The origins of edible brassicas

Article

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A native of sea-cliffs in the UK, wild cabbage (*Brassica oleracea*) is the ancestor of many edible brassicas

The origins of edible brassicas

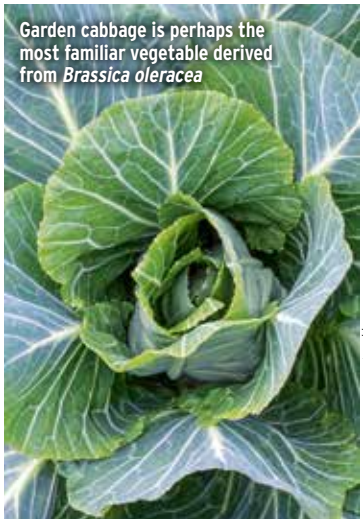
GEOFF DIXON

explores the origin of vegetable brassicas and discusses their flexibility and diversity

GARDENERS' PLANTS result from evolution in the wild, selection in cultivation and most recently by scientifically directed breeding. The history of our vegetables is full of fascinating sagas which are equally colourful as those of ornamentals. Growing food supplies allowed the development of stable and civilized societies.

Enclosing gardens (the *hortus conclusus* of religion, art and legend) protected crops from browsing animals and facilitated mankind's move from hunter-gathering into permanent communities. Domestication of cereals, legumes and members of the cabbage family (*Brassicaceae*, also known as *Cruciferae*) were major steps in mankind's social evolution. The early Greek, Roman, Indian and Chinese writers recorded this development which has continued into today's societies.

Brassicas provide edible leaves, flowers and roots that can be eaten fresh, cooked or processed. They also provide animal fodder and forage, permitting year-round meat and milk production. Their proteins and oils can be used in many edible products and for illumination and as industrial lubricants. For flavouring they provide mustards and herbs. Many species are also used as ornamentals in gardens, and as green manures and composting crops. The tiny, rapidly reproducing rock cress, *Arabidopsis thaliana*, is widely used to study genetics and even in space research (Dixon 2006).



Garden cabbage is perhaps the most familiar vegetable derived from *Brassica oleracea*

Carol Sheppard/ARS

Origins

Brassicas had primitive common ancestors that evolved around 24 million years ago in the Horn of Africa and Arabian Peninsula (Arias *et al*. 2014). Their descendants migrated northwards into the Fertile Crescent, the region of early agricultural development in what is now parts of Egypt, Turkey, Syria, Iraq and Iran.

Two key species, *Brassica oleracea* and *B. rapa*, and a product of their natural hybridization, *B. napus*, are, respectively, the foundations for most European, Oriental and some oilseed and edible brassicas. B*rassica napus* contains the chromosome sets of both *B. oleracea* and *B. rapa* (Hammer *et al*. 2013). Several similar, naturally formed, fertile hybrids are found in the brassica family, highlighting its diversity and flexibility. This natural hybridization was initially unravelled by a Korean horticultural botanist, U (1935). His findings are supported by molecular studies that have emphasized the diversity and flexibility of both wild and cultivated brassicas (Bonnema *et al*. 2011).

Wild populations of *B. oleracea* and its closely associated species colonized cool, moist environments on the coasts of western Europe and the Mediterranean approximately three million years ago (Arias *et al.* 2014).

Wild *B. napus* is restricted in its range to northern Europe and Scandinavia. *Brassica rapa* colonized widely from the Fertile Crescent into parts of Russia, China, southeast Asia and Japan (Tsunoda *et al*. 1984). Both *B. oleracea* and *B. rapa* possess similar genetic constituents and have taken parallel evolutionary pathways, resulting in similarities between their respective crops (Cheng *et al*. 2016).

European brassicas

Variants of *B. oleracea* probably evolved both naturally and from selection in domestication at several times and places. As a result, relationships and naming can be complex and confusing. Hence, for practical breeding and gardening purposes a Dutch plant breeder, Hille Toxopeus, proposed using a horticulturally based nomenclature (Toxopeus 1974, Toxopeus *et al*. 1979). This involved the use of subspecies and variety to classify these crop types, guided by the morphology of the edible parts and their growth habits. His work supported earlier classifications suggested by Nieuwhof (1969) and Wellington & Quartley (1972). More recent molecular studies have supported the probability of selection pressures exerted by early gardeners (Purugganan *et al.* 2000).

Mike Grant

Different types of kale

Tim Sandall / RHS

● **Cabbage** The popular image of vegetable brassicas is probably the cabbage, epitomised in literary terms such as 'cabbage garden', often synonymous with 'vegetable garden'.

There are three groupings of cabbage: white-headed (*B. oleracea* var. *capitata* f. *alba*), red-headed (f. *rubra*) and Savoy (var. *sabauda*) (Nieuwhof 1969). Selection has favoured overlapping leaves with spherical, flattened or conical, compact heads formed from smooth, curled or savoyed leaves. These were suited initially for climates and gardening niches across Europe, but eventually moving worldwide as convenience foods.

● **Kale** This brassica probably resembles most closely the earliest vegetable forms, and kale (*B. oleracea* var. *acephala*) is cultivated across Europe. Residual populations of original wild kale are still found in Crimea.

Kale types were taken by Celtic tribes and later the Romans from the Mediterranean and developed into hardy, reliable food sources for migrating communities resulting in many forms. These include borecole or curly kale, collard, marrow-stem kale, palm-tree kale, Jersey kale, Portuguese kale and thousand-headed kale (Monteiro & Williams 1989). Kale has achieved great popularity recently as an ingredient of healthy eating.

● **Cauliflower** Cauliflowers (*B. oleracea* var. *botrytis*) were known by Pliny, and cultivation of many types had spread widely across Europe by the late 15th century (Gray 1982). From these annual and biennial cauliflowers others were selected for temperate upland regions, while types suitable for hot and humid tropics were developed, especially in 19th century India. ➤

A classification that relates cauliflower types with their region of cultivation was proposed by Crisp (1982), specifying Northwest European biennials, Northern European annuals, Italian, Asian and Australian types. Recent breeding programmes have incorporated genes taken from ancient Italian landraces, producing an increased range of curd colours and shapes.

● **Broccoli** The relationships between cauliflower and broccoli (*B. oleracea* var. *italica*) were clarified by Massie *et al*. (1996) and by King (2003). Their research shows that the cauliflower curd arose in southern Italy from a heading calabrese broccoli via an intermediate Sicilian crop type.

Originally, the term broccoli (from Latin *brachium*, arm or branch) described a range of edible floral shoots, including some from cabbages (Thompson 1976). The term is now restricted to head types carrying terminal inflorescences, including multiple green (calabrese), purple or white flowers.

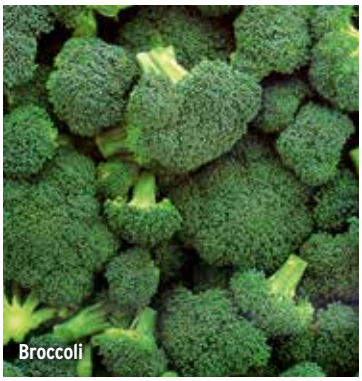
Green broccoli is a popular convenience vegetable and breeding for raised concentrations of chemicals thought to be beneficial to health has increased its value.

● **Brussels sprout** Although known in medieval Europe, Brussels sprouts (*B. oleracea* var. *gemmifera*) became popular in 18th-century Brussels. Subsequently, French and English gardeners identified their value as winter vegetables. Locally adapted, open-pollinated land-races were selected for use in early autumn, mid-season and late winter.

Japanese breeders produced F_1 hybrids in the mid 20th century, providing breeding models for hybridizing other brassica crops.


Cauliflower

Geoff Dixon


Broccoli

Geoff Dixon

● **Kohlrabi** The succulent, edible swollen-stemmed kohlrabi (*B. oleracea* var. *gongylodes*) gained popularity in central and southern Europe from the 15th century onwards. Those areas remain its European culinary stronghold, in contrast to the UK where it is little used. It is also well established in China and Vietnam.


Brussels sprouts

Geoff Dixon


Kohl rabi

Carol Sheppard / RHS

Oriental brassicas

Selections of *B. rapa* are grown extensively throughout Asia, showing a diversity which equals that of European brassicas (Mizushima & Tsunoda 1969). Originally, *B. rapa* spread from the Fertile Crescent into Mongolia, China and then to Japan. Much of its diversity probably developed after its primitive types reached China (Kumazawa 1965). However, headed Chinese cabbages now dominate cropping, with adaptations for various climate zones. Differentiating types of Asian vegetable is complicated by the diversity of local selections and names applied by Chinese, Japanese and other Asian growers.

● **Pak choi** This is perhaps the most ancient of Oriental brassicas, evolving in cultivation during the 5th century AD. Pak choi (*B. rapa* subsp. *chinensis*) is grown widely throughout Asia, although Japanese gardeners still call it the 'Chinese vegetable'. Pak choi has also gained popularity in North America, Australia and Europe, encouraged by Asiatic migrants. Subspecies *chinensis* is the 'large white cabbage' of China,

while var. *narinosa* is the 'small white cabbage' (Min 1957).

Selections bearing narrow, flat petioles are probably closest to the original plants. Petiole colour varies between white and green, the former is an autumnal vegetable while the latter has greater cold tolerance and bolting resistance. Rosette types of pak choi (*B. rapa* var. *rosularis*) have thick, lustrous leaves arranged in tight concentric rings.

Some types of pak choi are grown for their edible flowering shoots, with selections varying in flower colour from yellow to purple. Chinese broccoli (*B. oleracea* var. *alboglabra*) is also used for its flowering shoots and is more closely related to European brassicas, particularly kales, but probably entered China in antiquity (Larkcom 1991).

All types of pak choi have gained widespread international popularity as ingredients of fresh, salad and stir-fry dishes.

● **Chinese cabbage** Much of the variation in Chinese cabbage (*B. rapa* subsp. *pekinensis*) was developed by Chinese gardeners during the last 600 years. Derivatives reached Korea in the 13th century, southeast Asia in the 15th century and Japan in the 19th century.


Chinese cabbage

Geoff Dixon

The particular headed shape of Chinese cabbage with wrapping leaves was first recorded in China in 1753. These probably reached Japan from Shandung in the Meiji Era. Shapes of Chinese cabbage are grouped as non-, half- and complete-headed types with long, short, tapered, round-topped, wrapped-over and joined-up leaf forms.

Variants have been selected for leaves overlapping at the top of the conical head, and these are called heavy-leaved, early-maturing and round-headed, and are adapted for warmer climates. There are also requirements for cultivars that are cold-tolerant, since the crop is now grown almost year-round in north China and parts of Korea.

Chinese cabbages are popular worldwide as salads, stir-fry and steamed vegetables. In some parts of Asia they are used in preserved and fermented dishes, such as kimchi in Korea.

● **Mizuna** Strong-flavoured, loose-leaved greens known as mizuna and mibuna (*B. rapa* var. *japonica*) are probably of Chinese origin but have been cultivated in Japan since antiquity. Mizuna has a low, bushy shape with deeply dissected, dark green foliage while mibuna has longer, thinner, green leaves (Larkcom 1991).

Possibly some at least of these ➤


Pak choi

Tim Sandall / RHS


Mizuna

Bob Martin / RHS


Turnip is an ancient crop

Rebecca Ross / RHS

brassicas arose from hybridization between *B. rapa* and related mustard species.

Plant breeders have produced cultivars of mizuna that are heat- or cold-tolerant while mibuna fares best under cooler conditions.

● **Turnip** Turnips (*B. rapa* var. *rapifera*) are highly regarded in Japan, whereas in Europe they are mainly regarded, at least since the mid 20th century, as animal fodder. They are the oldest recorded *B. rapa* crops as Greek descriptions exist from the time of Alexander the Great. His empire included much of the Fertile Crescent and from there seed probably travelled into Asia. For developing civilisations turnips provided a reliable staple food.

The extent of the usefulness of turnips may be gauged from the multiplicity of forms selected by early gardeners, classified by Sinskaia (1928) and Shebalina (1968) as Afghan, Asia Minor and Palestine, Japanese, Russian, Teltou, and West-European turnips. There is now an increasing consumer interest in succulent, early turnips such as White Milan types.

The morphologically closely related swede,. developed from *B. napus*, was first recorded in 17th century Sweden (Sturtevante 1919). It was then used in England as part of crop rotations invented during the Agricultural Revolution. In North America swede is referred to as rutabaga.

Directed breeding

Variation in and selection of brassicas by gardeners was encouraged by the flexibility and diversity of open-pollinated landraces developed for millennia in Europe and Asia. These diversity traits offered opportunities for improving yield, quality and, crucially, tolerance to locally important pests and diseases. Numerous locally adapted cultivars resulted, such as the examples described by Ciancaleoni *et al*. (2014).

In the 20th century these diversity traits encouraged scientifically directed plant breeding. The result is a wide availability of F_1 hybrids designed initially for commercial growers but with significant benefits for gardeners, in terms of vigour, reliability and freedom from pests and diseases.

Examples of more recent developments include miniature cauliflower, broccoli and cabbages suited for smaller households, variation in cauliflower curd colours, and changes in the entire form of Brussels sprouts to give 'kale sprouts'. The last, also known as 'flower sprouts' or 'kalette', is said to be a cross between Brussels sprout and kale.

Introducing greater succulence, flavour and health-promoting properties are key objectives for brassica breeders. Brassicas contain naturally occurring chemicals, such as sulphorathane, that are claimed to reduce proneness to human diseases such as coronary failures, cancers and strokes. As a result, new cultivars are coming into production containing increased concentrations of these substances.


Miniature cauliflower is a recent development, aimed at smaller households and the snack market

Geoff Dixon


Kale sprout or kalette is a modern hybrid marketed as versatile and easy to prepare

Tozer Seeds

Conclusion

The naturally flexible attributes of the *Brassicaceae* for exchanging genes across species and genera simplifies the task of plant breeders when developing improved cultivars. This does, however, cloud still further the taxonomic relationships within the *Brassicaceae*, particularly the boundaries between species within *Brassica* itself.

Although not in the *Brassica* genus, we should not forget the vast amounts of genetic knowledge that have resulted from studies of rock cress, *Arabidopsis thaliana*. Its biological simplicity and ease of culture under laboratory conditions have enabled studies revealing molecular processes of huge botanical, zoological and human medical value.

For gardeners this relative ease of breeding offers better crops with improved environmental benefits.

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