The major production constraints and their impacts are described below.

**Physical Constraints**

**Drought and Heat**

Chickpea is mostly grown in low rainfall environments. Inadequate soil moisture is therefore a critical production constraint and may occur throughout the growth cycle. Winter/spring rains in west Asia, or soil moisture remaining from the wet season in the Indian subcontinent and East Africa, may not be sufficient for farmers to sow; for many regions, variability in main season rainfall explains much of the year-to-year variation in chickpea area. Receding soil moisture, particularly in low rainfall areas in India and Pakistan, may also be inadequate to sustain seedlings. Intermittent moisture stress of established crops can result from breaks in winter and early spring rainfall, but a more serious problem is terminal moisture stress suffered by spring-sown crops (and winter crops in the Indian subcontinent) as podding coincides with rapidly declining soil moisture. Terminal drought is a major constraint in an estimated 80% of the global chickpea area.

Heat stress (temperature >35 °C) during the reproductive phase has become a serious constraint as chickpea moves from cooler long-season environments to warmer short-season environments, an increased area under later sowing, and expected increases in temperatures due to increased climate variability.

**Cold**

Low temperatures affect the plant in two main ways: tissue damage through disruption of cell membranes and abortion of flowers. Sensitivity to low temperatures (<−5 °C) is one reason for spring sowing in higher elevation areas of west Asia. However, genotypes have now been identified that can survive temperatures as low as −25 °C. Winter sowing of these cold-tolerant genotypes can increase yield potential by ~70% through increased biomass production and improved water-use efficiency. Where the crop is sown in autumn/winter, such as in northern India, Pakistan, and Australia, chilling damage in the early flowering phase narrows the ‘window’ for pod setting. Sowing is normally delayed so that commencement of flowering coincides with mean daily temperatures favorable for podding (15 °C).

**Hostile Soils**

A range of soil chemical and physical problems limit chickpea growth. The most important of these is salinity, since chickpea is comparatively intolerant of the ionic imbalances characteristic of ‘saline’ soils. ‘Sodic’ soils, in which high levels of exchangeable sodium are associated with increased bulk density, low water infiltration, and poor aeration, are also common in northern India and in other regions where soil pH is very high. Retarded root growth and poor nodulation inhibit chickpea growth and productivity under such conditions. Other locally important soil factors are acidity (poor nodulation), deficiencies of iron and zinc, and either a deficiency or toxicity of boron.

**Diseases**

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Ascochyta Blight

Ascochyta blight is the most important disease of chickpea worldwide and has been recorded in nearly all producing countries. Recent epidemics in the United States (1980s) and Australia (1990s) caused major industry disruptions, reflected by a sharp decline in the area sown. Elsewhere, for example, in west Asia and the Mediterranean region, the threat of ascochyta blight causes sowing to be delayed, thereby significantly reducing yield potential. The causal agent of ascochyta blight is *Ascochyta rabiei* (Passerini) Labrousse (syn. *Phoma rabiei* and teleomorph *Didymella rabiei* (Kovachevski)), a fungus spread by infected seed and crop residues, long-range dispersal of sexually produced ascospores, or, within the crop, short-range dispersal of asexually produced pycnidiospores. Lesions are formed on leaves, stems, pods (Figure 4), and seeds. The disease progresses quickly under favorable wet conditions and can cause total crop failure. Ascochyta can be controlled by an integrated disease management approach based on host resistance and, depending on location, removal of infected plant debris, delayed sowing, seed dressing, and foliar fungicides.

![Figure 4 Ascochyta blight on pods. The concentric rings of dark-colored pycnidia (fruiting bodies) are a useful diagnostic feature for this disease in chickpea.](https://search.credoreference.com/content/topic/chickpea)

**Other Foliar Diseases**

Botrytis gray mold (*Botrytis cinerea* Pres.) is the most important of the foliar diseases after ascochyta. The pathogen has a very broad host range; therefore, the disease is widely distributed. Most damage occurs under high humidity and generally at temperatures higher than optimum for ascochyta. Botrytis has contributed to the decline of the Bangladesh chickpea industry and has also caused significant or total crop losses in the higher rainfall zones of northeastern India and in Australia. The following diseases are also regarded as locally significant: sclerotinia stem rot (*Sclerotinia sclerotiorum* (Lib.) de Bary), phoma blight (*Phoma medicaginis* Mallr. and Roumeguère), alternaria blight (*Alternaria alternata* (Fries:Fries) Keissler), stemphylium blight (*Stemphylium saraciniforme* (Cavara) Wiltshire), and rust (*Uromyces ciceris-arietini* Jaczewski in Boyer & Jaczewski).

**Fusarium Wilt**

Fusarium wilt is the other major disease of chickpea and, like ascochyta blight, causes economic
damage in a large number of producing countries. It is a soil- and seed-borne disease caused by
different races of the fungus *Fusarium oxysporum* f.sp.*ciceris* Matuo and K. Sato. The races are
differentiated on their ability to incite specific reactions causing two types of symptoms: yellowing
syndrome and wilting syndrome. The wilting syndrome is more destructive and economically more
important than yellowing syndrome. Fusarium wilt is more frequently expressed under warm, dry
growing conditions and is therefore a greater problem in the Indian subcontinent and in regions where
the crop is spring-sown. Fungicidal seed dressings provide protection against seed-borne infection, but
the longevity of the pathogen in soil makes host resistance the most successful way of combating the
disease.

**Root and Collar Rots**

A number of fungal root or collar diseases have the potential to inflict significant yield losses. Dry root
rot (*Rhizoctonia bataticola* (Taubenhaus) Butler) is the most important of these, especially on the
Indian subcontinent. The disease generally presents as a sudden drying of scattered plants at the
podding stage and is favored by hot, dry conditions. Other diseases include wet root rot (*Rhizoctonia
solani* Kühn), black root rot (*Fusarium solani* (Martius) Saccardo), collar rot (*Sclerotium rolfsii* Saccardo),
and phytophthora root rot (*Phytophthora medicaginis* Hansen and Maxwell). The latter has been
recorded in a number of countries, but economically significant damage has only been observed in
northeastern Australia where it is the major production problem.

**Viruses**

Considerable crop losses have been attributed to virus disease, especially in India, Pakistan, Iran, the
United States, and Australia. In most cases, a complex of viruses has been implicated. Aphids,
particularly *Aphis craccivora* Koch, are almost always the vector responsible for disease transmission. In
India, chickpea stunt is the name given to a syndrome characterized by foliage discoloration (red in desi
and yellow in kabuli), stunting, phloem browning, and plant death. The disease has been ascribed to the
leafhopper-transmitted chickpea chlorotic dwarf virus and some aphid-transmitted luteoviruses,
including bean leafroll luteovirus. Other viruses known to cause disease are alfalfa mosaic virus,
cucumber mosaic virus, beet western yellows virus, and subterranean clover red leaf virus.

**Nematodes**

Nematodes reduce yield by colonizing and damaging roots, reducing the efficiency of nitrogen fixation
and in some cases acting synergistically with fungal diseases such as fusarium wilt. Many nematode
species are known to infect chickpea although only three are considered economically important. Root-
knot nematodes (*Meloidogyne* spp.) cause abundant formation of galls, whereas both cyst nematode
(*Heterodera ciceri* Vovlas, Greco & di Vito) and root-lesion nematodes (mainly *Pratylenchus thornei*
Sher and Allenand and *P. neglectus* (Rensch) Chitwood and Oteifa) damage root cellular tissue causing
necrotic regions. Root-knot nematodes and root-lesion nematodes have an extensive host range and
are widely distributed; cyst nematode has a very limited host range and its distribution is confined to
the Middle East.

**Insects**

The small number of insect pests causing economic damage to chickpea is attributed to the antibiotic
effect of the plant’s acidic (mainly malic acid) exudate. The most widespread and damaging pest is the
pod borer (*Helicoverpa* spp.). Various larval instars feed on leaves, flowers, and pods. Most yield loss is
caused when late instar larvae enter the pod and partly or fully consume the developing seed. There is
little effective host resistance within chickpea so control is reliant on a combination of chemical and biopesticides (such as nuclear polyhedrosis virus). Genetic transformation has been used to develop chickpea containing the toxins from the bacterium Bt and it is currently undergoing field testing.

The other major field pest is leaf miner (*Liriomyza cicerina* (Rondani)) whose distribution is confined to the Mediterranean region. Larvae tunnel through the leaf parenchyma causing loss of photosynthetic tissue and premature leaf drop. Infestation of stored seed is mainly by small bruchid beetles (*Callosobruchus* spp.). Larvae emerge from eggs laid on the (stored) seed surface and tunnel beneath the seed coat where they feed and pupate. Adults emerge from the seed, ready for the next life cycle and leaving a substantial cavity.

**Weeds**

Chickpea's slow early growth and low total biomass predispose the crop to severe weed competition. In most countries, weed control is done by manual weeding or cultivation by animal- or tractor-drawn implements. These practices are feasible where crop area is small, although yield potential is often compromised where wide rows are employed to facilitate cultivation. Options for pre- and postemergent control of both grass and broadleaf weeds are now available and used extensively in Australia, the United States, and Canada. Grass herbicides are very effective, have no toxicity to chickpea, and contribute to the productivity of ensuing cereal crops by eliminating graminaceous diseases that can otherwise survive on grass weeds. The development of herbicide-tolerant varieties will also provide further weed control options.

**Utilization**

**Nutritional Status**

Desi chickpea seeds are composed of the embryo (1.5%), seed coat (15.5%), and cotyledons (83%); the seed coat fraction of kabuli seeds is much lower (6.5%), resulting in a higher cotyledon fraction (92%). Protein averages 23% and is deficient in the sulfur-containing amino acids methionine and cystine. Carbohydrate, the main constituent, averages 63.5% of total seed and is mainly starch. Soluble sugars comprise ~10% of the starch and include oligosaccharides such as stachyose and raffinose that cannot be broken down by human digestive enzymes. Gases produced by bacterial degradation of these oligosaccharides cause flatulence and intestinal discomfit. Oils comprise ~5% of the seed but are well below commercially extractable levels. Chickpea is generally low in antinutritional factors such as protease and amylase inhibitors, whose activities are further reduced by cooking, and protein-binding phenolics, which are largely removed with processing.

**Uses and Processing**

Chickpea is a key dietary component in many countries where animal protein is too expensive or in other countries where the crop has a long history of cultivation and consumption. The complementarity of pulse and cereal proteins has given rise to many traditional dishes in which chickpea is combined with wheat, rice, or some locally important cereal, such as teff, to provide the bulk of dietary protein and calories. The use of chickpea as human food is hugely varied, reflecting both the crop’s antiquity and its broad cultural base (Table 2). The mature seed, either whole or processed, accounts for nearly all consumption. However, there are specialty uses for the green, immature plant. Fully podded plants are commonly sold in street markets in India and the Middle East. The seeds are either roasted in the pod, consumed raw as a snack, or boiled; fresh leaves are also used as a vegetable. Ripe seeds (desi and kabuli) are presoaked and boiled, with or without the addition of vegetables or meat, to produce a
range of traditional dishes. Kabuli seeds are also canned after cooking, but a more important use is as hommos bitihneh (pureed and mixed with oil). Both desi and kabuli seeds are also roasted. This process generally requires a quick soaking followed by high-temperature treatment (e.g., at 250 °C) for 2–3 min in preheated sand or an oven. Variations to the soaking, roasting, and final processing (e.g., decortication, polishing, or sugar coating) give this snack food its regional characteristics.

<table>
<thead>
<tr>
<th>Plant/seed part used</th>
<th>Process/product</th>
<th>Country/region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green leaves</td>
<td>Boiled as vegetable</td>
<td>Indian subcontinent (ISC)</td>
</tr>
<tr>
<td>Immature plant</td>
<td>Roasted, pods shelled</td>
<td>ISC, Middle East, Ethiopia</td>
</tr>
<tr>
<td>Unripened pods</td>
<td>Pods shelled, seeds raw or boiled</td>
<td>ISC, Ethiopia, Turkey</td>
</tr>
<tr>
<td>Whole seed – kabuli</td>
<td>Soaked, boiled alone or with vegetables, rice, meat, spices</td>
<td>Most countries</td>
</tr>
<tr>
<td></td>
<td>Soaked, boiled, canned</td>
<td>North America, Europe, Australia, Middle East</td>
</tr>
<tr>
<td></td>
<td>Soaked (briefly), roasted</td>
<td>Middle East, North Africa</td>
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<tr>
<td></td>
<td>Soaked, boiled, pureed (hommos)</td>
<td>Middle East, North Africa</td>
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<tr>
<td>Whole seed – desi</td>
<td>Soaked, boiled with vegetables, rice, spices</td>
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<td>Soaked (briefly), roasted</td>
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<td>Flour (besan)</td>
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<tr>
<td></td>
<td>Mixed with wheat flour, bread</td>
<td>ISC, Middle East</td>
</tr>
</tbody>
</table>

Most desi seeds are milled to produce dhal, a process that involves removal of the seed coat and cleaving of the cotyledons (Figure 5). Milling of chickpeas is a major industry in the Indian subcontinent and the newer high-throughput mills achieve a dhal yield close to the theoretical maximum of 83–85%. Dhal is the main form of consumption in the Indian subcontinent; the prepared dish, also called ‘dhal,’ is almost always part of the main meal. The third main use of chickpea is as ‘besan,’ the flour milled from...
Besan is used for a range of purposes, most commonly as a batter or to produce fried, extrusion products.

Figure 5 Dhal produced from desi seeds following removal of the seed coat and separation of the cotyledons.

Chickpea also plays an important, if secondary, role in animal nutrition. In Mexico, desi types are grown specifically for inclusion in pig rations. Elsewhere, residues from processing (seed coat and kibble from milling and damaged or undersized seeds from grading) are routinely used in intensive livestock production. Residues from harvest (stems, leaves, pods, and seeds) are also a valuable feed source for ruminant animals.

**Genetic Improvement**

Worldwide, there has only been a limited breeding effort in chickpea compared to the major cereals and oilseeds. Primitive landraces still account for much of the crop area in developing countries despite the new varieties being released by national programs and the major international centers ICRISAT and ICARDA. Major breakthroughs have been achieved in developing resistance to the major diseases ascochyta blight and fusarium wilt. Cold tolerance, coupled with ascochyta resistance, has been deployed in new varieties that enable winter sowing in traditional spring-sowing areas, and early maturing varieties, providing some escape from drought, have facilitated the wider adoption of chickpeas in central and southern India. Mechanization of harvest has been facilitated by the development of erect plant types, which grow up to 1 m tall and have stronger, more lodging-resistant branches than the traditional semierect forms.

There is a paucity of genes for many economically important traits in *C. arietinum*, presumably as a consequence of the genetic ‘bottleneck’ caused by domestication. However, genes conferring improved resistance to many biotic stresses, such as bruchids, cyst nematode, and phytophthora root rot, can be found in either or both the closely related ‘wild’ species *C. reticulatum* and *C. echinospermum*. Breeding programs are regularly using backcross programs to incorporate a range of attributes from these species into adapted backgrounds. Introgression of genes from unrelated taxa has also been achieved by *Agrobacterium*-mediated transformation. ‘Transformed’ plants containing genes with the potential to confer improved protein quality and insect and disease resistance have been developed to undergo field evaluation.
In recent years, there have been major advances in chickpea genomic resources; saturated genetic maps and the publication of genome sequences of kabuli and desi chickpea types are key steps that will allow researchers and breeders to develop a full understanding of the variations found in each genotype.

Exercises for Revision

- Why are chickpeas and other grain legumes important for sustainable farming systems?
- What are the three main groups of the species and how do their end uses differ?
- What is the most important disease of chickpea worldwide?
- What are the main abiotic constraints of chickpea?
- What is the average protein content of the grain?
- Which two wild relatives of chickpea are being exploited by breeding programs?

Exercises for Readers to Explore the Topic Further

- The Cicer genus contains nine annual species. How diverse are they and what is their potential for use in chickpea improvement programs?
- What are the products made from besan (chickpea flour) in the subcontinent?

See also

Agronomy of Grain Growing: Chickpea: Agronomy; Appendix 1: Nutrient-Composition Tables for Grains and for Grain-Based Products; Appendix 2: Lists of Standardized Testing Methods for the Analysis of Grain and Grain-Based Foods; Food Grains and the Consumer: Consumer Trends in Grain Consumption; Cultural Differences in Processing and Consumption; Fortification of Grain-Based Foods; Genetically Modified Grains and the Consumer; Grains and Health; Food Grains and Well-being: Functional Foods: Overview; Food-quality Testing: The Application of Sensory Science to the Evaluation of Grain-Based Foods; Grain Composition and Analysis: Standardized Test Methods for Grains and Grain-Based Products; The Composition of Food Grains and Grain-Based Products; Units of Grain Science and Trade: Equivalence between the US, Chinese, and Metric Units; Grains Around the World: Grain Production and Consumption: Europe; Grain Production and Consumption in Oceania: Australia and Pacific Countries; Grain Production and Consumption: Overview; Grain Production and Consumption: South America; Grain Production and Consumption: Africa; Production and Consumption of Grains: India; Non-food Products from Grains: Cereal Grains as Animal Feed; Proteins: Nitrogen in Grain Production Systems; Nitrogen Metabolism; Protein Synthesis and Deposition; The Protein Chemistry of Dicotyledonous Grains; Scientific Organizations Related to Grains: Research Organizations of the World: Asia-Pacific, Central–South America, and Africa–Middle East; Research Organizations of the World: CGIAR; The Basics: Taxonomic Classification of Grain Species; The Grain Chain: The Route from Genes to Grain-Based Products; The Grain Crops: An Overview; The Legumes and Pseudocereals: Grain Legumes and Their Dietary Impact: Overview.

Further Reading

- P.M. Gaur; A.K. Jukanti; R.K. Varshney Impact of genomic technologies on chickpea breeding

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- Saxena, N.P. Chickpea P.R. Goldsworthy; N.M. Fisher The Physiology of Tropical Field Crops 1984 Wiley Chichester 419-452.
- H.A. Van Rheeener; M.C. Saxena Chickpea in the Nineties 1990 ICRISAT Patancheru.
- S.S. Yadav; R. Redden; W. Chen; B. Sharma Chickpea Breeding and Management 2007 CAB International Wallingford.

Relevant Websites

- http://www.ars.usda.gov - R&D undertaken on chickpea in the USA.
- http://www.icarda.org - Information on kabuli chickpeas, mainly in Mediterranean-type environments.
- http://www.icrisat.org - Information on chickpeas (mainly desi) in semiarid areas.

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This article is a revision of the previous edition article by E.J. Knights, volume 1, pp 280–287, © 2004, Elsevier Ltd.

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