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REVIEW ARTICLE

ORIGIN, DISTRIBUTION, TAXONOMY, BOTANICAL DESCRIPTION, GENETICS AND CYTOGENETICS, GENETIC DIVERSITY AND BREEDING OF TURNIP (*Brassica rapa* L.)

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ABSTRACT

Turnip belogs to the Family Brassicaceae, Genus *Brassica* , Species *Brassica* rapa and Variety *Brassica* rapa var. *rapa* L. Turnip (Brassica rapa syn. B. campestris L. ssp. rapifera Matzg), belonging to the Brassica genus, has been an important global crop for centuries, first being cultivated in China in 2500 B.C. In England around 1700, Charles "Turnip" Townshend promoted the use of turnips in a four-year crop-rotation system that enabled year-round livestock feeding. In most of England, the smaller white vegetables are called turnips, while the larger yellow ones are referred to as swedes. In the United States, turnips are the same, but swedes are usually called rutabagas. The turnip, *Brassica rapa* var. *rapa,* is a root vegetable commonly grown in temperate climates worldwide for its white, bulbous taproot. Small, tender varieties are grown for human consumption, while larger varieties are grown as feed for livestock. The turnip is also known as white turnip, neeps, tourn, rapes. In France it is navet, also known as rave, bulbe de racine ; du grec ραπυς, ραπυος : rave. Human selection has shaped wild Brassica rapa into diverse turnip, leafy, and oilseed crops. The turnip or white turnip is a root vegetable. Some smaller varieties are grown for human consumption while others are used as fodder. The leaves are sometimes eaten as “turnip greens”. Turnip grows in temperate climates. This species (*Brassica rapa*) has also been bred to produce the widely-cultivated seed-oil crop known as rape or canola. This oil is used for cooking, but also lubricating oils, plastics manufacturing and biodiesel. The byproducts (seed solids) are used in animal feeds. The term turnip also is used for two other vegetables, *Brassica napus* var. *napobrassica* (or *B. napobrassica*) and *Pachyrhizus*. *Brassica napus* var. *napobrassica* (a cross between *Brassica rapa rapa* and cabbage) is commonly known as rutabaga or yellow turnip in the United States and as swede in Southern England and most Commonwealth countries. The fully developed tender roots of turnip are uprooted on attaining the marketable size. Normally the roots are harvested when they are 5–10cm in diameter depending upon the variety. On an average it yields 200–400q/ha. Whip tail is caused due to deficiency of Molebdinum. This is more common in acidic soils. However, it is controlled by the application of 1.2kg/ha of sodium or ammonium molybdate. In this review article on Origin, Domestication, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding, Uses, Nutritional Value and Health Benefits of Turnip are discussed.

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INTRODUCTION

Turnip belogs to the Family Brassicaceae, Genus *Brassica* , Species *Brassica* rapa and Variety *Brassica* rapa var. *rapa* L. (Wikipedia. 2024; NEW, 2024). The turnip or white turnip (*Brassica rapa* subsp. *rapa*) (WCD, 2024) is a root vegetable commonly grown in temperate climates worldwide for its white, fleshy taproot. Small, tender varieties are grown for human consumption, while larger varieties are grown as feed for livestock. The name turnip – used in many regions – may also include rutabaga, *neep* or *swede* (Wikipedia. 2024). In England around 1700, Charles "Turnip" Townshend promoted the use of turnips in a four-year crop-rotation system that enabled year-round livestock feeding. In most of England, the smaller white vegetables are called turnips, while the larger yellow ones are referred to as swedes. In the United States, turnips are the same, but swedes are usually called rutabagas (Wikipedia, 2024). The origin of the word *turnip* is uncertain, though it is hypothesised that it could be a compound of *turn* as in turned/rounded on a lathe and *neep*, derived from Latin *napus*, the word for the plant. According to An Universal Etymological English Dictionary, *turn* refers to "round *napus* to distinguish it from the napi, which were generally long" (Wikipedia. 2024). *Brassica rapa* is a diverse wild plant species known with several common names: wild turnip, field mustard,

turnip mustard, wild mustard, wild kale or bird rape. It has bright yellow flowers which attract bees (Gordgen, 2024). Oilseed rapes are the world's third most important source of vegetable oils after palm and soybean. The rapeseed production has witnessed a steady upward movement during the past 25 years and presently, it contributes about 14% of the global vegetable oils. More recently, the introduction of low erucic acid varieties enhanced its value as edible oil, particularly among the health conscious consumers and varieties with low glucosinolates increased the value of its defatted meal for use as a feed for livestock. The development of double-low varieties (canola) has made rapeseed one of the major plant oil sources at the global level, and now there is a constant tendency to increase its share in production of oilseeds (Gupta and Pratap, 2007). Rapeseed of commercial interest is grown in the cooler areas of the world covering mainly North America, northern part of Europe, Canada, China, and India. This is obtained from the species of *Brassica*, members of Cruciferae, and within the genus are some 160 species, mainly annual and biannual herbs. Oleiferous rapes are generally derived from two *Brassica* species, *Brassica napus* L. and *B. campestris* L. syn. *B. rapa* L. To distinguish between them, *B. rapa* is known as turnip rape and *B. napus* as Swede rape with winter types existing in both of them. *B. campestris* is also referred to as toria, sarson, summer turnip rape, Polish rape, and so on. Similarly, different names are also given to *B. napus* such as Argentine rape, Swede rape, and colza. All the rapeseed contributing cultivated *Brassica* species are highly polymorphic including oilseed crops, root crops, and vegetables such as Chinese cabbage, broccoli, and Brussels sprouts. However, our discussion in this and the subsequent chapters shall concentrate mainly on the oilseed rapes (Gupta and Pratap, 2007).

The crop Brassicas have been very important as food crops in the form of vegetables, oilseeds, feed and fodder, green manure, and condiments and have played a great role in the human history by contributing a good share of food in one form or another. Two species, *B. juncea* and *B. campestris* having a range of morphotypes, are the crops of antiquity in India where much before the Christian era, they were used for many purposes including oil for cooking and frying, spice for seasoning food. The *Brassica* genus is a very complex member of the Cruciferae family, and as such it contains many cultivated plants and wild species. It therefore poses several taxonomic and classification problems. Also, there is a lack of consistency in the names of different oil-yielding Brassicas throughout the globe, which aggravates the problem further (Gupta and Pratap, 2007). The turnip, *Brassica rapa* var. *rapa,* is a root vegetable commonly grown in temperate climates worldwide for its white, bulbous taproot. Small, tender varieties are grown for human consumption, while larger varieties are grown as feed for livestock (KYT, 2009). The turnip is also known as white turnip, neeps, tourn, rapes. In France it is navet, also known as rave, bulbe de racine ; du grec ραπυς, ραπυος : rave (KYT, 2009). The study of domestication contributes to our knowledge of evolution and crop genetic resources. Human selection has shaped wild *Brassica rapa* into diverse turnip, leafy, and oilseed crops. Despite its worldwide economic importance and potential as a model for understanding diversification under domestication, insights into the number of domestication events and initial crop(s) domesticated in *B. rapa* have been limited due to a lack of clarity about the wild or feral status of conspecific noncrop relatives (McAlvay et al., 2021). The turnip or white turnip is a root vegetable. Some smaller varieties are grown for human consumption while others are used as fodder. The leaves are sometimes eaten as “turnip greens”. Turnip grows in temperate climates. In some countries, the name turnip is used for the rutabaga, which is a related but different vegetable with yellow roots (WCD, 2024). Turnip has been recorded escaping cultivation in many regions of North America, including New England. Turnip has been cultivated in Europe as a root vegetable since prehistoric times, and has been used as a fodder or forage for livestock for at least six hundred years. This species (*Brassica rapa*) has also been bred to produce the widely-cultivated seed-oil crop known as rape or canola. This oil is used for cooking, but also lubricating oils, plastics manufacturing and biodiesel. The byproducts (seed solids) are used in animal feeds (Gobotany, 2024). Turnip (A), turnip greens (B) and turnip tops (C) are used as vegetable (Fig.1).

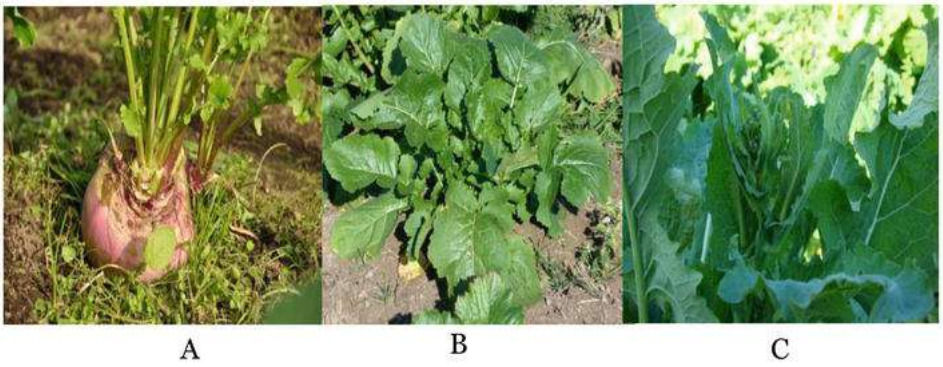

Fig. 1. Leafy vegetable crops from the Brassica rapa group: Turnip (A), turnip greens (B) and turnip tops (C)

Brassica species are characterized by their tremendous intraspecific diversity, exemplified by leafy vegetables, oilseeds, and crops with enlarged inflorescences or above ground storage organs. In contrast to potato tubers that are edible storage organs storing energy as starch and are the vegetative propagation modules, the storage organs of turnips, grown from true seed, are swollen hypocotyls with varying degrees of root and stem that mainly store glucose and fructose (Liu *et al.,* 2019). Domestication is a process of adaptation to agroecological niches and human preferences driven by a complex mix of ecological, biological, and cultural factors. The study of domestication provides insight into the nature of contemporary crop genetic resources and evolutionary processes in general. The identity of the wild relatives of a crop is a key piece of information in disentangling the often-complex domestication history, allows the direct comparison of wild to domesticated forms, and can contribute useful alleles responsible for agronomically important traits. However, the identification of truly wild populations is often complicated by the presence of conspecific feral populations that are common for many crops.

Unlike wild populations, feral plants derive from domesticated crops that have either escaped from cultivation on their own (endoferal) or through crossing with wild populations (exoferal). Additionally, complex histories of hybridization and introgression among wild, feral, and domesticated forms within and across species make identification of truly wild populations difficult (McAlvay *et al*., 2021). One of the most widespread crop species, *Brassica rapa* L. (Brassicaceae: 2*n* = 20), includes turnips, leafy greens, such as bok choy, napa cabbage, mizuna, tatsoi, rapini, grelos, and choy sum, and oilseed crops, such as turnip rape, toria, and yellow sarsons as well as weedy forms (*B. rapa* ssp. *sylvestris*) which may be wild or feral (McAlvay et al., 2021). *Brassica rapa* is a plant species growing in various widely cultivated forms including the turnip (a root vegetable); Komatsuna, napa cabbage, bomdong, bok choy, and rapini. *Brassica rapa* subsp. *oleifera* is an oilseed which has many common names, including rape, field mustard, bird's rape, and keblock. The term rapeseed oil is a general term for oil from *Brassica* species. Food grade oil made from the seed is also called canola oil, while non-food oil is called colza oil. Canola oil is sourced from three species of Brassica plants: *Brassica rapa* and *Brassica napus* are commonly grown in Canada, while *Brassica juncea* (brown mustard) is a minor crop for oil production.

Turnip (*Brassica rapa* syn. *B. campestris* L. ssp. *rapifera* Matzg), belonging to the *Brassica* genus, has been an important global crop for centuries, first being cultivated in China in 2500 B.C. It is known by many Chinese names, such as Feng, Manjing, Yuancaitou, Yuangen, Pancai, Buliuke, Jiuyingsong, Yuanluobo, and Zhugecai. As a *B. rapa* subspecies, this turnip group represents one of the oldest groups of cultivated *B. rapa* type. In the Tibet Autonomous Region of China, turnip is called “Niuma” and is widely used as a vegetable, fodder, oilseed, traditional Tibetan medicine, and as raw material in butter lamps. Additionlly, it is considered an ideal cash crop for cold areas at high altitudes area due to its relatively short growth period and its high resistance to barren conditions, and cold climates (Li *et al.,* 2021). Genetic diversity analysis is the basis of variety resource evaluation, utilization, and preservation, as well as breeding new varieties. Many studies on the genetic diversity of turnip have been conducted following morphological characteristics or limited molecular markers, revealing that turnip (*Brassica rapa*) has a high genetic variation. However, morphological descriptions vary significantly based on environmental factors, *e.g*., farming practices, age, and the developmental stages of plants. In recent decades, different types of molecular markers, including restriction fragment length polymorphisms (RFLP), amplified fragment length polymorphisms (AFLP), random amplified polymorphic DNA (RAPD), simple sequence repeats (SSR), and single nucleotide polymorphism (SNP), have been applied to evaluate the genetic diversity of *Brassica*, particularly turnip-type rapeseed, in different regions by many researchers. Among these markers, the development of SSR technology has been widely used for analyzing genetic diversity in plant species due to its low cost and simple use to reveal the genetic relationships among different varieties (Li *et al.,* 2021).

Brassica rapa has several subspecies with different uses as crop plants. Turnip (*Brassica rapa* subsp. *rapa*) is used as a root vegetable. It’s a biannual plant with a swollen, wide and tuberous root. Field mustard (*Brassica rapa* subsp. *oleifera*) is used as oilseed crop. It’s an annual plant with a thin root. The leafy forms are used as leaf vegetables such as pak choi (*Brassica rapa* subsp. *chinensis*) (Gordgen, 2024). Turnip is the common name for a root vegetable, *Brassica rapa* var, *rapa (Brassica rapa rapa)*. This plant is grown in temperate climates worldwide for its bulbous, edible root, and the leaves also are consumed. Small, tender, varieties are grown for human consumption, while larger varieties are grown as feed for livestock. The term turnip also is used for the bulbous storage root (NEW, 2024). The term turnip also is used for two other vegetables, *Brassica napus* var. *napobrassica* (or *B. napobrassica*) and *Pachyrhizus*. *Brassica napus* var. *napobrassica* (a cross between *Brassica rapa rapa* and cabbage) is commonly known as rutabaga or yellow turnip in the United States and as swede in Southern England and most Commonwealth countries. *Pachyrhizus* is known as jicama in the United States and yam bean in Southern England and most Commonwealth countries. *Brassica rapa rapa*, which is known as turnip in the United States, Southern England, and most Commonwealth countries, is known as swede in Ireland and Northern England. This article will use turnip in the sense of *Brassica rapa rapa* (NEW, 2024).

Cultivation: Turnips are cold hardy vegetables which can be grown early in the spring for a summer harvest or in the summer for harvesting in late fall. They prefer a fertile, well draining soil which has a pH between 6.0 and 7.0. The soil should have a loose texture for optimum root development. Turnips will grow best in full sun but will tolerate partial shade. The average daily temperature should fall between 10–18°C (50–65°F) for adequate growth. Turnips are usually direct seeded and can be sown as soon as the soil is workable in the Spring. For a Fall harvest, sow seeds about 2 months before the first frost in your area. Prepare the soil for planting by loosening it with a fork to a depth of about 30–38 cm (12–15 in). Remove any large rocks if present. Incorporate 2–4 inches of compost into the soil prior to planting. Sow seeds by broadcasting and raking 13 mm (0.5 in) into the soil. Thin seedlings to a final spacing of 7.5–10 cm (3–4 in). Alternatively, seeds can be sown in rows spaced 30–45 cm (12–18 in) apart. Water turnip plants evenly and keep the soil moist for optimum growth. Mulching the plants will help to conserve moisture in the soil. Pull any weeds as they appear, the soil can be cultivated down to 2.5–5.0 cm (2–3 in) when the plants are small but this should be reduced as the plants grow larger to prevent damage to delicate feeder roots. Turnip greens can be harvested from the plant when the leaves are about 10 cm (10 in) tall. If growing turnips for both greens and roots then only remove 2–3 leaves from each plant. Roots are ready to harvest when they reach 2.5–7.5 cm (1–3 in) in diameter. Small turnips can often be harvested by gently pulling from the soil by hand but larger roots in heavier soil may need gently dug up with a garden fork. Store unwashed roots in a root cellar or basement (Fig. 2) (Plantvillage, 2024).

Harvesting and postharvest management: The fully developed tender roots of turnip are uprooted on attaining the marketable size. Normally the roots are harvested when they are 5–10cm in diameter depending upon the variety. The roots become tough and fibrous if harvesting is delayed. The harvesting should be done in the evening. The yield of turnip varies with varieties as well as growing season. On an average it yields 200–400q/ha. Its harvested roots along with the green tops are properly washed to remove the adhered soil. The side roots are trimmed off.

Fig. 2. Turnips growing in the cool months

These are sent to the market in baskets either along with green tops or after cutting them off near the surface of the crown. After removing old and diseased leaves the foliage is made into bunches for marketing. The roots are sorted into different grades according to colour, shape and size to give an attractive appearance in the market. Then these are immediately transported to the market and disposed off. The roots can be stored safely for 2–3 days under cool and moist conditions. However, it can be stored for 8–16 weeks at 00C with 90–95% relative humidity **(**Eagri, 2024).

Physiological disorder: Whip tail is caused due to deficiency of Molybdenum. This is more common in acidic soils. Young leaves become narrow, cupped, showing chlorotic mottling especially around the margin, develop deep patches which ultimately affect the root growth. The affected plants are removed from the field during thinning. Further appearance of this disorder can be controlled by liming the soil and bringing the pH to 6.5. However, it is controlled by the application of 1.2kg/ha of sodium or ammonium molybdate **(**Eagri, 2024).

In this review article on Origin, Domestication, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding, Uses, Nutritional Value and Health Benefits of Turnip are discussed.

ORIGIN AND DISTRBUTION

The oldest references regarding origin and cultivation of rapeseed come from Asia, though the evolution of this crop took place in many countries throughout the globe, including China, India, Switzerland, Germany, Australia, Denmark, the Netherlands, Rome, and Europe. However, most of the work on development of modern and high-quality rapeseed known as canola was done in Canada. Lack of consistency in names, inclusion of too many forms in one species, and the entirely different forms of present day Brassicas from their ancestors make this genus a complex member of Cruciferae and poses several taxonomic and classification problems. Still many attempts have been made to establish the origin of various *Brassica* species and their interrelationships through cytogenetic, chemotaxonomic, and molecular studies (Gupta and Pratap, 2007).

Turnips are believed to have originated as a crop in the cooler parts of Europe, presumably from biennial oilseed forms. The crop has been under cultivation since ancient times and was known to Greeks and Romans at the beginning of the Christian era. It was introduced into Britain from France by the Romans, and into North America by the early European settlers in the 17th century (Vidhi, 2024). Turnip, (*Brassica rapa, variety rapa*), hardy biennial plant in the mustard family (Brassicaceae), cultivated for its fleshy roots and tender growing tops. The turnip is thought to have originated in middle and eastern Asia and is grown throughout the temperate zone (EEB, 2024). Wild forms of the turnip and its relatives, the mustards and radishes, are found over western Asia and Europe. Starting as early as 2000 BC, related oilseed subspecies of *Brassica rapa* like *oleifera* may have been domesticated several times from the Mediterranean to India, though these are not the same turnips cultivated for its roots. Furthermore, estimates of domestication dates are limited to linguistic analyses of plant names. Edible turnips were possibly first cultivated in northern Europe, and were an important food in the Hellenistic and Roman world. The turnip eventually spread east to China, and reached Japan by 700 AD (Wikipedia, 2024).

The history of turnips roots deep into ancient times. These robust vegetables are more than just a staple crop. They hide a rich backstory that shows how human cultivation shaped their journey. Let’s unearth the story of turnips and their journey from wild roots to dinner plates around the world. Long before supermarkets, ancient civilizations recognized the value of turnips. Evidence points to the fact that turnips were one of the first domesticated crops. Their resilience to cold weather made them essential for survival. Neolithic farmers likely began growing turnips over 3,500 years ago. These growers selected the best plants, leading to larger and tastier turnips. In regions like the Near East and the Mediterranean, turnip cultivation thrived. Turnips didn’t stay put in their ancient birthplaces. Traders and travelers carried the turnip seeds far and wide. This led to its global spread. With each area it

reached, local farmers adapted the turnip to their climate and cuisine. Delving into the journey of turnips reveals a rich tapestry woven through time. Turnips Through the Ages mirrors the evolution of societies. This humble root vegetable left its mark on agriculture. It shaped numerous cultural narratives. Let's unearth the layers of history and influence wrapped around the turnip. From ancient epochs to modern farming, turnips have been pivotal. Originally domesticated in prehistoric times, these robust roots battled harsh climates and poor soils. Gained renown for resilience and adaptability. Integral in crop rotation systems, enhancing soil health. Valued for their nutrient-rich greens and roots Historically, turnips helped societies survive famines. Farmers relied on them to feed populations and livestock alike. Turnips seamlessly wove into cultural fabric. Festivals, folklore, and art featured this versatile vegetable. It became a symbol of sustenance and prosperity. From ancient carvings to Renaissance paintings, turnips held a presence. They graced tables in tales and proverbs, teaching moral lessons (Maddox, 2024).

The origin of the turnip (*Brassica rapa var. rapa*) is a bit of a mystery. It likely once grew wild across Europe and Asia, and it was an important agricultural crop by the time of the Romans. In the first century BCE, Pliny the Elder regarded the turnip as one of the most important vegetables of his time. But turnips have taken quite a tumble over the last two millennia, going from ancient favorite to cover crop, livestock feed and staple food of the poor (a cultural association that still lingers). While more common in Europe and Asia, these vegetables and their greens are often overlooked in the U.S., except for certain regional recipes (in the South, for example, turnip greens take their place alongside collards as a cultural icon) (Foodprint, 2024).

TAXONOMY

Turnip belogs to the Family Brassicaceae, Genus *Brassica* , Species *Brassica* rapa and Variety *Brassica* rapa var. *rapa* L. (*Bioweb, 2007;* Wikipedia. 2024; NEW, 2024). The turnip or white turnip (*Brassica rapa* subsp. *rapa*) (WCD, 2024) is a root vegetable commonly grown in temperate climates worldwide for its white, fleshy taproot. Small, tender varieties are grown for human consumption, while larger varieties are grown as feed for livestock. Turnip (*Brassica rapa* L., 2n = 2x = 20, formerly *B. campestris* subsp. *rapifera*) belongs to the large Brassica family and bears similar yellow (and occasionally white) flowers. It does not cross readily with the *oleracea* (cabbage types) and belongs to a separate species, *B. campestris*. Another crop swede (*B. napus* L. var. *napobrassica*) is directly related to turnip (Vidhi, 2024). Brassica rapa is a species in the angiosperm family Brassicaceae. The Brassicaceae family consists of 338 genera and approximately 3710 species (Beilstein et al. 2008) of which several are agronomically important. In the Brassica genus six species are agronomically important. Three of them are diploid: Brassica rapa (AA genome, 2n=20), containing three main morphotypes (turnip types, leafy types and oil types); Brassica nigra (BB genome 2n=16) (black mustard) and Brassica oleracea (CC genome 2n=18) including cabbages, broccoli, cauliflower and kohlrabi (above ground turnip). Three of those six are amphidiploids: Brassica juncea (AABB genome, 2n=36) (Indian or brown mustard and several leafy types); Brassica napus (AACC genome, 2n=38) including oilseed rape and the turnip forming Swede, and Brassica carinata (BBCC genome, 2n=34) (Ethiopian mustard). Within those six species Brassica rapa is the species that was domesticated first. It has been cultivated for many years from central Asia to Europe and northern America. The crop is cultivated for the oil content (Yellow Sarson) and for vegetable purposes (Peter Vos, 2009).

Brassica rapa (2n = 20, synonymous with *B. campestris* L.) is an economically important species belonging to the *Brassica* genus, Brassiceae tribe, from the Brassicaceae family. The *Brassica* genus includes many important crops. Among them, relationship of six species formed the model of U's triangle, with three basic diploid species, namely *B. rapa* (A genome, n = 10), *Brassica oleracea* (C genome, n = 9) and *Brassica nigra* (B genome, n = 8), which gave rise to three amphidiploid species, namely *Brassica napus* (AC genome, n = 19), *Brassica juncea* (AB genome, n = 18) and *Brassica carinata* (BC genome, n = 17) (Cartea *et al.,* 2021). *Brassica rapa* is an important oil and vegetable crop in many parts of the world, whose seeds are used for oil, and leaves, flowers, stems and roots are used as vegetables. *B. rapa* vegetables are consumed worldwide and provide a large proportion of the daily food intake in many regions of the world. Cultivation of this species for many centuries in different parts of the world has caused a large variation in the plant organs that are consumed (roots, leaves, and flower buds), which has resulted in the human selection of different morphotypes, depending on local preferences (Cartea *et al.,* 2021)

Based on their morphological appearance and on the organs used, *B. rapa* crops can be classified into two groups (Cartea *et al.,* 2021):

Vegetable types used for their tubers (=hypocotyl), leaves and flower buds, which include the *rapa* (= *rapifera* or *ruvo*) group and the leafy vegetable forms. These vegetable types belong to six groups: *rapa*, *chinensis, pekinensis*, *parachinensis*, *nipposinica*, *perviridis* and *narinosa*. Oleiferous types, of which canola is a specific form, having low erucic acid levels in its oil and low glucosinolate content in its meal protein. Until recently, these groups were considered as separate species because of the wide range of variability they show and the fact that they evolved in isolation from each other. Vegetable *B. rapa* crops, including rapifera and leafy types, are important crops in European and Asian countries, particularly in China, Korea, and Japan. Their consumption varies widely around the world and they are consumed as raw or steamed vegetables. The largest and most diverse *B. rapa* group consists of crops belonging to the *pekinensis* type, which includes popular crops in Chinese cuisine such as pet-sai or Chinese cabbage. They are characterized by having large leaves and forming heads of different shapes. Chinese cabbage, for example, is the cabbage used for preparing dishes such as sauerkraut and kimchi, the famous fermented dish favored by Koreans. Its seeds have also been used for the hot mustard favored in Chinese cuisine. Pak-choy or bok-choy (*chinensis* group) are also popular crops in Asian culture. They have been used for their leaves, which do not form heads and are smooth. It is assumed that pak-choy types with narrow or wide green-white petioles were the first *B. rapa* crops to evolve in Central China. Another group of cultivars that is characterized by many narrow leaves belong to the *perviridis* group, which includes neep greens from Europe and

the Japanese cultivar Komatsuna. Finally, we have the *nipposinica* group, which includes Japanese crops like mizuna or mibuna, which can be eaten raw or cooked at any stage, from seedling to mature plant (Cartea *et al*., 2021).

The *rapa* or *rapifera* group is characterized by the thickening of the hypocotyls, which can show different colors and shapes, and has a mainly horticultural and forage use. Turnips are both cultivated as fodder crops or as vegetables, and depending on the region, the tubers, leaves and shoots are used. Turnip greens are the young leaves harvested in the vegetative growth period. Turnip tops are the fructiferous stems with flower buds and the surrounding leaves that are consumed before opening and while still green (Cartea *et al*., 2021).

The *oleifera B. rapa* group includes oilseed crops that are known in Europe as rapeseed or turnip rape. It is believed that European forms developed in the Mediterranean area and then they were distributed from Europe to China. In India, crops used for oil production belong to the *trilochularis* and *dichotoma* groups. Sarson and toria types belong to this group. There are three ecotypes: brown sarson, toria and yellow sarson. Out of these, brown sarson appears to be the oldest one. Yellow sarson is characterized by its yellow colored seeds and self-compatibility. Many of the cultivars have 3–4 valved siliquae, and for this reason, it was named trilochularis. It is believed to have evolved from brown sarson as a mutant and has survived because of its self-compatible nature. It might have been selected by farmers for its attractive yellow-colored seeds and bigger seed size (Cartea *et al.,* 2021)

The scientific classification for the plant is either Brassica rapa or Brassica campestris. Brassica is the Latin word for cabbage, rapa means turnip, and campestris refers to “of fields” in Latin. Pliny, an ancient Roman author, used the names rapa and napus to descibe turnips that were long, flat, or round. English of the Middle Ages turned napus into naep in Anglo-Saxon. Combined with the word turn, which means “made round,” the name turnip was created. The turnip itself is a, “root vegetable in the Cruciferae, or mustard, family”. However, technically this root vegetable is not actually a root at all, but a “swollen stem which grows beneath the surface of the soil”. The plants are, “almost perfectly round and have white flesh and thin, rough leaves covered by prickly hairs”. These leaves are tough, usually light green in color, and the covering, which resembles hair but is actually just a sort of growth, is usually present. Turnips are bulbous in shape and are often a mixture of the colors purple, white, and/or yellow (Wikipedia. 2024).

The genus to which turnips belong, *Brassica*, is classified in the mustard or cabbage family, Brassicaceae. This genus is remarkable for containing more important agricultural and horticultural crops than any other genus. Almost all parts of some species or other have been developed for food, including the root (rutabagas, turnips), stems (kohlrabi), leaves (cabbage, brussels sprouts), flowers (cauliflower, broccoli), and seeds (many, including mustard seed, oilseed rape). Some forms with white or purple foliage or flowerheads also are grown sometimes for ornament. This genus also includes a number of weeds, both wild taxa and escapees from cultivation. It includes over 30 wild species and hybrids, and numerous additional cultivars and hybrids of cultivated origin. Most are annuals or biennials, but some are small shrubs (NEW, 2024).

Infraspecific taxonomy of *Brassica rapa* is given in Table 1(McAlvay et al., 2021).

Table 1. Infraspecific Taxonomy of *Brassica rapa*

Geography	Common Name	Latin Binomial	Plant Organ(s) Used
C. Asia	Yellow sarson	ssp. *trilocularis* (Roxb.) Hanelt	Seeds/leaves
C. Asia	Toria/Brown sarson[a]	ssp. *dichotoma* (Roxb.) Hanelt	Seeds/leaves
E. Asia	Komatsuna	ssp. *perviridis* Bailey	Leaves/inflorescences
E. Asia	Bok Choy	ssp. *chinensis* (L.) Hanelt	Leaves
E. Asia	Napa cabbage	ssp. *pekinensis* (Lour.) Hanelt	Leaves
E. Asia	Choy sum	var. *parachinensis* (L.H. Bailey) Hanelt	Leaves/inflorescences
E. Asia	Mizuna	ssp. *nipposinica* (L.H. Bailey) Hanelt	Leaves
E. Asia	Tatsoi	ssp. *narinosa* (L.H. Bailey) Hanelt	Leaves
E. Asia	Taicai	ssp. *chinensis* Makino var. *tai-tsai* Hort	Leaves
E. Asia	Zitaicai	var. *purpuraria* (L.H. Bailey) Kitam	Leaves/inflorescences
Europe	Rapini	ssp. *sylvestris* L. Janch. var. *esculenta* Hort	Leaves/inflorescences
Eurasia	Turnip rape	ssp. *oleifera* (DC.) Metzg.	Seeds
Eurasia	Turnip	ssp. *Rapa*	Root-hypocotyl/leaves
Eurasia	Weedy (wild/feral)[b]	ssp. *sylvestris* (L.) Janch.	Leaves/inflorescences

Synonym (Vélez-Gavilán, 2018.).

1. Barbarea derchiensis S.S.Ying
2. Brassica antiquorum H.Lév
3. Brassica asperifolia Lam.
4. Brassica brassicata A.Chev.
5. Brassica briggsii Varenne
6. Brassica campestris L.
7. Brassica celerifolia (Tsen & S.H. Lee) Y.Z.Land & T.Y.Cheo

8. Brassica chinensis L.
9. Brassica cibaria Dierb.
10. Brassica colza H.Lév.
11. Brassica cyrenaica Spreng.
12. Brassica dubiosa L.H.Bailey
13. Brassica macrorhiza Gray
14. Brassica napella Chaix
15. Brassica narinosa L.H.Bailey
16. Brassica nipposinica L.H.Bailey
17. Brassica oleronensis A.Sav. ex Foucaud
18. Brassica parachinensis L.H.Bailey
19. Brassica pekinensis (Lour.) Rupr.
20. Brassica pekinensis Skeels
21. Brassica perfoliata Crantz
22. Brassica perviridis (L.H.Bailey) L.H.Bailey
23. Brassica petsai (Lour.) L.H.Bailey
24. Brassica pseudocolza H.Lév
25. Brassica purpuraria (L.H.Bailey) L.H.Bailey
26. Brassica quadrivalvis Hook.f. & Thomson
27. Brassica rapifera (Metzg.) Dalla Torre & Sarnth.
28. Brassica rapoasiatica Sinskaya
29. Brassica rapoeuropea Sinskaya
30. Brassica saruna Siebold
31. Brassica septiceps (L.H.Bailey) L.H.Bailey
32. Brassica sphaerorrhiza Gray
33. Brassica trilocularis Hook.f. & Thomson
34. Brassica trimestris Boenn.
35. Brassica tuberosa Salisb.
36. Caulanthus sulfureus Payson
37. Crucifera rapa E.H.L.Krause
38. Napus campestris (L.) Schimp. & Spenn.
39. Napus rapa (L.) Schimp. & Spenn.
40. Raphanus campestris (L.) Crantz
41. Raphanus rapa (L.) Crantz
42. Sinapis dichotoma Roxb.
43. Sinapis pekinensis Lour.
44. Sinapis rapa (L.) Brot.
45. Sinapis tuberosa Poir.

BOTANICAL DESCRIPTION

The most common type of turnip is mostly white-skinned apart from the upper 1–6 centimeters, which protrude above the ground and are purple, red, or greenish wherever sunlight has fallen. This above-ground part develops from stem tissue, but is fused with the root. The interior flesh is entirely white. The entire root is roughly conical, but can be occasionally tomato-shaped, about 5–20 centimeters in diameter, and lacks side roots. The taproot (the normal root below the swollen storage root) is thin and 10 centimeters or more in length; it is trimmed off before marketing. The leaves grow directly from the above-ground shoulder of the root, with little or no visible crown or neck (as found in swedes) (KYT, 2009).

The most common type of turnip is mostly white-skinned apart from the upper 1 to 6 centimetres (1⁄2 to 2+1⁄2 inches), which protrude above the ground and are purple or red or greenish where the sun has hit. This above-ground part develops from stem tissue, but is fused with the root. The interior flesh is entirely white. The root is roughly globular, from 5–20 cm (2–8 in) in diameter, and lacks side roots. Underneath, the taproot (the normal root below the swollen storage root) is thin and 10 cm (4 in) or more in length; it is often trimmed off before the vegetable is sold. The leaves grow directly from the above-ground shoulder of the root, with little or no visible crown or neck (as found in rutabagas). Turnip leaves are sometimes eaten as "turnip greens" ("turnip tops" in the UK), and they resemble mustard greens (to which they are closely related) in flavor. Turnip greens are a common side dish in southeastern U.S. cooking, primarily during late Fall and Winter. Smaller leaves are preferred. Turnip roots weigh up to 1 kilogram (2 pounds 3 ounces), although they are usually harvested when smaller. Size is partly a function of variety and partly a function of the length of time the turnip has grown (Wikipedia. 2024).

Flower petal color yellow. Leaf type the leaves are compound (made up of two or more discrete leaflets or the leaves are simple (*i.e.,* lobed or unlobed but not separated into leaflets). Leaf arrangement alternate: there is one leaf per node along the stem. Leaf blade edges the edge of the leaf blade has lobes, or it has both teeth and lobes or the edge of the leaf blade has teeth or the edge of the leaf blade is entire (has no teeth or lobes). Flower symmetry there are two or more ways to evenly divide the flower (the flower is radially symmetrical). Number of sepals, petals or tepals, there are four petals, sepals, or tepals in the flower. Fusion of sepals

and petals both the petals and sepals are separate and not fused. Stamen number 6. Fruit type (general) the fruit is dry and splits open when ripe. Fruit length 35–110 mm (Gobotany, 2024).

Turnip, *Brassica rapa*, is an herbaceous annual or biennial plant in the family Brassicaceae grown for its edible roots and leaves. The plant possesses erect stems and 8–12 leaves forming a crown. The leaves are light green in color, hairy and thin. The plant produces light yellow flowers which are clustered at the top of a raceme and are often extended above the terminal buds. The leaves can reach 30.5–35.5 cm (12–14 in) in length, while the branching flower stems can reach 30.5–91.5 cm (12–36 in). The taproot of the plant is is a bulbous tuber, almost perfectly round, which is usually a mixture of purple, white and yellow. Turnip is usually grown as an annual and harvested after one growing season. Turnip may also be referred to as annual turnip and originates from Europe (Plantvillage, 2024).

The plant is a diploid or tetraploid. Cotyledon: Length: short-medium or long, Width: narrow, medium or wide Fisrst leaf: Hairiness on margin: very sparse, sparse, medium, dense or very dense. Leaf : Attitude: erect, semi-erect, medium, nearly horizontal or horizontal . Reflexion of top: absent or very weak, weak, medium, strong or very strong . Green colour: very pale, pale, medium, dark or very dark . Lobes: absent or present. Number of lobes (fully developed leaf): few, few to medium, medium, medium to many or many . Incisions of blade base (cultivars with leaves without lobes only): absent or very weak, weak, medium, strong or very strong . Undulation of margin: absent or very weak, weak, medium, strong or very strong. Dentation of margin: absent or very weak, weak, medium, strong or very strong. Length (blade and petiole): short, medium or long. Width (widest point): narrow, medium or broad. Hairiness of upper side: absent or very weak, weak, medium, strong or very strong. Anthocyanin colouration: absent or very weak, weak, medium strong or very strong . Root Speed of formation: very slow, slow, medium, fast or very fast. Position in soil: very shallow, shallow, medium, deep or very deep . Cork layer around skin: absent or present . Chlorophyll colouration of skin at top: absent or present . Anthocyanin colouration of skin at top: absent or present . Expression of anthocyanin colouration of skin at top: reddish or bluish . Streaking of anthocyanin colouration of skin at top: absent or present . Intensity of colouration of skin at top: weak, medium or strong . Colour of skin below ground: white, yellow, red or purple. Colour of flesh: white or yellow. Intensity of yellow colour of flesh: weak, medium or strong. Anthocyanin colouration of flesh: absent or present . General shape: flat-round, elongated or tapering . Length: very short, short, medium, long or very long. Width (at widest point): narrow, medium or broad . Relative position of widest point: low, medium or high. Curvature of main axis: absent or present . Shape of crown: strongly indented, indented, level, raised or strongly raised. Shape of base: strongly indented, indented, truncate, round or pointed. Flower Colour of petal: lemon-yellow or orange-yellow. Length of petal: short, short to medium, medium, medium to long or long. Width of petal: narrow, medium or broad . Length of stem: short to medium, medium or medium to long. Diameter of stem (about 10 cm above root neck): small to medium, medium or medium to large. Siliqua: Anthocyanin coloration of siliqua: absent or very weak, weak, medium, strong or very strong. Length (between peduncle and beak): short, medium or long. Length of beak: short, medium or long. Length of peduncle: short, medium or long. Seed: Colour (of ripe seeds): yellow, yellow-brown, light red-brown or dark red-brown. Weight per 1000 seeds: low, low to medium, medium, medium to high or high (Vidhi, 2024).

The most common type of turnip is mostly white-skinned, apart from the upper 1–6 centimeters, which protrudes above the ground and is purple, red, or greenish wherever sunlight has fallen. This above-ground part develops from stem tissue, but is fused with the root. The interior flesh is entirely white. The entire root is roughly spherical, but occasionally is squircle in shape (properties between those of a square and those of a circle). The root typically is about 5–20 centimeters in diameter, and lacks side roots. The taproot (the normal root below the swollen storage root) is thin and 10 centimeters or more in length; it is trimmed off before marketing. The leaves grow directly from the above-ground shoulder of the root, with little or no visible crown or neck (as found in rutabagas). Turnip leaves sometimes are eaten, and resemble mustard greens; varieties specifically grown for the greens resemble mustard greens more than those grown for the roots, with small or no storage roots. Varieties of *B. rapa* that have been developed specifically for use as leaf vegetables are called Chinese cabbage. Both leaves and roots of turnips have a pungent flavor similar to raw cabbage or radishes that becomes mild after cooking. Turnip roots weigh up to about 1 kilogram, although they can be harvested when smaller. Size is partly a function of variety and partly a function of the length of time that the turnip has grown. Most very small turnips (also called baby turnips) are speciality varieties. These are only available when freshly harvested and do not keep well. Most baby turnips can be eaten whole, including their leaves. Baby turnips come in yellow, orange, and red-fleshed varieties as well as white-fleshed. Their flavor is mild, so they can be eaten raw in salads like radishes (NEW, 2024). Botanical description is given in Fig. 3.

		
Seedlings	**Seedlings**	**Seedling**

Greens

Greens

Greens

Field

Roots

Roots

Fig. 3. Botanical Description

Seed Production

The turnip (*Brassica rapa* var. *rapa*) is a biennial crop that is planted in late summer/early fall and forms fleshy tubers for food in temperate regions. The harvested tubers then overwinter and are planted again the next spring for flowering and seeds (Fig.4) (Yan Zehng *et al.,* 2018).

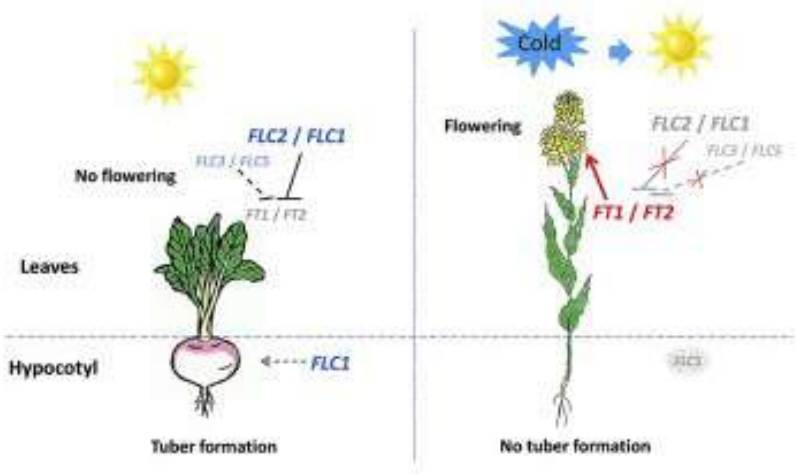

Fig. 4.Graphical abstract

Turnips are biennial plants that are grown as annuals because, after overwintering, they flower and form seeds in their second year. However, turnips can be tricked into flowering in the spring of their first year by a cold snap followed by warm weather. When this happens, the roots become woody and the greens become tough and bitter, but you have the flowers and the seeds (Garden.eco., 2023). Both seed to seed and root to seed methods are employed for turnip seed production. Seed to seed method is preferred forv raising certified seeds. Isolation distance for certified seed is 1000 m and for foundation seed is 1600 m (Garden.eco., 2023).

The method of raising seed crop as well as the techniques of seed production is the same as for radish. The Asiatic turnips produce seed in plains, whereas European ones in hills only. The selected roots are used to prepare the stecklings by pruning the root tip

from the base and leave one-third of crown after trimming off the top. These stecklings are transplanted 60cm × 60cm apart in the hills and 45cm × 35cm apart in the plains. An isolation distance of 1,000–1,600m should be kept from Chinese cabbage, mustard and other turnips to avoid contamination by crossing with these crops. Application of 84kg of N, 50kg/ha each of P and K results into good seed yield in turnip. When 70% of the pods turn light yellow, they should be harvested immediately to avoid shattering and damage by birds. On an average, seed yield of 5–6q/ha is obtained **(**Eagri, 2024). The 1881 American *Household Cyclopedia* advises that turnips can be grown in fields that have been harrowed and ploughed. It recommends planting in late May or June and weeding and thinning with a hoe throughout the summer. As a root crop, turnips grow best in cool weather; hot temperatures cause the roots to become woody and bad-tasting. They are typically planted in the spring in cold-weather climates (such as the northern US and Canada) where the growing season is only 3–4 months. In temperate climates (ones with a growing season of 5–6 months), turnips may also be planted in late summer for a second fall crop. In warm-weather climates (7 or more month growing season), they are planted in the fall. 55–60 days is the average time from planting to harvest. Turnips are a biennial plant, taking two years from germination to reproduction. The root spends the first year growing and storing nutrients, and the second year flowers, produces seeds, and dies. The flowers of the turnip are tall and yellow, with the seeds forming in pea-like pods. In areas with less than seven-month growing seasons, temperatures are too cold for the roots to survive the winter. To produce seeds, pulling the turnips and storing them over winter is necessary, taking care not to damage the leaves. During the spring, they may be set back in the ground to complete their lifecycle (Wikipedia, 2024). Turnips grow in a similar pattern to carrots. The turnip root grows during the first year, with leaves forming above the ground. The turnip may be harvested at this time. Turnip seed, thought, is gathered from the best turnips at the harvesting stage. At the second growing, new leaves form alongside flowers. Flowers turn into seed pods if they are fertilized, or pollinated (Fig. 5) (Wikipedia, 2024).

Flowers

Flowers

Flowers

Green seed pods

Dry seed pods

Seeds

Fig. 5. Root to Seed production of turnip

GENETICS AND CYTOGENETICS

Genetics of Turnip *is given by* Vidhi (2024):

Flesh colour – White dominant to yellow and monogenic
Skin colour – Two independent loci, both the dominant genes give rise to purple phenotype
Cream corolla – Single recessive gene (cr)
Light yellow corolla – Single recessive gene (ly)
Dark yellow corolla – Single recessive gene (dy)
Cupped petal – Single recessive gene (cup)
Apetalous – Single recessive gene (pl)
Puckered leaf – Single recessive gene (pkl)
Anthocyaninless hydathode – Single recessive gene (ahd)
Anthocyaninless bud tip – Single recessive gene (ab)
Anthocyaninless anther tip – Single recessive gene (aa)

Anthocyaninless style tip – Single recessive gene (as)
Rolled petal margin – Single dominant gene (Ropm)
Bolting – Two major additive genes
Club root (Plasmodiophora brassicae) resistance – Three independent dominant genes
Powdery mildew (Erysiphe crucifer arum) resistance – Quantitative inheritance, partially recessive genes
Turnip mosaic virus resistance – Single dominant gene

Crop brassicas include three diploid [*Brassica rapa* (AA; 2*n* = 2*x* = 16), *B. nigra* (BB; 2*n* = 2*x* = 18), and *B. oleracea* (CC; 2*n* = 2*x* = 20)] and three derived allotetraploid species. It is difficult to distinguish *Brassica* chromosomes as they are small and morphologically similar. We aimed to develop a genome-sequence based cytogenetic toolkit for reproducible identification of *Brassica* chromosomes and their structural variations. A bioinformatic pipeline was used to extract repeat-free sequences from the whole genome assembly of *B. rapa*. Identified sequences were subsequently used to develop four c. 47-mer oligonucleotide libraries comprising 27,100, 11,084, 9,291, and 16,312 oligonucleotides. We selected these oligonucleotides after removing repeats from 18 identified sites (500–1,000 kb) with 1,997–5,420 oligonucleotides localized at each site in *B. rapa*. For one set of probes, a new method for amplification or immortalization of the library is described. oligonucleotide probes produced specific and reproducible *in situ* hybridization patterns for all chromosomes belonging to A, B, C, and R (*Raphanus sativus*) genomes. The probes were able to identify structural changes between the genomes, including translocations, fusions, and deletions. Furthermore, the probes were able to identify a structural translocation between a pak choi and turnip cultivar of *B. rapa.* Overall, the comparative chromosomal mapping helps understand the role of chromosome structural changes during genome evolution and speciation in the family Brassicaceae. The probes can also be used to identify chromosomes in aneuploids such as addition lines used for gene mapping, and to track transfer of chromosomes in hybridization and breeding programs (Agrawal *et al.,* 2020).

GENETIC DIVERSITY

Turnip (*Brassica rapa* var. *rapa* L.) is an important crop species belonging to the Brassicaceae family. It is an annual or biennial plant with wide variation in size, shape and color (Fig. 6.) (Abdel-Razzak, 2021).

Fig. 6. Genetic variability for root shape, size and color of turnip

The objectives of this study are (i) to determine the genetic diversity and morphological resemblances among the *B. rapa* landraces of northwestern Spain in order to have information relative to the resources preserved, and (ii) to evaluate their agronomic characteristics, considering the three potential products that can be harvested. A collection of 120 landraces was evaluated for 34 morphological and agronomical traits by an augmented design at two locations. Two landraces were the most promising for turnips production (MBG-BRS0183 and MBG-BRS0256), two showed the best characteristics for turnip greens (MBG-BRS0082 and MBG-BRS0184), and three were the most appropriate landraces for turnip tops production (MBG-BRS0143, MBG-BRS0173 and MBG-BRS0401). Landraces were classified into five clusters (A–E) using the Ward–MLM (Modified Location Model) strategy: (A) included plants with the worst agronomic potential, (B) included most of the turnip populations with rosette growth habit, (C) included turnip populations without rosette growth habit, having more vigorous plants than cluster B, (D) gathered the most vigorous local varieties, with the highest early vigor, fresh matter content per leaf, and number of secondary stems per plant, and (E) landraces characterized by their earliness, large flowering periods, high numbers of secondary stems, and large seed weights. As conclusion, landraces evaluated in this work displayed enough variability to differentiate among appropriate populations for each one of the distinct crops. Their classification, using the Ward–MLM strategy, grouped accessions with similar characteristics into homogeneous categories (Padilla *et al*., 2005).

Information on genetic diversity and genetic relationships among taxa of *Brassica rapa* (n = 10, AA genome) is currently limited. Grown for oil, vegetable and fodder use in Europe and Asia, previous studies have indicated western and eastern groups corresponding to independent centres of origin. This study evaluated patterns and levels of genetic diversity in 93 accessions [includes 25 Agriculture and Agri-Food Canada (AAFC) breeding lines (BL)] of *B. rapa* based on 307 amplified fragment length polymorphisms (AFLP), testing subspecific separateness and the affiliation of four previously unassigned AA genome species (*B. perviridis, B. purpuraria*, *B. ruvo* and *B. septiceps*). AFLP data revealed three main clusters (I, II, III) corresponding to European (I), Indian (III), and a mixed Asian/European/Indian (II) purported origins of the taxa, with several subclusters observed in I and II. Mean AFLP polymorphism levels for Asian, European, Indian and AAFC-BL accessions were 79, 74, 66 and 62%, respectively. Few of the subspecies formed unique clusters and some, particularly subspecies chinensis and pekinensis, were assigned to several clusters. AFLP-based genetic distance information can be used by breeders to select diverse genotypes for cultivar development and fingerprinting of genotypes/cultivars. For example, a single AFLP primer pair was sufficient to uniquely identify all breeding lines in the AAFC *B. rapa* breeding programme (Warwick *et al*., 2008).

Turnip of the Brassica genus is a traditional crop that is widely cultivated in farming and farming-pastoral regions in Tibet. It is mostly utilized as animal fodder and vegetable around the Tibetan plateau. Given their high altitudes and variable climate types, different regions of Tibet plateau are home to a rich diversity of turnip. A mass of studies related to genetic diversity of highland crops have been carried out in recent years. However, the genetic diversity of Tibetan turnip remains to be elucidated to date. In this study, we performed morphological investigation and simple sequence repeat analysis, to characterize the genetic diversity and population structure of Tibetan turnips. Then, we explored the physiological response of seedlings under low-temperature stress. We also performed a field experiment, to identify clubroot-resistant cultivars. Results showed significant differences in phenotypic traits among different sources of 25 Tibetan turnip accessions. The genetic similarity dendrogram showed that the genetic distance in the 25 accessions was between 0.61 and 0.77. When the similarity coefficient is between 0.644 and 0.646, they can be divided into three subgroups, and they presented a certain relationship between geographical origin and its genetic distance. The central diffusion location suggests that the genetic diversity and population structure of these Tibetan turnip accessions are consistent with their geographical origin. In addition, the potential clubroot resistance accession is 156-13, and the chilling resistance accessions are 156-8 and 156-10. These results suggest the Tibetan turnip is a valuable resource for the genetic analysis and breeding of new clubroot-resistant cultivars (Gao et al., 2020). Nucleotide diversity within populations of *B. rapa* showed higher diversity in turnip samples from Central and Western Asia, intermediate levels of diversity in European crops and weeds, and lowest diversity in East Asian crops and South Asian oilseeds. The analysis of molecular variance analysis revealed that most of the variation present is within populations (52.39%), followed by geographical groups (28.54%), and among populations within geographical groups (19.07%) (McAlvay *et al*., 2021).

Different regions of the Qinghai–Tibet Plateau (QTP) are home to a rich diversity of turnip owing to their high altitudes and variable climate types. However, information on the morphology and genetic diversity of Tibetan turnip remains limited. Therefore, the genetic diversity of 171 turnip varieties from China and elsewhere (Japan, Korea, and Europe) was analyzed using 58 morphological characteristics and 31 simple sequence repeat (SSR) markers in this study. The varieties showed that the genetic distance ranged from 0.12 to 1.00, and the genetic similarity coefficient ranged between 0.73 and 0.95. Cluster tree showed two distinct clusters. Both morphotype and geography contributed to the group classification. A combination of morphological traits and molecular markers could refine the precision of accurate identification compared to the separate morphological and molecular data analyses. The sampling ratio of 15% to utmost precisely represent the initial population was compared to ratios of 10% and 20%, and the sampling ratio of 15% is recommended for future works when a primary core collection of turnip resources is constructed. These results could furnish a foundation for germplasm conservation and effective turnip breeding in future studies (Li *et al.,* 2021).

Its classification is based on morphological characteristics, leading to a division of the cultivated forms into three main subspecies: turnip, oilseed and leafy types. Thus, it plays a vital role in agriculture, and contributes to both national economies and human health. Molecular genetics and traditional breeding programs of *B. rapa* are essential to crop improvement. Analyses of genetic diversity using DNA-based markers and metabolite profiling across *B. rapa* reveals that they originate from Europe, Central Asia and North Africa, based on evidence of 2–5 distinct groups. Studies have detected comparable genetic diversity between and within various *B. rapa* accessions, including root, leafy vegetable and oilseed types (Abdel-Razzak, 2021).

The study was conducted for evaluation of genetic diversity of 11 Iranian turnip accessions with one British cultivar "Top Milan" cultivar, under field condition in Karaj. Twelve quantitative and Four qualitative traits were evaluated. Result revealed high variability among accessions. There were significant positive correlations between weight root and yield. Mean comparison of accessions showed that, Neyshaboor accession had the highest yield (2666.400 gr/m2) and weight root (177.760 gr) in compare with other accessions. In component analysis, five independent major factors explained 89.560 of total variance. based on cluster analysis Accessions were seprated into three groups. Morphological traits were useful for assessing the diversity and relationships in Iranian turnip accessions. In addition Accessions with desirable charachteristics can be identified to improve traits and use in breeding programs including increasing yield, improving agronomic charachteristics and improving quality (**Moghadam *et al.*, 2024**).

BREEDING

Breeding Objectives of Turnip (Vidhi, 2024)

- Early days to attain marketable root size
- Root colour as per consumers' preference, white, purple types more liked in India than golden ball types
- Stump rooted varieties with thin tap root and non-branching habit
- Slow bolting habit
- Appropriate dry matter (8-9%) in roots
- Resistance to club root, powdery mildew, turnip mosaic virus, white rust, phyllody, cabbage root fly, turnip root fly and aphids

Hybridization Technique of Turnip (Vidhi, 2024): Turnip has strong sporophytic system of self-incompatibility and is thus, highly cross- pollinated. Due to this, there is no need for emasculation and crosses can be made by enclosing flower heads from 2 compatible plants in a muslin bag with blowflies as pollinators. Before enclosing 2 flower heads in one bag, open flowers if any should be removed. Selfing can be accomplished by application of fresh pollen on style after removing the stigma. Sodium chloride and carbon dioxide could also be used to overcome self-incompatibility.

Breeding Methods of Turnip (Vidhi, 2024)

Mass Selection: This method of breeding has been commonly employed to breed several open-pollinated cultivars. Plants from selected roots are allowed mass-pollination in isolation.

Hybrid Breeding: There has been greater interest among breeders to produce hybrid cultivars of fodder swedes utilizing self-incompatibility. However, the same has not been achieved in case of horticultural types. Heterosis has been reported for several characters including the yield of root and leaf. Japanese breeders have been successful in developing several F_1 hybrid cultivars of white turnip. There has been some progress in breeding of F_1 hybrid turnip cultivars in the USA but the acceptance of these cultivars has been poor. However, considering the higher level of heterosis for root yield, and availability of sporophytic system of self- incompatibility, it is suggested that hybrid cultivars of turnip should be developed following the procedures as outlined in case of cabbage. The efficiency of traditional breeding programs; simple recurrent selection, mass selection and selfing with selection on improving growth, yield and root quality of the Egyptian turnip cultivar Balady have been achieved. Generally, the phenotypic correlation coefficients values for the varied possible pairs among different agronomic traits evidenced that 19 are derived from a possible 91 relationships and seem significant and are required to realize the selection aims. Simple recurrent selection exhibited higher effect on improving turnip agronomic traits such as plant and root fresh weights, leaf number, root diameter and total yield, over either mass selection or selfing with selection methods. From a quality prospective, all selected populations exhibited decreased root firmness, expressed as reduction in root fibers, which enhance root quality. Therefore, the high-efficiency of a selection-breeding program resulted in improving turnip yield and quality (Abdel-Razzak, 2021). This review will be focused on two *B. rapa* crops: turnip greens and turnip tops. In Northwestern Spain, Portugal and Southern Italy, both crops have a long tradition and they represent two important commodities, being part of very traditional recipes. Like other Brassica vegetable crops, they are generally either eaten after being cooked or they can also be processed as canned foods. Turnip greens and turnip tops have good commercial prospects and their consumption, both fresh and processed, has increased considerably in the last years. New uses and new markets for these crops (canned, frozen, fourth range-foods, …) have been grown lately. A collection of local varieties of turnip greens and turnip tops from Northwestern Spain is currently kept at the Misión Biológica de Galicia (CSIC) in Pontevedra, Northwestern Spain. These landraces are a valuable resource, since they are adapted to the climatic conditions of this area. Agronomical and nutritional evaluations of this collection were previously performed. Authors reported a high genetic diversity for several agronomic traits and found that some varieties are a valuable source of bioactive compounds such as glucosinolates and phenolic compounds. However, their cultivation is limited in southern areas or in the Mediterranean basin, probably due to a lack of adaptation. Still, these crops could occupy a prominent place in the Mediterranean diet, which is based on a high consumption of fruits and vegetables. The evaluation of *B. rapa* varieties with wide adaptability across diverse farming environments becomes essential for selecting varieties for future breeding programs based on producers' and consumers' preferences. With this goal in mind, a breeding program in turnip tops and turnip greens was started at IAS-CSIC in Córdoba (South of Spain) in recent years. The goal was to achieve varieties adapted to the environmental conditions of this area but preserving similar nutritional properties to those produced in their original region. In this review, we summarize the studies on the agronomical and nutritional value of these crops grown under Mediterranean climate conditions.

Data reported here might be useful for deeper understanding of these crops for both nutritional quality and bioaccessibility, resistance to biotic stress, and for selecting varieties adapted to Mediterranean conditions, thus contributing to the diversification of traditional Brassica vegetable production systems (Abdel-Razzak, 2021). Based on their morphological appearance and on the organs used, *B. rapa* crops can be classified into two groups:

i. Vegetable types used for their tubers (=hypocotyl), leaves and flower buds, which include the rapa (= rapifera or ruvo) group and the leafy vegetable forms. These vegetable types belong to six groups: rapa, chinensis, pekinensis, parachinensis, nipposinica, perviridis and narinosa.
ii. ii. Oleiferous types, of which canola is a specific form, having low erucic acid levels in its oil and low glucosinolate content in its meal protein. Until recently, these groups were considered as separate species because of the wide range of variability they show and the fact that they evolved in isolation from each other (Cartea *et al.,* 2021).

There are three ecotypes: brown sarson, toria and yellow sarson. Out of these, brown sarson appears to be the oldest one. Yellow sarson is characterized by its yellow colored seeds and self-compatibility. Many of the cultivars have 3–4 valved siliquae, and for this reason, it was named trilochularis. It is believed to have evolved from brown sarson as a mutant and has survived because of its self-compatible nature. It might have been selected by farmers for its attractive yellow-colored seeds and bigger seed size (Cartea *et al*., 2021).

Vegetable *B. rapa* crops, including rapifera and leafy types, are important crops in European and Asian countries, particularly in China, Korea, and Japan. Their consumption varies widely around the world and they are consumed as raw or steamed vegetables. The largest and most diverse *B. rapa* group consists of crops belonging to the pekinensis type, which includes popular crops in Chinese cuisine such as petsai or Chinese cabbage. They are characterized by having large leaves and forming heads of different shapes. It is assumed that pak-choy types with narrow or wide green-white petioles were the first *B. rapa* crops to evolve in Central China. Another group of cultivars that is characterized by many narrow leaves belong to the perviridis group, which includes neep greens from Europe and the Japanese cultivar Komatsuna. Finally, we have the nipposinica group, which includes Japanese crops like mizuna or mibuna, which can be eaten raw or cooked at any stage, from seedling to mature plant. The rapa or rapifera group is characterized by the thickening of the hypocotyls, which can show different colors and shapes, and has a mainly horticultural and forage use. Turnips are both cultivated as fodder crops or as vegetables, and depending on the region, the tubers, leaves and shoots are used. Turnip greens are the young leaves harvested in the vegetative growth period. Turnip tops are the fructiferous stems with flower buds and the surrounding leaves that are consumed before opening and while still green. In Europe, they are notably popular in Portugal, Italy and Spain, where they play an important role in traditional farming and in the diet. In these countries, *B. rapa* includes two main crops, turnip greens and turnip tops, as vegetable products. They are commonly consumed as boiled vegetables, being used in the preparation of soups and stews and they have a slightly spicy flavor like mustard greens. Turnip greens and turnip tops have good commercial prospects in both countries and, the number of companies selling *B. rapa* canned products has been increasing in the last years (Cartea *et al*., 2021).

Breeding for turnip greens and turnip tops: A breeding program in turnip tops and turnip greens was started at IAS-CSIC in Córdoba (South of Spain) in recent years. The goal was to achieve varieties adapted to the environmental conditions of this area but preserving similar nutritional properties to those produced in their original region. In this review, we summarize the studies on the agronomical and nutritional value of these crops grown under Mediterranean climate conditions. Data reported here might be useful for deeper understanding of these crops for both nutritional quality and bioaccessibility, resistance to biotic stress, and for selecting varieties adapted to Mediterranean conditions, thus contributing to the diversification of traditional Brassica vegetable production systems (Elena Cartea *et al*., 2021).

Varieties

Varieties specifically grown for the leaves resemble mustard greens more than those grown for the roots, with small or no storage roots. Varieties of *B. rapa* that have been developed only for use as leaves are called Chinese cabbage. Both leaves and root have a pungent flavour similar to raw cabbage or radishes that becomes mild after cooking. Turnip roots weigh up to about 1 kilogram, although they can be harvested when smaller. Size is partly a function of variety and partly a function of the length of time that the turnip has grown. Most very small turnips (also called baby turnips) are specialty varieties. These are only available when freshly harvested and do not keep well. Most baby turnips can be eaten whole, including their leaves. Baby turnips come in yellow-, orange-, and red-fleshed varieties as well as white-fleshed. Their flavour is mild, so they can be eaten raw in salads like radishes (KYT, 2009). There are many varieties of turnips, and each has a different flavor and storage capacity. Some common varieties include the Purple Top Strap Leaf, which originated prior to the year 1865, the Gold Ball, the Purple Top White Globe, the Purple Top Milan, the Goose Egg, the Orange Jelly, the Seven Top and the Shogun, which are both grown for their edible foliage (Wikipedia. 2024). Cultivated varieties of *Brassica rapa* include (NEW, 2024):

- Bok choy *(chinensis group)*
- Mizuna *(nipposinica group)*
- Aburana *(nippo-oleifera group)*
- Flowering cabbage *(parachinensis group)*
- Chinese cabbage *(pekinensis group)*
- Turnip *(rapa group)*
- Rapini *(ruvo group)*
- Tatsoi
- Komatsuna

There are two distinct groups varieties of turnip (Vidhi, 2024).

- Biennial or temperate or European type,
- Annual, tropical or Asiatic type.

The seed of former group can be produced in the hills and that of latter in plains. Many good varieties differing in shape and colour are now available for cultivation in both the groups.

Temperate Types (Vidhi, 2024; Eagri, 2024)**:**

Pusa Chandrima: This is a temperate type and has been developed by hybridization between Japanese White and Snowball. It is an early and high yielding variety. It is particularly suitable for the areas where growing period is very short. The roots are 8-9 cm long having 9-10 cm diameter. Tops are medium not so deeply cut. The root is smooth, pure white, fine grained with sweet and tender flesh. The leaves of 'Pusa Chandrima' are superior to Snowball in ascorbic acid content both in raw and cooked condition. It matures in 50-55 days. It has been released by IARI, Regional Station, Katrain.

Pusa Swarnima: This cultivar has been developed by hybridization between Japanese White and Golden Ball. It is earlier than Golden Ball by about a fortnight and gives 40% higher yield. Roots are flattish round, 6-7 cm long and 7-8 cm in diameter with creamy yellow, amber coloured, fine textured and mild flavoured flesh. It is superior to Golden Ball in seed yield and less susceptible to turnip malformation, a mycoplasmal disease. It has been released by IARI, Regional Station, Katrain. It matures in 65-70 days.

Purple Top White Globe: This is most popular variety of the temperate group. The roots are nearly round with purple colour at the top and white lower half. The flesh is white, firm, crisp and mildly sweet flavoured. The top is small erect, with cut leaves. It is an introduction and recommended by IARI. Regional Station, Katrain.

Golden Ball: The roots are perfectly globe shaped, medium sized and smooth. It has bright creamy yellow skin and pale, amber coloured flesh of fine texture and flavour. The tops are small, erect with deeply cut leaves. It is very shy seeder are highly susceptible to turnip malformation. It takes about 65-70 days from sowing to root formation. It has been recommended by IARI, Regional Station, Katrain.

Snowball: It takes about 60-65 days from sowing to root formation. The roots are globe shaped with pure white skin. Flesh is crisp, pure white and mildly sweet flavoured. This is also an introduction and has been replaced by Pusa Chandrima.

Asiatic Types (Vidhi, 2024; Eagri, 2024)**:**

Pusa Kanchan: This variety has been developed from a cross between tropical type (Local Red Round) and a temperate type (Golden Ball) and was released in early sixties. It has all the good qualities of both the groups. The skin is red and the flesh is creamy yellow and it has excellent flavour and taste. It has a shorter leaf top and produces seed in the plains. The best time of its sowing is September and its yield potential is 250-300 q/ha.

Pusa Sweti: This variety was developed by selection from an indigenous collection from Punjab and was released by IARI, New Delhi, in 1976. Roots are pure white, medium large, round and slightly flattish in shape. The flesh is white, soft textured, fine grained and mildly pungent. In the northern plains it can be sown from August to September. It takes 40-50 days to attain harvest maturity and yields 200-300 q/ha.

Early Milan Red Top: This is an extra early and high yielding cultivar reaching maturity in 45 days. The roots are deep flat with purplish red top and white underneath. The flesh is pure-white, well grained, crisp and mildly pungent. The tops are very small with 4-6 sessile leaves.

USES

Turnip roots are cooked and eaten as a vegetable, and the greens may be eaten as is or are prepared in such ways as boiling, streaming, stir-frying, and sauteing (Herbst 2001). Turnip leaves are sometimes eaten as "turnip tops" ("turnip greens" in USA), and they resemble mustard greens in flavour. Turnip greens are a common side dish in south-eastern US cooking, primarily during late autumn and winter. Smaller leaves are preferred; however, any bitter taste of larger leaves can be reduced by pouring off the water from initial boiling and replacing it with fresh water (KYT, 2009). Turnips are mainly used as an ingredient in soups and stews consumed mostly in the winter, but they have other potential uses as well. Turnips can be cooked as a mashed dish, baked, fried, boiled, or used to make wine. Their roots and their greens are very different food products, and the roots are more common to the Northeast United States, while the greens are part of the 'soul food', 'standard southern menu' (Wikipedia, 2024). In Turkey, particularly in the area near Adana, turnips are used to flavor şalgam, a juice made from purple carrots and spices served ice cold. Turnip roots and leaves serve as fodder for livestock, and may be grazed (with varieties with partially exposes roots) in pasture. Turnip lanterns are an old tradition, for their association with Halloween. Laurie Lee, in *The Edge of Day*, an autobiography of a childhood in the Cotswolds, mentions the Parochial Church Tea and Annual Entertainment, which took place around Twelfth night.

"We...saw his red face lit like a turnip lamp as he crouched to stoke up the flames" (NEW, 2024). Turnips are eaten as a vegetable after cooking. The shoots and leaves can be eaten fresh in salads or the entire plant can be used as a forage for livestock (Plantvillage, 2024).

Culinary Uses

Since turnips were at one point in American history fed to slaves because they were so cheap to grow, the reference to turnips by many people today as "soul food" implies some amount of discrimination. In many of the sources I encountered, it was mentioned that turnips were grown more today in the South, and since slavery was so prevalent in the South for longer than anywhere else in this country, the assumption is often made that African Americans are the biggest consumers of this food still to this day. The very presence of "soul food" cuisine is actually a stereotyped classification. The food has connotations of being cheap and easy to access, and its common association with a racial or ethnic group implies deep-rooted racism. Writers in Ancient Greece and Rome called turnips food for, "the poorer classes and country folk," as they were "a filling food for country people." The specification of this less expensive food as appropriate for a certain type of setting, *i.e.* rural farm towns and "the country" displays class-based prejudice (Wikipedia, 2024).

Medicinal Uses: However, the turnip is considered medicinally beneficial to people of all classes and geographical settings. The plant is thought to be good for the stomach and able to relieve constipation. The more turnips are cooked, the less likely they are to lead to indigestion, flatulence, and swelling. This is common to many vegetables. The less raw a vegetable is when it is consumed, the less chance there is for its consumers to have digestive issues with the food (Wikipedia, 2024).

Side Effects of Turnips: Turnip, a natural product, has no specific side effects. However, if any reaction is noticed on using it, seek immediate medical attention. Consult your Ayurvedic physician who has prescribed it to you; they will be able to identify the cause and treat it effectively (Singh, 2023).

NUTRITION VALUE

The turnip's root is high only in vitamin C. The green leaves of the turnip top ("turnip greens") are a good source of vitamin A, folate, vitamin C, vitamin K and calcium. Turnip greens are high in lutein (8.5 mg / 100g) (KYT, 2009). urnip nutrition (Lang, 2019). Turnips have an excellent nutritional profile. Like other cruciferous vegetables, they're low in calories but pack plenty of vitamins and minerals. A 1-cup (130-gram) serving of cubed raw turnips contains (Lang, 2019): Calories: 36, Carbs: 8 grams, Fiber: 2 grams, Protein: 1 gram, Vitamin C: 30% of the Daily Value (DV), Folate: 5% of the DV, Phosphorus: 3% of the DV and Calcium: 3% of the DV. The leaves contain even higher nutrient quantities, with 1 cup (55 grams) of chopped turnip greens providing (Lang, 2019): Calories: 18, Carbs: 4 grams, Fiber: 2 grams, Vitamin K: 115% of the DV, Vitamin C: 37% of the DV, Provitamin A: 35% of the DV, Folate: 27% of the DV and Calcium: 8% of the DV.

Turnip contains several organic compounds like glycosinolates, isothiocyanates, flavonoids, indoles, sulfur compounds, phenolics, carbohydrates, and volatiles. It has the following nutritional components (Table 2) (Singh, 2023):

Table 2.Nutritional contents of turnips

Nutritional Component	Amount
Energy	16 kcal
Water	95.7 g
Fat	0.16 g
Protein	1.04 g
Fibre	1.8 g
Carbohydrate	2.94 g
Iron	0.7 mg
Calcium	23 mg
Phosphorus	20 mg
Magnesium	10 mg
Sodium	25 mg
Potassium	137 mg
Vitamin C	4.4 mg

Nutritional value of turnip greens, cooked, boiled, drained, without salt arec given in Table 3 (Wikipedia, 2024).

Boiled green leaves of the turnip top ("turnip greens") provide 84 kilojoules (20 kilocalories) of food energy in a reference serving of 100 grams (3+1⁄2 oz), and are 93% water, 4% carbohydrates, and 1% protein, with negligible fat (table). The boiled greens are a rich source (more than 20% of the Daily Value, DV) particularly of vitamin K (350% DV), with vitamin A, vitamin C, and folate also in significant content (30% DV or greater, table). Boiled turnip greens also contain substantial lutein (8440 micrograms per 100 g) (Wikipedia, 2024). Nutritional value of turnips roots, cooked, boiled, drained, without salt are given in Table 4 (Wikipedia, 2024).

Table 3. Turnip greens, cooked, boiled, drained, without salt (Wikipedia, 2024)

Nutritional value per 100 g (3.5 oz)	
Energy	84 kJ (20 kcal)
Carbohydrates	4.4 g
Sugars	0.5 g
Dietary fiber	3.5 g
Fat	0.2 g
Protein	1.1 g
Vitamins	**Quantity %DV**†
Vitamin A equiv. beta-Carotene	42%; 381 µg 42%; 4575 µg
Thiamine (B1)	4%; 0.045 mg
Riboflavin (B2)	6%; 0.072 mg
Niacin (B3)	3%; 0.411 mg
Pantothenic acid (B5)	5%; 0.274 mg
Vitamin B6	11%; 0.18 mg
Folate (B9)	30%; 118 µg
Vitamin C	30%; 27.4 mg
Vitamin E	13%; 1.88 mg
Vitamin K	307%; 368 µg
Minerals	**Quantity** ; **%DV**†
Calcium	11%; 137 mg
Iron	4%; 0.8 mg
Magnesium	5%; 22 mg
Manganese	15%; 0.337 mg
Phosphorus	2%; 29 mg
Potassium	7%; 203 mg
Sodium	1%; 29 mg
Other constituents	**Quantity**
Water	93.2 g
Lutein	8440 µg

Table 4. Turnips roots, cooked, boiled, drained, without salt (Wikipedia, 2024)

Nutritional value per 100 g (3.5 oz)	
Energy	92 kJ (22 kcal)
Carbohydrates	5.1 g
Sugars	3.0
Dietary fiber	2.0 g
Fat	0.1 g
Protein	0.7 g
Vitamins	**Quantity** ; **%DV**†
Thiamine (B1)	2%; .027 mg
Riboflavin (B2)	2%; .023 mg
Niacin (B3)	2%; .299 mg
Pantothenic acid (B5)	3%; .142 mg
Vitamin B6	4%; .067 mg
Folate (B9)	2%; 9 µg
Vitamin C	13%; 11.6 mg
Minerals	**Quantity %DV**†
Calcium	3%; 33 mg
Iron	1%; 0.18 mg
Magnesium	2%; 9 mg
Manganese	3%; 0.071 mg
Phosphorus	2%; 26 mg
Potassium	6% 177 mg
Sodium	1%; 16 mg
Zinc	1%; .12 mg
Other constituents	**Quantity**
Water	93.6 g

In a 100-gram reference amount, boiled turnip root supplies 92 kJ (22 kcal), with only vitamin C in a moderate amount (14% DV). Other micronutrients in boiled turnip are in low or negligible content (table). Boiled turnip is 94% water, 5% carbohydrates, and 1% protein, with negligible fat (Wikipedia, 2024).

HEALTH BENEFITS

Both the roots and leaves are great sources of vitamin C, which protects your body from free radical damage when levels of these molecules become too high in the body. This nutrient also improves iron absorption and helps regulate blood cholesterol, among many other health benefits. Furthermore, turnip greens are rich in the fat-soluble vitamins K and A, the type that your body absorbs better when consumed with fats. Vitamin K plays an essential role as a clotting agent, meaning that it helps prevent excessive bleeding. Plus, vitamin A is vital for eye, skin, and lung health. Additionally, the leaves contain high amounts of folate**,** which aids the production of red blood cells and helps prevent developmental irregularities in foetuses (Lang, 2019)

Health Benefits (Singh, 2023):

Some of the potential health benefits of turnip are given below (Singh, 2023):

- **Potential uses of turnip to protect the liver:** Consumption of herbs and vegetables in case of liver diseases has drawn great attention. Turnip contains several organic compounds like glucosinolates, isothiocyanates, flavonoids, phenols, indoles, volatiles and sulfur compounds that may possess antioxidant activity. The compounds present in turnip may reduce the risk of liver damage and might help maintain its structure and function. However, more studies are needed to check the action of turnip to protect the liver.
- **Potential uses of turnip to protect the kidney:** Turnip may help to protect against kidney damage. It contains compounds like flavonoids, which may possess antioxidant activity and reduce oxidative stress in kidneys, thereby protecting it. However, more studies are needed to check the activity of turnips to protect the kidney. You must seek proper treatment if you have been diagnosed with kidney disorders**.**
- **Potential uses of turnip for diabetes:** Turnip may be used in case of diabetes. Turnip contains several constituents like quercetin, indole, alkaloids, etc. These constituents may be responsible for the anti-diabetic activity of turnip. A study on mice showed that turnip might show its anti-diabetic activity against type-2 diabetes. However, these studies were conducted on animals; therefore, more studies are required on humans to check the anti-diabetic effect. You must check your sugar levels regularly and seek medical advice in case of high sugar levels.
- **Potential uses of turnip for cancer:** Turnip may reduce the risk of cancer. It contains several compounds that may inhibit DNA damage and reduce the risk of tumours and cancers in the body. It may allow the body to detoxify the harmful chemicals better. Further studies are required on the human body to confirm the anti-cancer activity of turnips. Cancer is a serious disease; therefore, you must consult your doctor if you have been diagnosed.
- **Potential use of turnip against bacterial and fungal infections:** The use of natural products as antimicrobial agents has increased because of increased resistance and side effects of drugs. Turnip may be used in fungal and bacterial infections due to its presence on constituents like quercetin, glucosinolates, isothiocyanates, flavonoids, phenols, indoles, volatiles, sulfur compounds, and other biological compounds. However, more research is required to confirm the antimicrobial activity of turnips.
- **Potential use of turnip to relieve pain and swelling:** Turnip may be used to alleviate pain. Turnip consists of several natural analgesics like flavonoids (substances that reduce pain). A study on mice showed that turnips might possess analgesic properties. Swelling in the body may be caused due to various reasons like external stimuli, irritants, foreign organisms, etc. Flavonoids present in turnip may help reduce swelling too. However, further studies are needed on humans to check these effects. You must consult your doctor for a proper diagnosis and treatment related to any kind of pain.
- **Potential use of turnip to lower cholesterol levels:** Turnip may reduce bad cholesterol levels due to its antioxidant activity. The natural antioxidants like quercetin, tocopherols, ascorbic acid and beta-carotene present in turnip may help breakdown the LDL (low-density lipoproteins). This may lead to lower LDL levels in the body. More research is required to confirm the activity of turnips in lowering cholesterol levels. You must check your cholesterol levels and consult your doctor in case of abnormal cholesterol levels.

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