

BROCCOLI



Family	Brassicaceae
Genus	<i>Brassica</i>
Species	<i>B. oleracea</i> L.
Accepted name	<i>Brassica oleracea</i> var. <i>italica</i> Plenck*
Synonyms	<i>Brassica cretica</i> *
Popular cultivars	'Parthenon', 'Calabrese', 'Green Goliath', 'Bonanza', 'DiCicco', 'Waltham', 'Green Magic', 'Flash', 'Romanesco', 'Paragon'.
Climate	Broccoli is a cool-season crop.
Origin	Italy
Soil	Well-drained, consistently moist sandy to clay loam, pH 6 – 6.8
Growth	Grown before or after high temperatures in early spring or late summer.
World Production	Exceeds 25 million tons (cauliflower plus broccoli, 2021)
Major Producers	China, India, USA, Spain, Mexico

*IPNI (2023). International Plant Names Index. Published on the Internet <http://www.ipni.org>, The Royal Botanic Gardens, Kew, Harvard University Herbaria & Libraries and Australian National Herbarium. [Retrieved 04 March 2023].

Nutrient	Per 100 g raw edible portion
Water	91 g
Energy	28 kcal
Fat	0.35 g
Cholesterol	0 mg
Total Carbohydrate	5.06 g
Dietary Fibre	2.3 g
Sugar	1.48 g
Protein	0.3 g
Vitamin A	3000 IU
Vitamin B complex	1,587 mg
Vitamin C	93.2 mg
Calcium	48 mg
Phosphorous	66 mg
Sodium	27 mg
Iron	0.88 mg
Potassium	325 mg
Magnesium	25 mg

www.ars.usda.gov/ARSUserFiles/80400535/Data/SR/SR28/reports/sr28fg11.pdf
(Retrieved 04 March 2023)

Botany

Broccoli is a member of the cabbage or mustard family (Brassicaceae, syn. Cruciferae) of about 330 genera and 3,500 species, including about 40 Brassica species. It is classified as a cruciferous vegetable. Broccoli is an edible green plant that closely resembles cauliflower in appearance and is often eaten cooked or raw in salads. It is believed to have originated in Italy, where it was cultivated as early as the 6th century BC from the wild forms of *Brassica oleracea* L. In Latin, "brassica" means "cabbage/cole," and "oleracea" means "vegetable/herb." The many varieties in this group show considerable diversity in form, with different parts of the plant consumed as vegetables. Broccoli is an Italian term for the Latin "brachium", meaning "arm". The term refers to the young, green edible inflorescence (flower head) carried on an edible floral shoot. Broccoli is a cool-season crop that typically grows 60-90 cm tall. It has a large, edible head (referred to as the "curd" or "crown") that is made up of many small, fully differentiated flower buds that generally do not abort before opening. The leaves are dark green and are arranged in a rosette pattern around the stem. Broccoli is classified as *Brassica oleracea* var. *italica*, and its different types have conspicuous morphological variations. Calabrese broccoli has a single large flowerhead, while branching sprouting broccoli bears several relatively small flowerheads (sprouts), and Romanesco broccoli has flowerheads with multiple cone-shaped spirals of small flower buds. The green colour of the heads is caused by chlorophyll pigments in the outer leaf-like structures of the flower (sepals) that enclose the developing bud.

Harvesting and quality indices

Proper harvesting practices are essential for maintaining the quality and shelf life of broccoli. Broccoli is usually harvested when the head is fully formed but before the buds begin to open. Quality indices for broccoli include a compact head, uniform colour, and absence of any signs of damage or disease.

The harvesting practices for broccoli can vary depending on the region and the farming method used. Heads should be harvested at the right time to ensure optimal quality and yield. The ideal time for harvesting broccoli is when the head is 6 to 8 inches in diameter and the buds are tightly closed. Harvesting is done by hand and harvesting tools such as knives or pruning shears should be clean and sharp to minimize damage to the plant and to the head. It is important to cut the head at an angle so that rainwater can easily run off. Broccoli heads should be handled carefully to avoid bruising or damaging the plant. Workers should gently place the heads in a container to avoid damage to the head or the stem. After the broccoli heads are harvested, they should be sorted based on their size, colour, and overall quality. Damaged or diseased heads should be removed and discarded.

Pre-Cooling and Storage

Broccoli should be cooled as soon as possible after harvesting to prevent decay and maintain quality. Pre-cooling of broccoli is an essential step in postharvest handling to maintain its quality and extend its shelf life. Pre-cooling is the process of rapidly removing the field heat from the harvested product, which reduces respiration rates, minimizes water loss, and prevents the development of postharvest diseases.

There are several methods of pre-cooling broccoli, including hydrocooling, forced-air cooling, and vacuum cooling. Each method has its advantages and disadvantages, and the choice of pre-cooling method may depend on factors such as cost, availability of equipment, and the specific requirements of the market.



Hydrocooling involves immersing the broccoli heads in chilled water, which cools the product quickly and evenly. This method is commonly used for field-packed broccoli, as it is relatively simple and inexpensive. However, hydrocooling can also increase the risk of waterborne diseases and can cause surface damage to the heads if not done properly.

Forced-air cooling involves blowing chilled air over the broccoli heads, which removes heat and moisture from the product. This method is commonly used for bulk-packed broccoli, as it is fast and efficient. However, forced-air cooling can also cause moisture loss and shrinkage if not done properly.

Vacuum cooling involves placing the broccoli heads in a vacuum chamber and lowering the pressure, which causes water to evaporate and removes heat from the product. This method is fast and efficient and can maintain the quality of the product. However, vacuum cooling requires specialized equipment and can be expensive.

Top icing is often used to rapidly cool packed broccoli. Top icing has been shown to be effective in reducing postharvest water loss and maintaining the colour and quality of broccoli during transportation and storage. However, the use of top icing can also increase the risk of physical damage to the produce, such as bruising or freezing injury.

Broccoli can also be rapidly cooled by liquid-icing the field-packed waxed cartons.

The pre-cooling temperature for broccoli should be between 0°C to 5°C (32°F to 41°F) to prevent the growth of microorganisms and maintain the quality of the product. Cooling the broccoli heads to this temperature range as soon as possible after harvest is crucial to prevent the development of postharvest diseases, reduce respiration rates, and prevent water loss.

It is important to note that the cooling rate during pre-cooling is just as important as the final temperature. The quicker the broccoli can be cooled to the appropriate temperature range, the better the quality will be. In addition, broccoli should be cooled to the target temperature within two hours of harvest, and once cooled, it should be stored in a cool and humid environment to maintain its quality. Proper pre-cooling of broccoli is an essential step in postharvest handling and can help to extend the shelf life of the product and ensure that it reaches consumers in the best possible condition.

Proper storage of broccoli can help to maintain its quality and extend its shelf life for up to two weeks or more, depending on the initial quality and the storage conditions. It is important to monitor the temperature and humidity levels regularly and to remove any damaged or decayed heads to prevent the spread of disease.

After pre-cooling the heads should be stored in a cool and humid environment. The ideal storage temperature for broccoli is between 0°C to 5°C (32°F to 41°F). Broccoli is a cool-season crop and is sensitive to temperature changes, so it is important to store it in a cool environment to maintain its quality and extend its shelf life. At temperatures below 0°C (32°F), broccoli can suffer from chilling injury, which can lead to discoloration, pitting, and decay. On the other hand, temperatures above 5°C (41°F) can promote the growth of microorganisms and accelerate the deterioration of the product.



In addition to temperature, the humidity level in the storage environment is also important. Broccoli should be stored in a cool and humid environment to prevent moisture loss and maintain its texture and quality. The ideal relative humidity for broccoli storage is between 90% to 95%.

Transport

Broccoli should be transported in a cool and dry environment to prevent damage and decay during transit. Transportation of broccoli is an important aspect of postharvest handling, as it can have a significant impact on the quality and shelf life of the product. Proper transportation practices can help to minimize damage and maintain the quality of the broccoli during transit.

During transportation, it is important to keep the temperature and humidity levels consistent with the ideal storage conditions for broccoli. The temperature should be maintained between 0°C to 5°C (32°F to 41°F), and the humidity level should be between 90% to 95% to prevent moisture loss and maintain the quality of the product.

To prevent physical damage, broccoli should be packed in sturdy containers that can withstand the rigors of transportation. The containers should be well-ventilated to allow for proper air circulation, and the heads should be packed in a single layer to prevent crushing and bruising. It is also important to avoid exposure to ethylene during transport. Broccoli should be transported separately from ethylene-producing fruits and vegetables, and any containers or vehicles that have been used to transport ethylene-producing products should be thoroughly cleaned before loading broccoli.

Finally, it is important to handle and transport broccoli with care to prevent mechanical damage, which can result in bruising, cracking, or other physical damage. Proper handling practices, such as using appropriate lifting and loading equipment, can help to minimize damage and maintain the quality of the product during transportation.

Ethylene

Broccoli is sensitive to ethylene and should be stored away from ethylene-producing fruits and vegetables to maintain its quality and extend its shelf life. Exposure to ethylene can cause broccoli to turn yellow, become tough, and develop a bitter taste. Broccoli should be stored away from ethylene-producing fruits and vegetables, such as apples, bananas, avocados, and tomatoes. It is also important to avoid exposure to ethylene during transport and storage, as ethylene can accumulate in closed containers and cause damage to the product. To prevent ethylene damage, it is recommended to store broccoli in a separate room or container from ethylene-producing fruits and vegetables. If storing broccoli with other produce, it is important to ensure that the other products do not produce ethylene or are at a mature stage where ethylene production is low.

Broccoli itself can produce low levels of ethylene as it ages and deteriorates. Therefore, it is important to monitor the storage conditions and remove any damaged or decaying heads promptly to prevent the accumulation of ethylene and the spread of decay to healthy heads.

Physiological Disorders

Broccoli is a perishable vegetable that can develop postharvest physiological disorders due to various reasons, including improper handling, storage conditions, and transportation. Here are some examples of postharvest physiological disorders that can occur in broccoli:



Yellowing: Broccoli can develop yellowing of the florets and leaves after harvest due to a lack of oxygen or high levels of carbon dioxide in the storage environment. This can be prevented by storing broccoli in a well-ventilated environment with a controlled atmosphere.

Browning: Browning of the florets can occur due to physical damage, such as bruising or crushing during handling and transportation. This can be prevented by handling broccoli gently and storing it in proper conditions.

Moisture loss: Broccoli can lose moisture after harvest, leading to wilting and reduced quality. This can be prevented by storing broccoli in a high-humidity environment and by using proper packaging materials.

Toughening: Broccoli can become tough and fibrous after harvest due to exposure to high temperatures or ethylene gas. This can be prevented by storing broccoli at the proper temperature and by avoiding exposure to ethylene-producing fruits and vegetables.

Chilling injury: Broccoli can suffer chilling injury when stored at temperatures below 0°C (32°F), which can lead to discoloration and pitting.

Hollow stem: This disorder causes the stems of broccoli to become hollow at the cut end and may make the broccoli less appetizing. This is caused by a calcium deficiency in the plant.

Postharvest Pathology

Broccoli can develop fungal and bacterial decay during storage and transportation, leading to spoilage and reduced shelf life. This can be prevented by using proper sanitation practices, such as washing and disinfecting equipment and storage areas, and by storing broccoli at the proper temperature and humidity.

Some common postharvest diseases of broccoli include:

Black rot: This disease is caused by the bacterium *Xanthomonas campestris* and is characterized by black, sunken lesions on the stem and leaves of broccoli. It can spread rapidly and cause significant losses if left untreated.

Soft rot: This disease is caused by various bacteria, including *Pectobacterium* and *Erwinia*, and is characterized by soft, watery rot of the florets and stem of broccoli. It can occur during storage or transportation and can spread quickly in warm and humid conditions.

Downy mildew: This disease is caused by the fungus *Peronospora parasitica* and is characterized by yellow spots on the leaves of broccoli, which eventually turn brown and become covered with a downy growth of spores.

