Onion

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Scientific Classification and Etymology

The onion is a subspecies and primary member of the genus *Allium*. Because many *Allium* species share the common name onion, the "garden onion"—also known as the "bulb onion" and "shallot"—is referred to as *Allium cepa*.[1] The plant's name comes from the Latin *unio*, or *annianus*, and is associated with the Welsh *einion*, meaning "anvil."[2]

Scientific Classification	
Kingdom	Plantae
Phylum	Magnoliophyta
Class	Liliopsida
Order	Asparagales
Family	Alliaceae
Genus	*Allium*
Species	*A. cepa*

Historical Origins

Onions were originally native to central Asia, but today have a worldwide geographic range. They made their way to Egypt via trade, where they became a crucial food plant in the ancient world. Because onions were a cheap source of food, Egyptian slave laborers, those who constructed the pyramids, consumed them on a daily basis.[3] In addition, they were depicted in the funerary paintings in tombs and even placed on and around mummies.[4] Ancient Sumerians widely grew and cooked onions 4,000 years ago, and the plant has been discovered at the royal palace at Knossos in Crete.[5] Additionally, the ancient Greek physician Hippocrates wrote in the fifth and fourth centuries B.C. that a broad variety of onions were eaten regularly in Greece.[6] In ancient India, however, there was a fair amount of revulsion to onions. Orthodox Brahmins, Hindu widows, Buddhists, and Jains regarded onions as forbidden vegetables because of their strong odor and stimulating action.[7]

An illustration of a chive and onion *Flora von Deutschland* by Dr. Otto Wilhelm, 1885 (http://en. wikipedia. org/wiki/Chives).

During the fourth century B.C., Alexander the Great transported onions from Egypt to Greece, where they spread to other parts of Europe following Alexander's conquests.[8] For centuries thereafter, Europeans cultivated onions, which became especially popular in cooking in places such as present-day Germany at the start of the Middle Ages.[9] By the

fifteenth century, Europeans began introducing different cultivars and landraces to parts of the New World. Christopher Columbus' crews planted onions in Hispaniola as early as 1494, and the vegetable was mentioned as cultivated in the present-day United States as early as 1629. By the nineteenth century, various types of onion were growing all across the U.S.[10]

Generally speaking, those varieties of onion adapted to northern Europe were introduced to New England and the mid-Atlantic region, and those grown in southern Europe were brought to southern states. Some of the northern landraces include Red Wethersfield, bred in the Connecticut River Valley around 1800, and Southport Yellow Globe, developed prior to 1835 in and around Southport, Connecticut.[11] Southern varieties include White Portugal (or Silverskin), an old European variety grown in North America before 1800, and Bermuda, a variety that originated in Italy and was first grown in southern Texas in the late-1800's.[12]

The list of major producers of dry onion effectively illustrates the expansive geographic distribution of onions. In 1996, China led the world with more than 9.6 million tons of dry onion produced, followed by India (4.3 million), the U.S. (2.7 million), Turkey (1.9 million), Japan and Iran (1.2 million apiece), Pakistan (1.1. million), and Spain (1 million).[13]

Horticulture and Plant Specifics

The common onion no longer grows in the wild, and so is known only in cultivation. Onion leaves are characterized as the thickened bases of the plant's normal leaves from the previous season.[14] The outermost leaf bases, rather than swelling, thin, dry out, and become discolored, and thus form a covering for bulbs. The visible portion of the plant generally flowers in the spring.[15]

Bulbs consist of the fleshy, enlarged leaf bases of onions, and form in response to specific day lengths and temperatures (activity called "photoperiodic response"). Photoperiodic response includes long day and short day. Long-day plants require a day length of more than fourteen hours in order to initiate bulb formation, while short-day varieties need between twelve and fourteen hours of daylight in order to form bulbs.[16] Short-day onions are generally grown in warmer climates, including the Middle East and southern Europe. For these varieties, bulb formation occurs in spring and bulb harvest is performed in early-summer. Long-day onions, cultivated in northern Europe for hundreds of years and subsequently taken to New England, have adapted to northern latitudes. Bulb formation for these varieties takes place during the summer months, with bulb harvest in late-summer and early-autumn.[17]

Cultivated *Allium cepa* is placed into one of two horticultural groups: the Common Onion group and the Aggregatum group. The former contains the typical bulb onion as well as the majority of existing cultivars. Onions in this group show dramatic variation in color and shape, photoperiodic response, storage quality and pungency, and many other

characteristics. Their bulbs are usually large and single.[18] Species assigned to the Aggregatum group have active lateral bulbs, and thus form clusters of smaller bulbs. One subdivision of this group, multiplier onions, consists of varieties that can contain as many as twenty small, short and wide bulbs.[19]

Cultivation

Despite their broad geographical distribution, onions are very sensitive to climate and soil. (In Europe, for example, onions had to be selectively adapted to local growing conditions.[20]) As a result, onions require a number of specific conditions in order to achieve optimal growth. These include bountiful sunshine; stone-free, loamy, well-irrigated soil; and excellent drainage.[21] Onions will not grow well in a clay soil or in a soil with a high salinity. Furthermore, because they have relatively shallow (yet thick) roots, onions require significant amounts of nitrogen, phosphorus, and potassium for maximum yield. The concentration of these elements in soil, as well as high temperature, high light intensity, and soil moisture, will affect flavor and bulb development.[22]

Onions can be grown from dry sets as well as by seed. The United States grows most of its onions by the first of these methods, as it offers growers a much better chance at obtaining a crop than does direct seeding.[23] Dry sets are generally planted as early in the spring as possible—usually when the soil temperature is about 40°F—so as to produce an early crop. Sets are often placed close together—about 2.5 to 3.5 inches apart in rows 12 to 16 inches apart—as a means of encouraging large bulb growth.[24] Compost and other organic matter are sometimes added to further enhance bulb size.[25]

Growing onions from seed requires a different series of steps. The eighteenth-century farmer and journalist William Cobbett discusses in *The American Gardener* three ways by which to produce crops from seed. The first approach suggests that growers plant seed thinly to depths of two inches and in rows one foot apart. The seed is raked over and the plants are thinned to four to eight inches once they reach a height of three inches. When the leaf tips turn brown, the necks of the leaves are bent to the ground. The onions are pulled up when the leaves are nearly dead, and are thereafter dried and stored. The second approach involves each of the aforementioned steps, but instead of planting seeds one foot apart, growers are encouraged to sow a handful every six to seven inches. This approach does not allow for the development of large onions,

"Harvested onions" (Egyptian "Walking" variety), from http://www.flickr.com/photos/ejchang/1479672268/.

but it does produce a great quantity of onions that ripen at an earlier date. The final method of cultivation calls for sowing seed six inches apart between April and mid-June and pulling the onions up when their stems turn yellow. The plants are dried on a board and, once their leaves become withered, are placed in a bag and stored in a dry location until spring. The onions are then planted about six to eight inches from each other in rows one foot apart, but are not covered over with earth, and are harvested in the late-summer or early-fall.[26]

Growers frequently harvest onions once the leaves of the plants have fallen over. Curing is necessary after harvest, unless the crop is to go to market immediately. It serves to dry the skins and tops of onions as a means of safeguarding the vegetables against microbial attack and bulb weight loss. An onion is said to be cured when its neck is tight, its outer scales are dry, and no more than 3 to 5 percent of its original bulb weight has been lost.[27] Following curing, onions are stored, frequently for upwards of six months. Cold storage at temperatures around 32°F, with a humidity of 70 to 75 percent, produces the best results, though onions stored in the tropics need to be kept warmer. In these cases, studies have shown that some bulbs can be stored at temperatures of 75° to 85°F or higher for a period of five to six months without sprouting.[28]

Pathogens and Pests

Onions are vulnerable to a handful of diseases and disorders courtesy of fungi, bacteria, viruses, and insects, among other sources. These include:

Downy mildew on onion stems (http://mtvernon.wsu.edu/path_team/Disease%20Gallery/dg94L.jpg).

Downy Mildew (*Peronospora farinosa*): First reported in England in 1841, this fungus spreads rapidly in wet and humid conditions. When attacked, bulb tissue softens and shrivels, and the outer scales become amber-colored, watery, and wrinkled. Early infection can kill younger plants. Surviving species can appear dwarfed, pale, and distorted. The seeds from infected plants can affect entire crops if sowed. Treatment with 2 percent of the pesticide Zineb in sprays and dusts has been shown to control the spread of mildew.[29]

Onion Smut (*Urocystis cepulae* and *Urocystis colchici*): This fungus likely originated in the United States and was first reported in England in 1918. Infection usually occurs two to three weeks after sowing and is characterized by elongated streaks that discolor scales and growing leaves, which may become thickened and malformed. Measures to control smut include avoiding affected areas, applying hexachlorobenzene fungicide pellets to infected plants, and dusting with thiram—a general use pesticide.[30]

Onion Smudge (*Colletotrichum circinans*): Onion smudge was first reported in England in 1851 and is common in Europe and the central and northeastern United States. The fungus primarily attacks white species of onion, is mostly confined to the neck and scales

of the bulb, and rarely attacks active parts of the plant. Symptoms include tiny green and black dots, often arranged concentrically, on outer scales and, on colored varieties of onion, sunken yellowish splotches on fleshy scales. Onion smudge tends to form in warm, moist conditions, and its threat can thus be minimized by thoroughly drying plants after harvest.[31]

Garlic bulbs infected with the white rot fungus (http://www. garlicworld.co.uk/ images/rot.gif).

White Rot (*Phanerochaete chyrsosporium*): First observed in England in the mid-1800's, white rot tends to form in dry soil exposed to cool temperatures. The disease spreads rapidly when it attacks young plants. External signs of infection include yellowing and necrosis of leaf tips. Bulb scales may become spongy, become covered with white mycelium (the vegetative part of the white rot fungus), and develop black sclerotia (a compact mass of hardened sclerotia). Treatment with chemical agents such as mercuric chloride, lime, and 2,6-dichloro-4-nitroaniline has proven effective.[32]

Neck Rot (*Botrytis allii*): This disorder is caused by three different species of the fungus *Botrylis* and is probably the most widely distributed and most destructive disease of storage onions. The illness was documented in Germany in 1876, the United States in 1890, and England in 1894. Though infection occurs in the field, it is usually not noticed until after harvest. Symptoms include softening of bulb scales and the development of sunken brown lesions, with an observable boundary between fresh and tainted tissue. Over time, the bulb desiccates and collapses. White cultivars tend to be more vulnerable to the ailment than do colored varieties. Neck rot can be controlled through careful handling during harvest and providing sufficiently cool and dry storage conditions. Spraying with Zineb or carbamate can help combat infection after it has occurred.[33]

Soft Rot (*Erwina carotovora*): This bacterial rot does most of its damage to onions and other alliums during storage. It usually begins at the neck of the bulb and affects one or more scales, though does not spread rapidly from one to another. External symptoms include a lack of firmness and a foul-smelling discharge from the neck when the affected vegetable is squeezed. Soft rot tends to form in humid weather, and so growers in tropical climates must take care to rapidly and thoroughly dry bulbs at harvest.[34]

Aster Yellows*:* Aster yellow is a virus spread by the six-spotted leafhopper that can affect carrots, celery, and lettuce in addition to onions. The leaves of infected plants appear light-yellow, though in many cases only one part of the plant will display symptoms. Shoots may also become discolored, and roots often become short and twisted. Controlling the virus typically involves eradicating the leafhopper population.[35]

Onion Thrips (*Thrips tabaci*): Among insects that can attack onions and other allium plants, the onion thrip can do some of the most significant damage. The thrip punctures

leaves and sucks the sap that exudes, leaving whitish areas on the leaves. Infestation is worse in seasons of drought and can sometimes lead to the destruction of entire crops. Effective chemicals can control the pest; results have indicated that affected crops treated with chemicals have a considerably higher bulb-yield than affected crops not sprayed or dusted.[36]

Onion thrips on an onion stalk (http://www.entomology.umn.edu/cues/inter/inmine/inimage/onionthrips.jpg).

Nutrition

Depending on the variety, growing conditions and climate, the nutritional value of onions can vary. They are very low in calories, only about 30 per one half cup serving, and fat, sodium and cholesterol free while still being very flavorful. Onions are also a good source of vitamin C (5mg or 9% of daily value), B6 (0.1mg or 5% of daily value), potassium (126mg or 4% of daily value) and the flavonoid quercitin and trace mineral chromium.[37]

Medicinal Uses

Onions have been used in many medicinal practices. Similar to garlic, they contain sulfur-compounds such as allyl propyl disulphide that contribute to onions pungent odor. Onions have been shown to improve cardiovascular health. Studies in China which compared the health of two similar villages, one who grew onions and the other who did not, showed that the village who grew and consumed onions had a lower death rate due to cardiovascular disease in comparison to the village who did not consume onions.[38] Current research has shown that the more pungent the onion, the stronger the anti-platelet activity effect is. [39] This is due to the sulfur compounds, chromium and vitamin B6, all of which are known to decrease the homocysteine levels which is a known factor in heart attack, stroke and heart disease patients. Similarly atherosclerosis, cardiovascular disease, heart attack and stroke are all associated with platelet aggregation and the clogging of arteries and veins that these compounds can help mitigate. Due to the presence of these compounds, onions have been shown to control hyperglycemia and hyperlipemia as well.[40]

At the University of Wisconsin, current research is investigating how onion consumption and specific onion compounds affect the in vivo aggregation of blood platelets.[41] "Using an in vivo model, we are beginning to investigate and, in some cases, confirm the potency of the onion as a blood thinner and platelet inhibitor. Onions may be among the vegetables that will be prized not only for their addition to our cuisine, but for their

value-added health characteristics," said Irwin Goldman, Associate Professor of Horticulture, University of Wisconsin-Madison.[42]

Onions are also known for their blood sugar lowering abilities. Studies have shown that individuals that ingest onion have lower levels of glucose in their bloods. This is due to the allyl propyl disulfide which increases the amount of free insulin available by competing with insulin for binding sites in the liver, thus more insulin is available in blood stream to lower blood sugar levels.[43] In addition to sulfur compounds, onions also contain 20% of an individual's daily amount of chromium, a trace mineral, involved in the body's response to insulin. Chromium has been shown to decrease fasting blood glucose levels, improve glucose tolerance, lower insulin levels, and help lower triglyceride and cholesterol levels in the blood stream.[44]

Onions are also very beneficial to gastrointestinal health. By ingesting onions, especially the yellow varieties, at least twice a week, an individual's chance of contracting colon cancer can be greatly reduced.[45] Similar to other *Allium* species, onions have very high levels of flavonoids, specifically quercitin, which in laboratory studies on animals, quercitin protected colon cells from cancer causing agents.[46] In addition to colon cancer, onions, like garlic, are protective against many other types of cancer. (See garlic)

Bone health can also be improved by ingesting onions on a regular basis. In a recent study published in the Journal of Agriculture and Food Chemistry, the compound gamma-L-glutamyl-*trans*-S-1-propenyl-L-cysteine sulfoxide (GPCS), has shown to inhibit osteoclasts, or the cells that degrade bone, thus mitigating bone loss.[47] This research is especially important and beneficial to women with osteoporosis. GPCS acts in the same manner as the common osteoporosis drug Fosamax, but onions do not produced the same negative side effects.[48]

Culinary

Onions are the third largest fresh vegetable industry in the United States, leading to 20 pounds consumed per person in 2007. Used in the form of fresh, dehydrated, powdered, oil, juice, salt or pickled, onions are used ubiquitously in cooking, and most commonly in stews, soups, pizza and salads. Onions are often seen in restaurants as either an appetizer in the form of onion soup, onion rings, caramelized or can be used as a side dish to many main course meals. Their unique flavor is often used to enhance recipes and help bring out other flavors used.

The flavor of the onion is due to sulfur compounds developing throughout the growing season. There is a long and complex biosynthetic pathway that can vary depending on environmental factors such as water supply, growing temperature, sulfate fertility in soil, other environmental factors and length of storage.[49] Water supply plays a large role in determining how pungent and flavorful the onion will be.[50] Onions grown under dry conditions will have an increase in pungent flavors, while well watered onions will have a milder flavor.[51] The temperature onions are grown under also plays and important role in onion development. The hotter the conditions the more sulfur compounds will be

produced, leading to a more pungent flavor.[52] Thus there is high variability in flavor strength depending on where, when and how the onion was grown.

In preparing onion, there are several methods to avoid tearing of the eyes while cutting. The tearing is caused by the compound allyl sulfate, which is produced when the onion tissue is cut and exposed to air, leading to the burning and tearing of the eyes.[53] Either chilling the onions can reduce this and hour or more before cutting them thus slowing then enzymatic activity or glasses or goggles can be worn if necessary.[54]

Garlic

Scientific Classification and Etymology

Garlic is a species of plant of the genus *Allium*—which includes onions, leeks, and chives, among other species, and represents one of the largest plant genera on Earth.[55] The name garlic comes from the Anglo-Saxon word "garlec," meaning "spear," in reference to its spear-shaped leaves.[56]

Scientific Classification	
Kingdom	Plantae
Phylum	Magnoliophyta
Class	Liliopsida
Order	Asparagales
Family	Alliaceae
Genus	*Allium*
Species	*A. sativum*

Historical Origins

While some have maintained that garlic first originated in southern Europe, most believe that the plant originated from a wild ancestor (*A. longicuspis*) in south central Asia, an area occasionally referred to as the "garlic crescent."[57] Migrating populations carried it around the Mediterranean to places such as present-day Egypt, Greece, and Italy.[58] Today, garlic can be found in eastern Asia, Europe, the Americas, as well as parts of northern Africa.

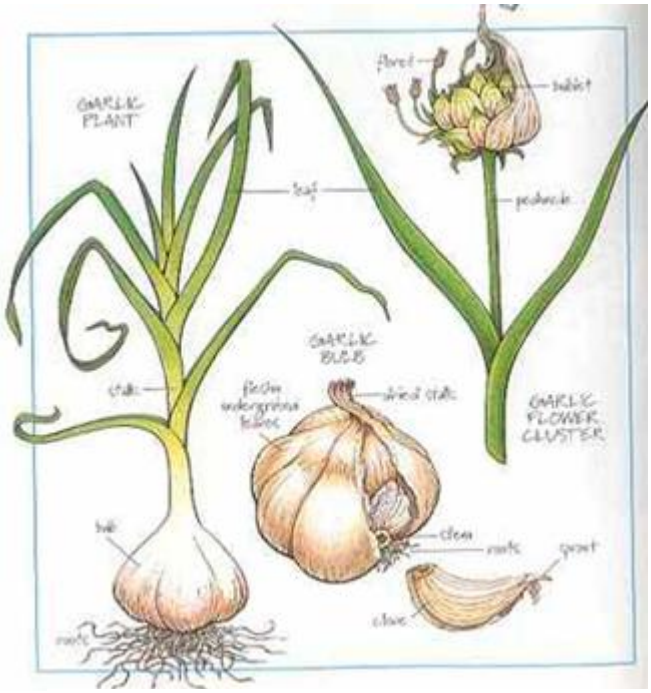
Garlic has been cultivated in the Middle East and Far East for at least 5,000 years and, as such, has been a valuable source of food and medicine, as well as a prized component of specific rituals, for many different societies. In Egypt, tomb art dating from the Early Dynastic Period (2925-2575 B.C.) depicts the consumption of garlic. Moreover, an Egyptian medical text called the Codex Elsers, which dates from approximately 1500 B.C., describes nearly two-dozen garlic preparations used to combat

Illustration of the garlic plant in *Medical Botany* by William Woodville (1793), from http://en.wikipedia.org/wiki/Image:Allium_sativum_Woodwill_1793.jpg.

ailments ranging from headache to fatigue.[59] Like the ancient Egyptians, the ancient Greeks depended on garlic for a number of medical-related reasons. The Greeks viewed garlic as a means of staving off aging and illness, and athletes participating in the Olympic Games would chew on garlic to improve strength and stamina.[60]

By the start of the first century B.C., garlic had been introduced into China, where its cultivation gained significant mention in treatises on agriculture beginning in the fifth century.[61] In Western Europe, the cultivation of garlic and fellow alliums is often thought to have been influenced by the contacts Crusaders made with the East in the eleventh, twelfth, and thirteenth centuries. Nonetheless, Charlemagne had listed garlic in his *Capitulare de Villis* some three centuries prior to the Crusades.[62] Garlic was introduced to the Americas by the Spaniards, and was evidently grown in Mexico by Cortés in the sixteenth century.[63] It was later cultivated by the Choctaw Indians in the present-day central Gulf Coast region of the United States. By 1800, American writers referred to garlic as among their garden esculents, even though, as the journalist and gardener William Cobbett observed, "Almost all nations except the English, the Americans, and the French, make great and constant use of Garlick."[64]

Although garlic was not especially popular in upstate New York at the beginning of the nineteenth century, the Hamilton College "1812 Garden" will nevertheless feature varieties of garlic that were presumably grown as esculents in the early-1800's. These include Purple Skin Rocambole and Spanish Red Roja.



The entire garlic plant, garlic bulb, and garlic flower (http://www.designmom.com/2007/04/thursday-letter-to-nie-nie-by-guest-mom.html).

Horticulture and Plant Specifics

Like onions and other alliums, garlic forms bulbs that develop entirely underground, and the plant may or may not flower in the spring. The bulb consists of bulblets (also known as cloves) clustered together between membranous scales and surrounded by the outermost skin of the bulb, which can be either white or red in color.[65]

Cultivation

Garlic can develop in a wide assortment of different soils, yet it grows best in rich, deep loams with ample amounts of moisture.[66] To achieve optimal growth, it is recommended that garlic bulbs be dried, treated with a fungicide, such as benomyl, to reduce the risk of rot, and exposed to cool temperatures—between 0°C and 10°C—for up

to eight weeks to ensure bulbing.[67] It is also advised that garlic cloves be planted either in the spring or early in the fall.[68]

Like onions, garlic bulbs form in dissimilar ways depending on factors including soil composition (as mentioned above), day length, climate, and altitude. In general, the longer the amount of time garlic is exposed to daylight and the higher the temperature, the quicker the bulb will develop and mature. Consequently, garlic grown in warmer climates, especially when planted in spring, will tend to have larger bulbs than garlic grown in colder climates. The plant is frost-hardy, however, so it need not be planted strictly in locations where snow and freezing temperatures are minimal. Garlic is grown at elevations above 4,000 feet in California, the largest producer of garlic in the U.S., and is usually well rooted by the first snows if planted between September and November.[69]

Plant spacing has a significant effect on the size of the bulb. In Italy, for example, workers prefer a spacing on the order of forty to fifty bulbs per square meter. Doubling this density increases the yield by 50 percent, though this reduces the size of the bulbs and renders them more suitable for processing than for sale as fresh produce.[70] When the tops of the garlic plant become dry and bend to the ground—forming a small bulb called a "scape"—they are removed so that they do not use resources and nutrients that should go to the bulb.[71] The bulbs are then typically harvested by hand and dried for upwards of ten days at temperatures of 20°C-30°C followed by a reduction to 0°C for storage. Application of maleic hydrazide and gamma irradiation can prolong storage life.[72] (Please note that the caretakers of the 1812 Garden will not use chemicals for maintenance, but will instead rely on organic methods of pest and weed control.)

"Wild garlic" (http://www.flickr.com/photos/mcdnry/478916722/).

Garlic does not produce seed. Consequently, plant breeders have not been able to develop many types of garlic cultivars. Growers must usually set aside at least one-tenth of their spring crop to be broken into cloves for planting in the fall.[73] If breeders consistently plant garlic in the same location for an extended period of time, the particular strain will develop specific characteristics, such as a particular external color, a certain number of cloves, or a certain bulb size.[74] Of course, because garlic responds dissimilarly to differences in soil composition, day lengths, climates, and altitudes, local growing conditions can alter the strain and produce varieties with new features.[75]

Pathogens and Pests

Garlic plants are susceptible to the same pathogens and pests discussed in the section on onions.

Medicinal Role and Properties

Ancient Times

Garlic has long been known for its medicinal properties. The use of garlic in multiple forms was very prominent in ancient medicine as well as in modern homeopathic and alternative remedies today. Garlic was a prominent remedy for many ailments ranging from the common cough and cold to stomach problems.[76] Dating back to the beginning of civilization, garlic has been documented as a remedy in China, India, Egypt, Greece and Rome. Additionally, garlic was found in Egyptian tombs and Greek Temples.[77] Whether this means garlic had religious or ritualistic significance for these ancient cultures, however, remains unclear. Nutritionist Richard S. Rivlin notes that the presence of garlic in tombs "is strong evidence that the vegetable was in use" in these societies, yet acknowledges that "we do not know" whether garlic was employed in religious customs and rituals.[78]

15th century illustration of a garlic harvest from Tacuinum *sanitatis*, the Medieval handbook of wellness from Arab medicine (http://en.wikipedia.org/wiki/Image:Tacuinum_sanitatis-garlic.jpg).

For thousands of years societies have used garlic in medicine for scores of different reasons. The Mesopotamians prescribed garlic for toothaches, painful urination and placed it inside amulets to prevent disease. Traditional Chinese medicine also linked garlic with the spleen, kidneys, and stomach. In ancient Greece the father of medicine, Hippocrates, used garlic frequently and included it into his arsenal of remedies.[79]

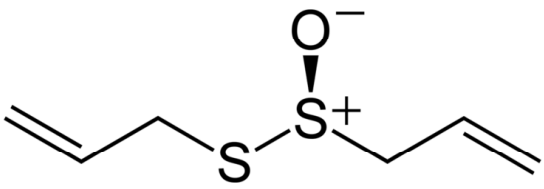
First-century testimonial by Dioscorides, an herbalist and a physician, and Pliny the Elder, an encyclopedist, dictated the next several centuries' beliefs concerning the medicinal powers of garlic. They believed that garlic expelled intestinal worms and skin parasites, protected against venomous animals, neutralized internal and external inflammations, relieved toothaches and coughs, and reduced hemorrhoids.[80] In the *Materia Medica*, Dioscorides believed that garlic's most important function was to remove excess fluid from the body by dilating blood vessels and stimulating kidney function.[81] Together, Dioscorides and Pliny the Elder controlled the knowledge and therapeutic usage of garlic for centuries.

Scientific Revolution and Beyond

Later in the seventeenth century, Discorides and Pliny the Elder's theories about garlic still held a high position in the field of medicine, but its ability to protect against diseases

such as respiratory disease was becoming widely accepted.[82] Garlic became a major ingredient in more that 50 prescription medicines that were recommended by London physician Thomas Willis for treating diseases, specifically respiratory disease. In addition to respiratory disease, the Royal Infirmary of Edinburgh identified that garlic was also an effective treatment for malaria, smallpox and in the form of an ointment for whooping cough as well. Later, during the Scientific Revolution in the early 1800's, Jacob Bigelow, a professor of medicine at Harvard, believed garlic as a medicine was most powerful in the form of an oil and that ingestion would quicken circulation, excite the nervous system and increase expectoration from the lungs.[83]

Garlic has been used for centuries in medicine and continues to be studied in modern times. The compound allicin, which is responsible for the distinctive odor of alliums, is the garlic's natural defense from insects, fungi and infection. The compound is produced by plant enzymes when the plant is injured or crushed and provides the plant with anti-fungal protection.[84] Allicin has been shown to reduce plasma concentrations of cholesterol, triglycerides, and low-density lipoproteins in the blood, and has also inhibited an enzyme necessary for cholesterol synthesis.[85] In 1858, Louis Pasteur discovered that garlic has antimicrobial properties as well. Pasteur showed that diluted solutions of its juice can inhibit the growth of pathogenic bacteria such as *Staphlyococcus, Streptococcus, Bacillus,* and *Vibrio cholera* sp., as well as yeasts and other fungi. But due to allicin's instability in the body, no further drug research was pursued.[86]



Allicin or $C_6H_{10}OS_2$ chemical structure (http://en.wikipedia.org/wiki/Image:R-allicin-2D-skeletal.png).

Scientific Studies

In addition to its anti-microbial properties, garlic is thought to be an anti-carcinogen. In China, where rates of stomach cancer are high, a study featuring 564 patients diagnosed with stomach cancer and 1,131 controls showed that there was a significant reduction in stomach cancer risk when participants ate allium vegetables such as garlic.[87] Garlic has also contributed to reductions in tumors in mice.[88] Isolated epidermal cells applied with 5μg per milliliter of garlic oil led to an increase in glutathione peroxidase activity and inhibited ornithine decarboxylase induction when the cells were exposed to nonphorbol ester tumor causing agents.[89] Garlic oil has also led to reductions in tumor sizes and tumor formation from the 12-0-tetradecanoylphorbol-13-acetate compound, which is a known carcinogen.[90] Garlic's anti cancer properties are thought to be due to garlic's enhancement of glutathione-dependent antioxidants in the epidermal cells.[91]

Garlic has also been shown to reduce hypertension. A 1990 study performed in China, which involved 47 participants with mild hypertension, treated patients with a randomized, placebo-controlled, double-blind trial. The patients had a diastolic range of 95-104 mm Hg blood pressure at the beginning of the study. Each patient took either a

preparation of garlic powder or a placebo for 12 weeks. Blood pressure was then checked at week 8 and week 12. Results showed significant differences between the garlic and placebo groups. Those taking garlic supplements showed an average of 102 to 92 mm Hg in blood pressure within the first 8 weeks and then fell to 89 mm Hg after week 12.[92] Triglyceride and cholesterol levels were also significantly reduced. Overall, garlic has played and will continue to play a large role in therapeutic and homeopathic remedies.

With the advent of new technology and advancements in medicine, research involving garlic and its potential uses could be expanded greatly in the future, leading to new treatments and cures for diseases.

Culinary and Nutritional Significance

Culinary Usage

Because of its potency, the result of the presence of sulfurous compounds, garlic was previously regarded with disdain in a handful of Western societies, particularly England and the United States in the eighteenth and nineteenth centuries. Some in England saw garlic as a "strong class barrier" suitable only for laborers and other lower-class individuals. Amelia Simmons, author of the first American cookbook, remarked that garlic was more appropriate for medicinal purposes than for culinary usage.[93]

"Garlic" (http://www.flickr.com/ photos/christing/150532387/sizes/s/).

Of course, the image of garlic as a "stinking rose" in England and the U.S. has largely subsided, particularly in the latter case. In 1924 the caesar salad was introduced in Tijuana, Mexico for American diners. The dish was prepared by rubbing a salad bowl with a clove of garlic to enhance the flavor of the lettuce, and almost immediately gained acceptance in the States as "American" food.[94] Thirty years later the food writer James Beard wrote about an old Provençal recipe that called for cooking chicken with forty cloves of garlic. Thousands of readers tried the recipe and enjoyed it. Evidently, garlic usage and consumption has increased fourfold since the early-1970's.[95]

Garlic is frequently used in combination with other foods as a means of bringing out distinctive flavors and aromas. Italian cuisine often combines garlic with tomatoes, as revealed in dishes such as cioppino, a tomato-based seafood stew. When combined with scallions and ginger, garlic helps form the background flavor present in most Chinese American dishes.[96] In addition, many foods are prepared using dehydrated garlic or garlic powder, the former of which can contain five times the flavor of fresh garlic. Spiced sausages and other assorted processed foods make use of garlic in these forms.[97]

Nutritional Aspects

Garlic is not a particularly nutritious food. Most varieties feature roughly 60 percent moisture, 30 percent carbohydrate, and small to trace quantities of protein, vitamins, and minerals.[98] The protein content of garlic, however, may be three to six times higher than that of other allium vegetables. Nevertheless, its caloric value is considerably greater than that of the 35 calories per 100 grams present in onions and leeks.[99]

Leek

Scientific Classification and Etymology

The leek is a species of the genus *Allium*, the family of plants that includes onion and garlic. The specific scientific name of leek is *A. ampeloprasum* var. *porrum*, and the plant belongs to the larger species *A. ampeloprasum*, which includes individual subgroups for species including kurrat and great-headed garlic.[100] The name is derived from the Old English word "laec," or "leac."[101]

Scientific Classification	
Kingdom	Plantae
Phylum	Magnoliophyta
Class	Liliopsida
Order	Asparagales
Family	Alliaceae
Genus	*Allium*
Species	*A. ampeloprasum*
Subspecies	*A. ampeloprasum* var. *porrum*

Historical Origins

A native of the Mediterranean region, most likely the eastern Mediterranean, leek is a variable species that can be found in many, if not most, regions of the globe. The plant was found in Europe during the Middle Ages, and early European settlers almost certainly brought it to the Americas. Today it also exists in northern Africa, the Middle East, and parts of southern and western Russia.[102]

The culture and use of leek can be traced back some 3,000 to 4,000 years to the early civilizations of the Middle East.[103] Ancient Egyptians had a fondness for leek. In fact, during the Early Dynastic Period (c. 2925 B.C.-2575 B.C.), they adorned their pyramid tombs with drawings and designs of the plant.[104] The ancient Greeks enjoyed leek as a source of food, as did the Romans, who preferred it to garlic and onions.

Garden leek with overlapping leaves forming the pseudostem (http://en.wikipedia.org/wiki/Leek).

(The Roman emperor Nero apparently consumed leeks on a regular basis.) Roman traders helped transport leek to much of the rest of Europe, and the vegetable became especially popular during the Middle Ages, when they were additionally believed to be an erotic stimulant that increased sperm count and stimulated desire.[105]

Leek is most commonly grown and used in Europe, and thus most appreciated in Europe. In northern England, leek growing has been and continues to be a competitive business, and parents have been known to pass secrets of cultivation along to their children.[106]

"Leeks" (http://www.flickr.com/photos/calliope/54833240/).

Horticulture and Plant Specifics

Leek is characterized by the formation of a pseudostem, which in some cases can exceed lengths of one meter, as well as a poorly developed bulb. Pseudostem is the term for the overlapping leaf bases of the leak, which tend to be flat and slender, and fold over each other to create a stemlike structure. Botanically, however, the edible part of the plant is not the stem, but rather the elongated leaf bases.[107]

The modern leek is not known in the wild—though a separate species does exist in the *Allium* genus called "wild leek." Interestingly, leek bears a striking resemblance to wild *A. ampeloprasum*, not only in flowers and foliage, but also in clove production. Like its wild relative, leek frequently produces a small number of large cloves and small exterior cloves. These cloves serve as defining features of *A. ampeloprasum*.[108]

Wild leeks in upstate New York (David Gapp).

Cultivation

Leek is a relatively hardy species that, unlike onion (and to a lesser extent garlic), does not have specific photoperiodic requirements for pseudostem formation. (Photoperiodic response refers to the amount of time the pseudostem must be

exposed to light in order for development to occur.) Accordingly, the plant can be grown in a broad range of latitudes.[109] But while leek can grow well under most soil conditions, it tends to do best in deep loams and peat with good drainage and a pH value around 7.0.[110]

Because leek does not form bulbs, does not enter a rest period, and does not have strict photoperiodic requirements, it is not only adaptable but can be harvested over longer periods of time than onions.[111] Like onions, though, leek will bolt (that is, develop an elongated stalk with flowers grown from within its main stem) if subject to low winter temperatures. If leek is exposed to prolonged periods of low temperatures, it becomes undesirable for market and cultivators must adjust planting and production dates.[112]

Leek starts from seed and require a rather long growing season to reach an optimal marketable size—usually at least two feet in height or about an inch in diameter.[113] In cool climates, leeks are often planted as early as possible in the spring, and are typically transplanted from hotbeds or cold frames into the open once the soil warms. Early plantings are generally ready by late summer, though leek can be harvested in any season. Production tends to be greatest, however, in late autumn, winter, and early spring, and lightest in summer.[114]

Wild leek flowers (David Gapp).

Leeks take up minimal horizontal space and thus require only about six inches of space between one another and two feet between rows.[115] Experiments with spacing have found that increasing the distance between leeks enables the individual plants to grow in size, but this contributes to a reduction in yield per unit area.

Harvesting leek can be challenging because the vegetable is planted deeper and has a more extensive and complex network of roots at harvest than other alliums.[116] Leek is thus easier to harvest by hand, though it can be harvested mechanically. Once the plant is harvested, it is trimmed and bunched for market. It is thereafter stored, usually for one to three months at 0° C with 90 to 95 percent relative humidity.[117]

Pathogens and Pests

Leek is vulnerable to the same pathogens and pests as other alliums, including smut, downy mildew, pink root, neck rot, and thrips.

Nutritional Aspects

Leeks provide all of the essential amino acids for humans, and are also a good source of vitamin C. Approximately one-half cup of leeks contains 9 percent of one's daily

recommended calcium intake, 14.8 percent of recommended iron intake, 31.3 percent of vitamin C intake, and 32 percent of folacin intake.[118] Leeks are also low in sodium, high in potassium, and rich in flavonoids, organic compounds that are not directly involved in an organism's normal growth processes.[119]

Medicinal Uses

Recent research published in *The International Journal of Cancer* in November of 2007 discussed flavonoid intake for women. The results showed that women with a diet abundant in leeks and other flavonoid-rich foods have a significantly lower chance of developing ovarian cancers. This prospective study performed by the Brigham and Women's Hospital and Harvard Medical School in Boston used flavonoids, which are compounds rich in anti-oxidants most commonly found in plants, fruits and teas. Their research was based on the intake of five different flavanoids: myricetin, kaempferol, quercetin, luteolin and apigenin. Women eating a diet specifically rich in kaempferol, which is found in high concentrations in the leaves of leek to protect the plant from ultraviolet radiation, exhibited a 40 percent reduction in the risk of developing ovarian cancer.[120] This research is still in the prospective stages, but it is leading the way and opening new doors in the study of cancer.[121]

Leeks are also very dense in oxalates, which are naturally occurring compounds found in plants, animals, and humans. Oxalates are an organic acid which, when in high concentrations in bodily fluids, have the potential to form crystals leading to health problems such as kidney stones. Thus individuals with a history of digestive tract, gallbladder, or kidney problems should watch their oxalate consumption and avoid eating leeks.[122]

Culinary Uses

"Leek harvest" (http://www.flickr.com/photos/paulhardy/57641328/).

Sometimes referred to as "green onions on steroids," leeks are available year round and are the mildest in flavor of the *Allium* family.[123] Depending on time of harvest, their flavor will change and in the spring and fall they will become increasingly sweet.[124] Most often paired with potatoes, they are used to make vichyssoise and can be used raw in salads. Both the stalk and the white onion base can be eaten, but the base can become woody and or unusable as the leak ages.[125]

A popular Scottish equivalent to the French vichyssoise is cock-a-leekie. This particular soup, like vichyssoise, contains leeks and potatoes, though chicken stock is also added. The original recipe featured prunes, and some cooks will garnish the soup with julienned prunes. Leeks are also included in stews such as the French pot-au-feu, which consists of low-cost cuts of beef and is slow-cooked, and are occasionally employed for use in vegetable and meat stocks.[126]

Cultural Significance

Leeks play an integral role in Welsh culture. They are one of the national emblems of Wales, and have been featured on the one pound Welsh coin—those minted in 1985.[127] In addition, leeks play an important cultural role in the Welsh national holiday, St. David's Day (March 1), named after St. David, the patron saint of Wales.[128] Sixty years after St. David's death (approximately 640 AD), the British King Cadwallader was attacked by the invading Saxons. According to legend, the Welsh, to distinguish themselves from the enemy, wore leeks in their helmets. This battle, known as the Battle of Heathfield, was won by the British. To honor this victory in the name of St. David, it is customary for residents of Wales to wear a leek or a daffodil in their pockets or hats on March 1.[129]

18th-century English artist William Hogarth produced a series of eight paintings titled "A Rake's Progress" (1732). The fourth painting, titled "The Arrest," illustrates the customary Welsh tradition of wearing a leek in ones hat on St. David's Day (http://en.wikipedia.org/wiki/Image:William_Hogarth_026.jpg).

Chives

Scientific Classification and Etymology

Chive is the smallest species of Alliaceae, the onion family. Because it grows in clumps instead of as individual plants, it is referred to as "chives" rather than "chive." The plant is classified as *Allium schoenoprasum*, with the latter name referring to the rush-like leaves of chives. "Chives" is derived from the fourteenth-century French word *cive*—itself derived from the Latin term for onion, *cepa*.[130]

Scientific Classification	
Kingdom	Plantae
Subkingdom	Tracheobionta
Division	Magnoliophyta
Class	Liliopsida
Subclass	Liliidae
Order	Asparagales
Family	Alliaceae
Genus	*Allium*
Species	*A. schoenoprasum*

Historical Origins

Chive is the most widely distributed member of the allium genus, and grows in the wild in North America and Eurasia. Because the plant is very resistant to cold weather and is winter dormant, it can grow in latitudes as high as far north as 70°.[131] As a result, in North America, chives can be found from Newfoundland to Alaska, from New York State to Minnesota and southern Oregon, and in the Rocky Mountains. The plant has a circumpolar distribution in Old World. It extends from Japan, China, northern India, and Iran in Asia and the Middle East, through the Balkan Mountains, northern Italy, and to the Pyrenees Mountains in Europe.[132]

Chive and onion illustration, 1885 (http://en. wikipedia. org/wiki/Chives).

Chives originated in the north temperate zone in North America, Europe, and Asia, making it the only allium species native to both the Old World and the New World. Although little is known of the early history of chives as a cultivated species, it has been established that the plant was known by the Chinese 5,000 years ago. Chives were also known and enjoyed by the ancient Greeks.[133]

It was not until the sixteenth century, however, that chives became popular in European gardens. At the time, they were used mostly for food, although the English botanist John Gerard wrote a medical guide in 1597 in which he described chives as an herbal remedy.[134] In the seventeenth century chives was introduced to Germany by the Italians. During the 1600's chives came to be regarded as a peasant food in England, yet it was used periodically as a potherb.

Though the English grew chives throughout the 1600's and 1700's—it was mentioned as part of the supplies of seeders in 1726—the vegetable began to lose favor in England in the latter half of the eighteenth century. Of course, this trend was not universal in the British Isles. Botanist E. Louis Sturtevant reported in the 1800's that Scottish families, which had traditionally consumed chives in heavy amounts, continued to enjoy chives on a regular basis. At the same time, chives were relatively popular among recreational gardeners in the U.S. The plant was featured in a list of American esculents in 1806.[135]

Horticulture and Plant Specifics

Chives is distinguished from other alliums by its flowers, growth in clusters, and its narrow slender leaves. The flowers of the plant are normally purple, pink, or sometimes white. As many as thirty flowers will form in a one- to two-inch ball at the end of the stalk.[136] The flowers stand upright, and open first at the top of the umbel (stalk) before opening gradually toward the direction of the base of the stalk. The leaves of chives usually stand between one and two feet above ground, with the flower stems reaching slightly greater heights.[137]

"Chives" (http://www.flickr.com/photos/97775656@N00/153709092/).

Cultivation

The most common method of planting involves seeding chives in single rows with about fourteen inches of space between them. A gap of thirty inches appears between every four or so rows. Because chives is dormant in the winter, growers will often seed the vegetable midway through summer, allowing them to harvest in mid-fall and then again in early-spring the following year. Leaves and flowers typically develop in abundance during the spring and in early summer, and it is this part of chives that gets consumed. (Bulbs do not get eaten because they are not well defined.) Growers can even harvest over successive four- to five-week intervals throughout the summer and autumn, for chives will continue producing clusters of leaves and flowers well after spring harvest.[138]

When chives is harvested, it is cut about one-half to one inch above the soil line. An additional one inch or two inches is removed from the freshly cut leaves. The leaves are thereafter cooled, washed, cut into pieces about one-eighth of an inch in size, and packaged and frozen as quickly as possible to maintain freshness.[139] Of course, while chives is often used for culinary purposes, it is most often homegrown and employed in ornamental designs.[140]

Pathogens and Pests

Like onions, chives is subject to assault from a handful of different diseases and disorders, including downy mildew, onion smut, and bulb and stem nematode. (These pests and ailments are described in greater detail in the section on onions.)

Nutrition

For an average male, 100g of chives will provide 30 calories and is very high in calcium (11.5 percent of daily intake), iron (16 percent), magnesium (12 percent), vitamin A (43 percent), and vitamin C (96.8 percent). [141]

Culinary Usage

Chives can be eaten either freshly cut or in the dehydrated form. When frozen, their flavor can last for several months. They are often used to flavor baked potatoes, soups, and are often used as a garnish. They can be found year round and are considered a fine herb in French cuisine.

Medicinal Usage

Similar to other alliums chives exhibit all of the same properties but weaker in effectiveness. Chives also have similar antibacterial properties to other alliums. See garlic and onion for medicinal effects.

Chemistry

See garlic and onion.

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