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Review Article

Brassica Vegetables: Diversity, Nutritional and Health Benefits, and Innovative Markets for Dietary Diversity

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Abstract

The genus *Brassica* comprises six crop species: *B. nigra*, *B. oleracea*, *B. rapa*, *B. carinata*, *B. juncea* and *B. napus*, which provide edible roots, leaves, petioles, stems, inflorescences and seed. All of these six species can be used and consumed as vegetable, although *B. nigra* is most exclusively cultivated as condiment mustard. Of these species, *B. oleracea* and *B. rapa* are highly polymorphic displaying a range of vegetable morphotypes. *Brassica* vegetable crops are a unique and diverse group. They are highly nutritious and have unique flavor and taste. *Brassicas* are good sources of dietary fiber, vitamin C, vitamin B6, vitamin K, minerals, and antioxidants glucosinolates and flavonoids, that exhibit anticarcinogen properties. They can accumulate considerable amounts of selenium when grown on high selenium content soils. This article highlights the nutritional and health benefits of vegetable *Brassicas*, as well as examples of breeding products and attractive product concepts that can stimulate *Brassicas* consumption and diet diversity.

Keywords: *Cruciferae*; Nutrition; Phytochemicals; Bioactive Compounds; Glucosinolates; Antioxidants, Diet; Breeding and Selection; New Attractive Products; Consumption

Introduction

Brassica vegetables are economically considered as the third most important group of vegetables after *Solanaceae* and *Cucurbitaceae*. In 2020, their estimated production was 100 million tons, cultivated in 4 million hectars, where cabbages and other *Brassicas* represent ¾ of the production and cauliflower and broccoli represent ¼ [1]. China is the main producer of *Brassica* vegetables with almost 45% of the total production [1].

Following the determination of chromosome numbers, Morinaga [2] carried out pioneering cytogenetical investigations involving hybridizations and the study of chromosome pairing behavior in *Brassica*. Morinaga explained that crop *Brassicas* comprise six species, of these three are diploids: *B. nigra*, *B. oleracea* and *B. rapa* (syn. *B. campestris*); and three are allotetraploids: *B. carinata*, *B. juncea* and *B. napus*. U [3] represented diagrammatically these cytogenetical relationships between the species of *Brassica* genus, in a famous triangle, referred to as the triangle of U (Figure 1), where capital caracters means citoplasmatic genome.

Figure 1: Citogenetic relations between the species of *Brassica genus*. Capital caracters means citoplasmatic genome.

Brassica oleracea and *B. rapa* are highly polymorphic displaying a range of vegetable morphotypes comparing with the other *Brassica* species. All of these six species can be used and consumed as vegetable, although *B. nigra* is most exclusively cultivated as condiment mustard.

The objectives of this article are to analyse the diversity and uses of vegetable *Brassicas*, their nutritional and health benefits, and to show examples of innovative markets for their dietary diversity like new or under exposed cultivars with desirable consumer attributes, products delivering improved or high nutrition content and products delivering convenience or ready-to-use.

Diversity and uses of *Brassicas*

Introduction

As referred the *Brassica* crops contain six species. *B. oleracea* and *B. rapa* are highly polymorphic displaying a range of morphotypes, although *B. nigra* is exclusively cultivated as condiment mustard. In next paragraphs we are going to analyse the diversity in the diferent vegetable *Brassicas*.

Brassica oleracea

The cultivated *B. oleracea* are collectively named as "Cole crops", a name given in 1901 by Bailey [4]. All coles might have a common ancestor, a wild *Brassica oleracea*, and the different coles were derived from this ancestor through mutation, selection and intercrosses (Figure 2) [5].

Figure 2: All coles might have a common ancestor, a wild *Brassica oleracea*, and the different coles were derived from this ancestor through mutation, selection and intercrosses [5].

The breeding selection of the wild *Brassica oleracea* and intercrosses with other wild *Brassicas* allowed a number of morphological forms to develop. Presently, the morphotypes of *B. oleracea,* some very popular worldwide, are divided into eight groups. These are: i) kales (group *acephala*); ii) cabbages (group *capitata*); iii) cawliflower and broccoli (group *botrytis* and group *italica,* respectively); iv) kailan or Chinese kale (group *alboglabra*); v) kohlrabi (group *gongylodes*); vi) Brussels sprouts (group *gemmifera*); vii) tronchuda cabbages (group *costata*); and collards (group *sabellica*).

Kales (gp. *acephala*) are leaf vegetable coles grown for their edible leaves. Kales do not form an head as with headed cabbages. They are headless coles since the central leaves do not form a head. They have green or purple leaves. Kales include among others: Galega kales, marrow stem kale, back kale or tuscan kale, borecole or curly kale, green and dwarf siberian kales, etc. They are used to be grown for edible foliage and are very popular in some European and Africa markets as "fresh leaves". Once cut and cleaned, the leaves are typically cooked by boiling, steaming or stir frying. Kale leaves thinly sliced in soup with pureed potatoes, or sautéed with garlic and olive oil is very popular in Portugal.

Cabbages (gp. *capitata)* are characterized by folding of the leaves into "heads". They include "white-green" head cabbages, and savoy and red cabbages, They have pale to dark green and red leaves. Savoy cabbages are characterized by crimped or crispy leaves. Red cabbages have smooth red leaves. Head cabbages can be loose-headed that are commonly sliced and steamed or firmt-headed used in pickling sauerkraut. Smooth-leafed, firm-headed white-green cabbages are the most common. Respecting the shape of the head it could be round, pointed or shaped. Once cut and cleaned, the cabbage leaves are typically cooked by boiling, steaming, stir frying, slow cooking, or roasting.

Cauliflower (gp. *botrytis)*, broccoli and sprouting broccoli (gp. *italica*) are inflorescence coles. Cauliflower and broccoli produce edible forms made up of modified inflorescences. In cauliflower, the undifferentiated mass of inflorescence meristems form a structure called curd. Broccoli has large inflorescences, commonly called heads. The flower heads of broccoli are usually dark green, arranged in a tree-like structure branching out from a thick stalk. The mass of flower heads is surrounded by leaves. Broccoli resembles cawliflower. Both were domesticated in Italy. It is now largely accepted that cauliflower was originated from broccoli. A single major gene mutation in broccoli produced cauliflower [6].

Broccoli comprise distinct heading forms: the standart broccoli, described before, with a single large terminal inflorescence made up of a mass of fully differentiated flower buds; and the sprouting broccoli, also called "*calabrese*" that is different from the standard broccoli since the inflorescence is branched and it produces small florets.

The most known cauliflowers are white curded. Although new vegetable morphotypes with green, yellow, violet and purple heads are now in the market, along with romanesco cauliflower, characterized by striking and unusual fractal patterns. Orange colour curd is a recent mutation. This mutant was first found in the Bradford Marsh, north of Toronto (Canada), in 1970.

Broccolis inflorescences are also green, violet or purple.

Kailan or Chinese kale (gp. *alboglabra*) is a leaf cole with glossy blue-green leaves with thick stems, and smaller florets (much smaller than sprouting broccoli). It doesn't need vernalization to flower, and so it flowers early. It is widely cultivated in Southeastern Asian countries where the edible flower buds, flower stalk and young leaves are consumed. Once cuted and cleaned, the leaves and flower buds are typically cooked by boiling, steaming, slow cooking and stir frying.

Kohlrabi (gp. *gongylodes*) with an enlarged basal stem is grown for its bulbous edible stem particularly in Vietnam in Asia, and in Germany and Austria in Europe. It can be eaten cooked, pickled and raw. In Germany and Austria, where is very popular, traditionaly the edible stem of kohlrabi is cooked (boiled, roast or in puree). In Vietnam, people eat it raw in salad or slaws, pickle it in kimchee, drop it into soup, and stir-fry it too.

Kohlrabi leaves are edible and can be used similarly to kale, but can take longer to cook. In Sicily (Italy) there are a landrace almost without stem that is used for their edible leaves, which are eaten boiled as a vegetable side dish with a dressing of extra virgin olive oil and a squeeze of lemon juice. The leaves can also be cooked with pasta, as a wet pasta dish.

Brussel sprouts (gp. *gemmifera*) which have a proliferation of heading buds, are grown for its edible buds which resemble to miniature cabbages. "*Gemmiferous*" means bud-producing. The most common method of preparing Brussels sprouts for cooking begins with cutting the buds off the stalk. Once cut and cleaned, the buds are typically cooked by boiling, steaming, stir frying, grilling, slow cooking, or roasting.

Tronchuda cabbage (gp. *costata*) landraces are a unique but diverse class of vegetables very relevant in portuguese diet. They can only be found in Portugal and in Galicia (Northwestern Spain). They were never previously submitted to selection and breeding. It is a short stem cole. Its inner leaves have a close rosette aspect, rarely compacted, and usually surrounded by well developed open outer leaves. This is one of the arguments why they are considered as midway coles, between kales and cabbages [5]. This caused some systematic confusion among authors. Some of them include tronchuda cabbages in kale group.

Tronchuda cabbages are used in Portugal, mainly in popular dishes as "*Cozido-à-Portuguesa*" (meat and vegetables stew; portuguese method) and "Codfish with tronchuda cabbage". Once cut and cleaned, the leaves are typically cooked by boiling with other vegetables. Its choice is due to their sweet flavour and the succulence of the whole leaves (including the petioles which are quite tender despite their thickness). Due to the tenderness of the leaves it is a fast cooking comparing to kales.

Collards (gp. *sabellica*) is a tronchuda like type with short stem and a hardly compacted rosette of green leaves. It is grown in Southern USA. Like tronchuda cabbages they are considered as midway coles, between kales and cabbages. Some authors included them in kales group. They are used in Southern braises and stews, as the hearty leaves can old up to longer cooking times. More recently collard greens have become increasingly popular to use as wraps in veggie based diets.

Brassica rapa

Because of foliar multiplicity, much confounding arose in naming the diversified morphotypes of *B. rapa*. At presente they are also divided into eight groups: i) Chinese cabbage (gp. *pekinensis*); ii) Pak-choi (gp. *chinensis*) iii) Choy sum (gp. *parachinensis*; iv) Mizuna or Mibuna (gp. *nipposinica* sin. *japonica*); v) Komatsuna (gp. *perviridis*); vi) Tatsoi or Tsa-tsai (*narinosa* sin. r*osularis);* vii) Turnip (gp. *rapifera*); and viii) Broccoleto (gp. *utilis*).

Pak-choi (gp. *chinensis*) with broad green leaves and a wide green-white petiole was the first *B. rapa* vegetable to evolve in central China. Pak-choy does not form head; it is headless. This is the most primitive form from which originated group *parachinensis.* Once cuted and cleaned, the leaves are typically cooked by boiling, steaming, slow cooking and stir frying.

Chinese cabbage (gp. *pekinensis*), in oposition to pak-choy is characterized by the folding of the leaves into "heads". There are loose-leaved and compact head forms, formed by tightly overlapping light green large leaves with large white petioles. They present also different shapes.

The vegetable morphotypes of Chinese cabbage are extensively cultivated in Japan, in China and in other Southeastern Asian countries. They are eaten fresh as raw salad, boiled or pickled in kimchee.

Choy-sum (gp. parachinensis) or flowering pak-choy was originated from pak-choy and is characterized by their distinct yellow flowers. The choy-sum is a green leafy *B. rapa* consumed by their flower buds and leaves. Flowering normally appears when plants are about 7 to 8 leaves. Edible plant, when it is near the flowering stage, consists of a single or branched leafy structure. The height of the plant varies on the growing conditions and on the cultivars. It is ordinarily used in Chinese cuisine. They are eaten boiled, steamed or stir fryed.

Mizuna or Mibuna (gp. *nipposinica* sin. *japonica*) it is a unique vegetable, that thoughout farming was selected by japanese growers. It possesses many basal branches and leaves. Forms large stump with many narrow thin leaves. There are two outstanding morphotypes: Mibuna with slight entire leaves and Mizuna with deeply dissected leaves. It can be harvest at any stage from micro--greens to mature plant.

Komatsuna (gp. *perviridis*) is a leafy *B. rapa* vegetable, with green-yellow leaves. I tis mainly grown in Japan where is extremely popular and readily available at local markets. It can be harvest at any stage from micro-greens to mature plant. Even the flower buds and yellow blooms are edible. Leaves can be used in salads, stir frying and soups. Flavor is mild and sweet with just a touch of zesty pungency characteristic of mustards.

Tatsoi or Tsa-tsai (gp. narinosa sin. r*osularis*) appears like pak--choi but diverge from typical pak-choi morphotypes by its flat appearance and many dark green leaves. It can be harvest at any stage from micro-greens to mature plant. Leaves can be used in salads and stir frying.

Turnip (gp*. rapifera*) in opposition to the *B. rapa* previously described turnip is of European origin. There are selections of turnips for roots, for leaves and for tops. The root production morphotypes are grown worldwide. Turnip tops and turnip greens have a deep tradition of usage in Portugal, Northwestern Spain and Southern Italy, being part of very popular recipies and festivities. Turnip forming roots are usually boiled. Turnip leaves and tops once cuted and cleaned, the leaves and flower buds are cooked by boiling, used in soups, steaming, and stir frying.

Broccoletos (gp*. utilis*) are turnip top morphotypes grown in Southern Italy where they are known by "*cima di rapa*" (turnip tops). Some authors include it in turnip group. Broccoletos are similar in appearance to sprouting broccoli since is green stem is topped with florets of flower buds. Although the stem of broccoleto is thin and tender in oposition to sprouting broccoli that is thick and tight. Additionally, instead of high packed florets, broccoleto has looser crowns of flower buds. Broccoletos once cuted and cleaned, the leaves and flower buds are cooked with pasta or boiled or steaming.

Brassica nigra

As menthioned *B. nigra* is almost exclusively cultivated as condiment mustard. Although since antiquity it is also collected from the wild, in the initial stages, as edible pungent leaves or for medicinal purposes. In Greece people consume its inflorescences boiled like we saw in turnip tops and broccoletos.

Brassica juncea

Brassica juncea is a root, stem and leaf vegetable in China, where these different morphotypes have a long history of cultivation. Root (gp. *megarrhiza*) and stem mustard (gp. *tsatsai*) morphotypes evolved independently from leaf mustard (gp. *multiceps*) forms. They are less important as vegetables than leafy mustards. In leafy mustards there are two diferente morphotypes: those with deeply dissected leaves that branched early during vegetative growth; and those headed forms with broad leaves and thick petioles. They are widely grown and consumed as root, stem and salt-pickled leaves as kimchee in China and in other Southeastern Asian countries. The leaves are charecterized by having a hot spicy flavour.

Brassica napus

Two vegetable forms of *B. napus* are now in cultivation: i) root forming swede or rutabaga; and ii) leafy vegetable rape morphotypes. Its root variants, swede or rutabaga, are grown as vegetable, particularly in Scandinavian countries and in England. Leafy rape vegetable morphotypes are grown and consumed in Portugal and in Northwestern Spain.

The rutabagas include two morphotypes, one with yellow flesh and the other with white flesh. Both are used as root vegetable, and consumed boiled as alternative to potato and turnip. Leafy rape is also used as alternative to turnip greens and turnip tops.

Brassica carinata

B. carinata, the Ethiopian mustard, is also used as vegetable mainly in Ethiopia where the poor farmers produce the crop for several uses (vegetable, medicinal, and oil). As vegetable young tender leaves are eaten raw in salads while older leaves and thick stems are cooked and eaten like turnip greens, tronchudas or collards. Flowering inflorescences may be cooked and eaten like sprouting broccoli.

Nutritional and health benefits of vegetable Brassicas

Introduction

The *Brassica* vegetables are higly nutritious. They are good sources of dietary fiber, vitamin C, vitamin B6, vitamin K and minerals (mainly calcium, potassium, magnesium, manganese, sulfur and iron). In addition they have glucosinolates, flavonoids, anthocyanins, terpenes, and other compounds, beneficial for human health, since they show anticancer, antioxidant and anti-inflammatory properties. Like other vegetables they are low calorie, gluten free, cholesterol free, and very low in sodium. *Brassicas* are capable of accumulating considerable amounts of selenium (antioxidant) when grown on high selenium content soils.

Nutritional benefits

Dietary Fiber

All *Brassica* vegetables contain significant amounts of dietary fiber [7]. Dietary fiber content of cauliflower was estimated to be around 5% of fresh weight or about 50% of dry weight, consisting of about 40% non-starch polysaccharides [8]. Cellulose and lignin concentrations in Brussels sprouts were estimated to be 36% and 14.5%, while in cauliflower they were estimated to be around 16% and 13% of dry matter, respectively [9].

Vitamins

Brassica vegetables are also rich in vitamins, including carotenes, tocopherols, vitamin C, and folic acid that have the potential to prevent and treat several diseases related to oxidative stress like cancerous and degenerative diseases [7].

Cao., *et al.* [10] studing the antioxidant capacity among 22 common vegetables observed that green leafy kale rated as the second highest among the vegetables tested. Brussels sprouts and broccoli were also graded high in their vitamin content comprising significant amounts of β-carotene and vitamins C and E [11]. Evaluation of α and β-, α-, and γ-tocopherols, and vitamin C in broccoli, Brussels sprouts, cabbage, cauliflower, tronchuda, and kale, showed significant variations between and within these *Brassicas* [11,12]. Vitamin C is the most abundant vitamin in all five *Brassicas* tested [11]. Kale had the highest amount of these vitamins, followed by broccoli, Brussels sprouts, cabbage and cauliflower. Research indicated that 79% of β-carotene, 82% of α-tocopherol, and 55% of vitamin C variability in broccoli were associated with genetic factors [11].

Kurilich., *et al.* [13] found that broccoli extracts are protective against reactive oxygen species (ROS) apparently due to the presence of vitamin C, quercetin, kaempferol, lutein, zeaxanthin, α-tocopherol, γ-tocopherol, and β-carotene [14]. Bioavailabilty is a critical factor in the determination of the role of these compounds in human health. Granado., *et al.* [15] observed that when 200 g of broccoli was consumed by healthy volunteers, significant modifications in the serum of both men and women were observed for lutein, whereas for γ-tocopherol a significant change was detected in women only, whereas no changes were observed for α- tocopherol, β-carotene, and retinol.

Carotenoids present in dark green leafy vegetables might be involved in the prevention of several diseases related to oxidative stress. Miyazawa., *et al.* [16] found that carotenoids content in some *B. rapa*, like komatsuna, is two-fold higher than in spinach. Sixteen carotenoids were identified in pak-choi, choy-sum and Chinese cabbage, out of which lutein and β-carotene were the most abounding [17]. Lutein has also been isolated from extracts of fresh raw kale, and high levels of other carotenoids, mainly β-carotene, were also detected [11,18]. Brussels sprouts and white cabbage, have been also described to contain significant amounts of trans-β-carotene and cis-β-carotene [19].

The main tocopherol in all vegetable *Brassica* vegetables is α-tocopherol with the exception of white cauliflower, which dominantly contains γ-tocopherol [20]. High levels of vitamin C have been observed in the most important coles and in Chinese cabbage. Goldoni., *et al.* [21] reported that the content of vitamin C in different cultivars of head cabbages for sauerkraut ranges from 12.0 to 112.5 mg/100g.

Brassica vegetables are also an excellent source of folic acid, a limited but important vitamin which deals as a coenzyme in many single carbon transfer reactions in the synthesis of DNA, RNA, and in protein contents [7]. Folic acid reduces the risk of neural tube defects and may be associated with the reduced risk of vascular disease and cancer [22], while low folate intake has been identified as a main cause of anaemia [23]. Brussels sprouts and broccoli were rated among the highest vegetable sources for folate, contributing about 110 to 135 and 70 to 90 µg/100g, respectively [24]. Cauliflower and green-white cabbage contain also folic acid [25].

Vitamin K are associated to a group of fat-soluble vitamins that play a role in regulating blood calcium levels, bone metabolism, and blood clotting. The humans need vitamin K because without it, the human body can not produce prothrombin, that is essential and necessary for blood clotting and bone metabolism. There are a correlation between low intake of vitamin K and osteoporosis. Phylloquinone or vitamin K1, is the main vitamin K originated from plants. Kale and all other *Brassica* vegetables are good sources of vitamin K.

Minerals

Brassica vegetables are rich in many minerals [7]. Among all the green leafy *Brassica* vegetables, kale is an outstanding source of minerals accumulating high levels of K, P, Ca, S, Fe, Cl, Sr, Cr, Mn, Se, and Zn [26]. Besides kales, different other *Brassicas* such as cauliflower, broccoli, white cabbage, Brussels sprouts and Chinese cabbage are reported to have high essential minerals and trace elements contents [27]. Interestingly is that all these *Brassica* vegetables exhibit excellent calcium bioavailability [28].

All *Brassicas* are capable of accumulating considerable amounts of selenium (antioxidant) when cultivated and grown on high selenium soils content. Finley [29] found that broccoli accumulates selenium to concentrations often found in soil, which remarkably increase its health-promoting properties. Banuelos and Meek [30] reported that broccoli grown on selenium enriched soil accumulated seven-fold more selenium than cabbage, collards and Swiss chard. Broccoli plants grown outdoors on a sphagnum, peatmoss, and vermiculite medium and fertilized with sodium-selenate and selenite accumulated 278 mg/g dry weight selenium, in the edible florets, compared to the non-fertilized control, which accumulated only 0.13 mg/g dry weight [31]. In broccoli, selenium is stored as selenocysteine [7], which is immediately absorved by human tissue. Selenium-enriched broccoli was found to reduce colon cancer and mammary tumors in animal models [7,31,32]. Cabbage sprouts and fully developed heads also accumulated selenium and the accumulation was higher in the sprouts than in the mature heads [33].

Aggregate Nutrient Density Index

Aggregate Nutrient Density Index (ANDI) is a scoring system based on nutrient content, rated on a 1-1,000 scale, that was proposed by Dr. Fuhrman [34]. This index assignes scores to a variety of vegetables based on how many nutrients they deliver to our body in each calorie consumed. It was calculated by evaluating the content of dietary fiber, vitamins, minerals, phytochemicals, antioxidant capacities, etc. It is an index that estimates the nutritional quality of vegetables [7]. It guides on increasing the nutrient density of the diet. The higher the ANDI score, and the greater percentage of those vegetables in the diet, the better our health [7].

Leafy *Brassica* vegetables have the highest ANDI scores. Kale, collard, tronchudas, turnip greens and mustard greens have an ANDI score of 1,000; pak-choy of 865; Chinese cabbage of 714; Brussels sprouts of 672, cabbage of 481; turnip of 473; broccoleto of 455; kohlrabi of 352; cauliflower of 315; and rutabaga of 296 [72]. Kales, as well as tronchudas and collards, contain a higher content of fiber, calcium, and sulfur when compared to broccoli, the reference within *Brassica* vegetables [7].

A recent meta-analysis found that greater leafy green vegetables intake was associated with 14% decrease in risk of type 2 diabetes [36]. Another previous study reported that each daily serving of leafy green vegetables produces a 9% decrease in risk of type 2 diabetes [37]. Khan., *et al.* [38] saw that oral feeding of *B. juncea* diet (10% w/w) for 60 days to normal rats led to significant hypoglycemic effect. This effect was attributed to stimulation of glycogen synthetase (leading to increase in hepatic glycogen content) and suppression of glycogen phosphorylase and other gluconeogenic enzymes.

Health benefits

Introduction

Brassica vegetables contain about 50 different glucosinolates, a group of secondary plant metabolites found mainly in the *Brassicaceae* family. Glucosinolates are associated to disease protection. Epidemiological data show that a diet rich in *Brassicas* can reduce the risk from distinct and diverse forms of cancers and that the risk can be substantially reduced by an intake of at least 10g per day [39-43]. Epidemiological studies have reported that diets rich in broccoli, may reduce the risk of prostate cancer, and consumption of one or more portions of broccoli per week can reduce the incidence and the progression from localized to aggressive types of prostrate cancer [42]. The evidence regarding the anticarcinogenic effect of phytochemicals in *Brassicas* are those from *in vivo* studies, mainly with broccoli, using human volunteers and animal models [42-44]. In order to provide evidence of the relationship between whole broccoli and cancer prevention, Farnham., *et al.* [46] investigated the diversity of induction of the phase II detoxification enzyme quinone reductase, in murine hepatoma cells, by 71 inbred and 5 hybrid lines of broccoli. They found that the rate of induction of quinone reductase in hepa 1c1c7 by the broccoli inbred lines ranged from 0 to 15,000 units and that the rate of induction was highly correlated (r = 0.85) to the concentration of glucoraphanin in each broccoli inbred. Besides broccoli, kale and Brussels sprouts, exhibited also protection against prostate cancer, breast cancer, lung cancer and chemically induced cancers [39-43].

Among the effects that the consumption of *Brassica* vegetables and glucosinolates has on human health, they rank and rise for their anti-cancer, antioxidant, anti-inflammatory, anti-diabetic, anti-microbial, anti-parasiticidal, anti-mutagenicity, antiglycation, antifibrotic, antispasmodic, bone formation and cholinesterase inhibitory activities [47].

Higher antioxidant potential of *Brassica* vegetables is also due to their higher content of phenolic bioactive compounds [48]. This higher content of phenolics has been associated with beneficial health effects, such as reduced risk of age-related chronic diseases, and advantageous manipulation of gut microbiota [49]. In this article we will analyse only the flavonoids since they are the most common and widely group of *Brassica* phenolics.

Glucosinolates

Brassica vegetables are the richest sources of glucosinolates in the human diet. Research studies of glucosinolate profiles reveal significant quantitative and qualitative differences among accessions within each *Brassica* group, developmental stages, plant parts, climatic conditions, and agronomic practices [43]. Kushad., *et al.* [50] found in 65 cultivars of brocolli, that glucoraphanin was the main glucosinolate and that there was more than 27-fold difference between the highest concentration in ‘Brigadier’ and the lowest concentration in ‘EV6-1’. Fahey., *et al.* [51] evaluated glucosinolate content of broccoli sprouts and found that they have 20- to 50-fold higher glucosinolates contente than tissue from mature plants. In broccoli heads, the most significant glucosinolates are glucoraphanin, glucobrassicin, progoitrin, and gluconasturtiin [7,50,52,53].

Hansen., *et al.* [54] also reported in their survey with 21 cultivars of red cabbage and 6 green-white cabbages, that there was a remarkable variation in the concentration of the individual glucosinolates between the cultivars investigated. Red cabbage cultivars were found to have substantially higher concentrations of glucoraphanin in comparison to green-white ones. There were also significant differences within the red cabbage cultivars. In the red cultivars investigated ‘Rodima’ contained the highest concentration with 7.4 mg/g dry weight glucoraphanin whereas ‘Primero’ contained the lowest concentration containing only 0.6 mg/g dry weight. The green-white cabbage cultivars had substantially higher levels of glucoiberin in comparison to red ones. The green-white cabbage ‘Bartolo’ had the highest level of 7.4 mg/g dry weight, whereas the ‘Candela’ contained the lowest level of 1.7 mg/g dry weight. The red cultivars ranged from approximately 3 mg/g dry weight to 0.3 mg/g dry weight. The red cabbages cultivars were also found to have substantially higher concentration of gluconasturtiin in comparison to the green-white ones. The ‘Amager Garo’ contained the highest concentration whereas ‘Primero’ contained the lowest, 1 and 0.1 mg/g dry weight, respectively.

A great number of glucosinolates have been identified in green-white cabbages, namely glucoraphanin, glucoiberin, glucobrassicin, progoitrin, gluconasturtiin, sinigrin, epiprogoitrin, gluconapoleiferin, glucoalisin, gluconapin, 4-hydroxybrassicin, glucobrassicanapin, methoxyglucobrassicin, and neoglucobrassicin [43,55]. In cauliflowers, Brussels sprouts, kohlrabi, collards, kales and tronchudas the main glucosinolates are glucobrassicin, progoitrin and sinigrin [43,52,55,56]. Brussels sprouts also contained substantialy amounts of gluconapin [43,50].

Identical variations were also detected in turnips and rutabagas. Carlson., *et al.* [57] analysed for fourteen glucosinolates 29 cultivars of turnips and 12 rutabagas. The major glucosinolates in turnip roots were progoitrin, gluconasturtiin and glucobrassicin. In rutabaga roots besides these three glucosinolates there was glucoerucin. In another study Carlson., *et al.* [58] compared the glucosinolates levels in tops and roots of 21 selected cultivars of turnip: 14 cultivars recommended for human consumption of either tops or tops and roots; 5 cultivars recommended for consumption of roots; and 2 cultivars used for animal feed. The research showed substantialy lower levels of progoitrin and 1-methylpropyl glucosinolates in tops and roots of cultivars used as vegetables, comparing to those grown for animal feed. Contents of 1-methylpropyl, gluconapin, and glucobrassicanapin glucosinolates were higher in turnip tops than in roots; while progoitrin, glucoerucin, glucoerucin, gluconapoleiferin, glucoalyssin, gluconasturtiin, glucobrassicin glucosinolates and total glucosinolates were all higher in the roots.

Yang and Quiros [59] made a survey to study the aliphatic, indolic and aromatic glucosinolates variation in young leaves of 82 cultivars of *B. rapa* made up of the following crops: Chinese cabbage, pak-choy, mizuna, komatsuna, turnip, broccoleto and rapeseed. They identified 14 distinct glucosinolates present. They do not found distinct glucosinolates but their amount varied largely among cultivars and morphotypes, with the exception of the Chinese cabbages that have a tendency to contain similar amount and glucosinolate profile. glucobrassicanapin, gluconapin (aliphatic), glucobrassicin, neoglucobrassicin (indolic), and gluconasturtiin (aromatic) are the main glucosinolates in most of the cultivars investigated. It was found in three turnips ('Kenshin Kabu', Kamo Kabu' and 'Royal Crown' - all from Japan) two glucosinolates not commonly found in *B. rapa* and in other *Brassica* species (2-methyl-2propenyl and n-butyl). The absence of glucoraphanin (the most common glucosinolate in broccoli) was found in all the 82 accessions of *B. rapa* surveyed which indicates that only functional *Brgsl-Alk* alleles are present in *B. rapa*.

Turnip contain higher total glucosinolates than Chinese cabbage and rapeseed, but the variation between the last two crops was not significant. The mean total aliphatic glucosinolates in turnip, Chinese cabbage, and rapeseed was significantly different ($P < < 0.01$). Total aliphatic glucosinolates of Chinese cabbage was significantly lower than that of turnip and rapeseed ($P = 0.05$). The methylsufinylalkyl/alkenyl means were also significantly different in these three *Brassicas* ($P < 0.05$), but the variation was only significant between that of Chinese cabbage and turnip ($P < 0.05$). Overall, aliphatic glucosinolates amount in Chinese cabbage is significantly lower than indolic glucosinolates amount ($P < 0.01$). Pak-choi does not have a high content of aliphatic glucosinolates either, although its aliphatic glucosinolates amount is higher than its indolic glucosinolates amount. Turnip, broccoleto, and rapeseed all have significantly higher aliphatic glucosinolates amount than indolic glucosinolates amount ($P < < 0.01$).

Turnip 'Tokyo Top' contained the highest amount of total (7.452 μmol/g fresh weight leaf tissue) and aliphatic glucosinolates (6.823 μmol/g fresh weight leaf tissue). In opposition, Chinese cabbage 'Matsushima' contain only 0.011 μmol/g fresh weight of aliphatic glucosinolates and an unknown cultivar of Chinese Cabbage from Taiwan, lacked aliphatic glucosinolates. Turnip 'Tokyo Top', had also the highest content of 5-C side-chain glucosinolate (3.324 μmol/g fresh weigh leaf tissue), while its 4-C side-chain glucosinolate amount (3.499 μmol/g fresh weigh leaf tissue) was also rather high in comparison to other *B. rapa* evaluated.

All these results put forward that there are considerable differences in the health benefits among *Brassicas* species and cultivars, which is important not only from a health perspective, but also as a marketing mechanism to advocate and promote a particular cultivar.

Glucosinolates and their hydrolysis products, are also responsible for the bitter taste, sulfurous aroma and pungency of *Brassica* species. These taste and flavor sensory perceptions depend if *Brassicas* are consumed raw or cooked and they can be objected and disapproved or appreciated and valued by consumers. In sensory perception panels bitter and pungent notes are, in general related with increase values of total glucosinolates. In broccoli Schonhof., *et al.* [60] reported that the genotypes with the highest total glucosinolate values (> 400 mg/100g fresh weight) had most intense and bitter sensory notes than those with total glucosinolate concentrations below 20 mg/100g fresh weight.

Flavonoids

Flavonoids are importante in the maintenance of good health and in the prevention of multiple diseases associated to oxidative stress such as cancer, coronary heart disease and atherosclerosis [43].

Miean and Mohamed [61] examined the flavonoid amount of 62 vegetables and detected that broccoli, cauliflower, kailan, green--white cabbage, and Chinese cabbage, had between 148 and 219 mg/kg of flavonoids. Broccoli had myricetin, quercetin, and luteolin; cauliflower had myricetin and quercetin; kailan had quercetin and apigenin; and green-white cabbage had only myricetin. In a complementary research, Hertog., *et al.* [62] calculated the metanol-extracted flavonoids from edible part of 28 vegetables and notice that quercetin levels, of most of them, were below 10mg/kg, except in broccoli (30 mg/kg), in kale (110 mg/kg), and in onion (486 mg/kg). Turnip, broccoli, and kale had 48, 72, and 211 mg/kg of kaempferol, respectively. Kaempferol had also been identified in green-white and tronchuda cabbage leaves [63,64].

Moreno., *et al.* [65] found that the major flavonol in broccoli florets are quercetin and kaempferol, representing up to 90% of the total flavonoids amount. The favonoids amount in 'Marathon' and 'Lord' broccoli florets was 6 mg/100g fresh weight. Gliszczynska--Swiglo., *et al.* [66] report that quercetin and kaempferol contents in broccoli inflorescence varied from 1.4 to 8.1 mg/100mg fresh weight and from 3.6 to 21.3 mg/100g fresh weight respectively.

Innovative markets for dietary diversity

Introduction

Breeding trends within *Brassicas* can be broadly divided into three categories: i) Crop improvement: addressing the needs of the growers including increased yields, stability in performance, timely maturity, disease and pest resistance; ii) Product improvement: aimed at meeting consumer demands which include complex character traits like appearance, storage quality, taste, flavor and enhanced nutritional values; and iii) Attractive product concepts that can stimulate *Brassicas* consumption like new or under exposed cultivars with desirable consumer attributes, products delivering improved or high nutrition content, and products delivering convenience or ready-to-use.

Because yield and quality are the important traits to the producer, *Brassica* breeders have historically applied significant selection pressure to these traits. Besides it is unusual farmers to be paid for nutritive components. So there have not been monetary motivation for producers to give attention to dietary traits. Although nowadays consumers are becoming more aware of these dietary and nutritional traits and their health benefits and so breeders and producers need to fullfill this demand.

Breeding for healthy glucosinolates

Introduction

Brassica breeding objectives should include increase of healthy glucosinolates content. Although breeding *Brassicas* for improved glucosinolate content is a hard target that need know-how and skills in many disciplines, such as, breeding, biochemistry, sensory panels, and soil science. Two case studies of breeding for hight content healthy glucosinolates are presented in this article: "'Beneforté' a super healthy broccoli bred" and "Selection of baby turnips with high content of healthy glucosinolates".

'Beneforté' a super healthy broccoli bred

'Beneforté' broccoli is a product of conventional breeding (no genetic manipulation), developed by British scientists at the John Innes Centre and the Institute of Food Research, as a cross between a standard broccoli and a glucosinolate-rich wild specie *Brassica villosa* from southern Italy. The development and commercialisation of 'Beneforté' broccoli can be considered in three phases. Fistly, the development of hybrids between the wild specie *B. villosa* and a standard broccoli. Secondly the mapping of quantitative trait loci (QTLs) in segregating backcross populations developed from these F1 hybrids and the identification of a major QTL on linkage group 2 that determined the levels of methionine-derived glucosinolates. Thirdly, the development of high quality F1 hybrid cultivars containing the high glucoraphanin trait and large--scale field trials to certify the high glucoraphanin phenotype over many year in diferente environments. The development programme has led to the commercialization of high glucoraphanin broccoli hybrids with the trade mark 'Beneforté' broccoli [67].

In other words, 'Beneforté' broccoli is a new form of broccoli that contains a single Myb28 allele derived from the wild specie *B. villosa* that accumulates 3-fold higher level of the glucosinolate glucoraphanin in its florets than common broccoli cultivars grown in the same condition. And have levels of other health glucosinolates, minerals and vitamins similar to other broccolis.

When consumed glucoraphanin is degraded by hydrolysis into the bioactive isothiocyanate sulforaphane. Studies have confirmed that eating 'Beneforté' broccoli results in two to four times higher level of sulforaphane in the blood compared with standard broccoli. Sulforaphane possess multiple anti-cancer effects, such as acting as inhibitors, blocking phase 1 enzymes that convert procarcinogens to carcinogens, regulating phase 2 detoxification enzymes and thus promoting the body's ability to get rid of potential carcinogens, reducing chronic inflammation and perhaps most critically, through the induction of cytoprotective enzymes an antioxidant gene expression.

As the evidence in favour of 'Beneforté' broccoli is mounting, we are beginning to see that these benefits may not be only limited to potential for cancer protection. One recent study found that glucoraphanin-rich 'Beneforté' broccoli can help re-tune our metabolism, activating natural defences to make sure that our metabolic system - mitochondria - functions well. By doing this, 'Beneforté' could perhaps offer protection against conditions associated with ageing, such as diabetes type 2, cardiovascular disease along with some forms of cancer [67].

Following successful preliminary studies, it looks as though the active broccoli component sulforaphane has the ability to block specific destructive chemicals, called metalloproteinases, as well as blocking inflammation, thus protecting against cartilage destruction. Based on this finding, researchers are now undertaking a human trial with 'Beneforté' broccoli to see what impact it will have on the joints of patients with arthritis. It looks increasingly likely that sulforaphane, so abundant in broccoli 'Beneforté', favourably regulates certain key signalling pathways relevant to preventing various chronic diseases associated with ageing.

Selection of baby turnips with high glucosinolate content

As referred in *B. rapa* turnips and broccoletos have higher content of aliphatic glucosinolates than Chinese cabbages and pak-choys and some turnips, like 'Tokyo Top' have much higher total glucosinolate content than other turnips and oriental *Brassicas* [59]. So the development of new cultivars of turnips with health benefits derived from high glucosinolate content is real. Breeders can be effective in meeting this target if selection is successful and if there is an accessible technique to measure the content of the glucosinolates, which is the case.

Attractive product concepts that can stimulate Brassicas consumption

Introduction

In this section are presented six case studies of attractive product concepts that can stimulate *Brassicas* consumption: i) Greens revolution with *Brassicas* baby leaf; ii) Gluten free veggie wraps and rolls with flat shape white cabbage; iii) Kohlrabi raw veggie sticks; iv) Detox *Brassicas* juice; v) *Brassica* sprouts and micro-greens; and vi) *Brassicas* as vehicle for selenium supplementtion.

Greens revolution with Brassicas baby leaf

Baby leaf greens are young, freshly grown salad vegetables harvested when they are 15 to 25 days old and ready-to-use. They are more tender, tasty and bite-sized. The blends of baby leaf greens with *Brassicas* besides fiber, glucosinolates, polyphenols and other anti-oxidants they are an excelent source of minerals, of vitamin K, and they offer more vitamin C than one orange or an apple, and more available calcium than enriched milk.

There are "ocidental" and "oriental" *Brassica* blends of baby leaf greens ready-to-use. In the ocidental blends we can found besides baby kale and baby mizuna, baby spinach, baby green and red Swiss chards, baby green and red oak, baby romaine and baby red lola rosa leaf lettuces, and baby green and red radicchio leaf chicory. The chicory leves gaves the pleasant bitterness. The vegetables of the oriental *Brassica* blends of baby leaf greens are pack-choy, tatsoi, mizuna, choy sum, and Chinese mustard (*B. juncea*). Tatsoi is the 'gourmet' in the oriental blend. It has a agreeable and syrupy flavor like a mild mustard flavor. When is mixed with other baby leaf it augment the flavor and nutritional value. Mizuna has succulent green leaves with a light oriental flavor. The taste of the oldest leaves are similar to leaf chicory but without the bitterness. Chinese mustard gaves the hot bit-spicy flavor in the oriental blend.

Looking for the blends of *Brassica* baby vegetables we found only three families: i) *Brassicaceae*, with kale, pack-choy, tatsoi, mizuna, choy-sum and Chinese mustard; ii) *Chenopodiaceae* with Swiss chard and spinach; and iii) *Asteraceae* with lettuce and chicory. The vegetables of the *Chenopodiaceae* family are among the greater oxalate dense vegetables, but also excellent sources of fiber, vitamins, carotenoids and flavonoids, calcium and manganese. Those of the *Asteraceae* family are rich in conjugated quercetin, flavonoids, and tocopherols. All those vegetables have high ANDI [7,68].

Because each *Brassica* and each vegetable contains an unique combination of minerals and nutraceuticals a great diversity of *Brassicas* and other vegetables is good in the blends of baby leafy greens [43]. Besides they all give different textures and flavors.

Gluten free veggie wraps and rolls with flat shape white cabbage

"Cabbage wraps and rolls" is a concept based on a square cabbage leaf from specifically selected flat shape, thin vein, and fine leaf structure white cabbage cultivars with a mild flavor and hight glucosinolate and vitamin C contents. The flat shape white cabbage makes it easy to cut. These leaves can be used as a roll or a wrap. They are healthier than the traditional Chinese rolls or Mexican tortillas wraps and suitable for use in a low calorie, gluten free, cholesterol free diet. These leaves of the flat shape cabbage can also be used for sushi, lasagna, or as part of a healthy gluten free veggie sandwich.

Kohlrabi raw veggie sticks

Kohlrabi as a cole crop, has healthy glucosinolates, high vitamin C and anti-oxidant content. It is a precious vegetable because of its crunch stem. It has a taste and consistency analogous to that of a broccoli stem, but with a flavor that is sweeter and less sulfurous.

As referred, in Germany and Austria, where kohlrabi is very popular, bulbous stem is cooked before eating. But its sweet flavour and taste (different from turnip) and crunchy flesh makes it ideal for eating raw. Instead of fried potatos, kohlrabi raw veggie sticks can be used (alone or with raw carrots) as a delicious healthy snack. Besides in oppositition to potato cuted kohlrabi does not oxidise after cutting or discolour when exposed to the air which means long shelf live.

Detox Brassicas juice

In the British "*Daily Mail*" Online newspaper of 21 July 2008 there was a new that broccoli juice helped patient Ray Wiseman, 79 years old, to beat a bladder cancer diagnosed him five years ago [69]. The physicians did not forecast and await him to survive. But the patient took a broccoli juice every day prepared by his wife Joan. For each half-tumbler dose she combines a head of broccoli with some apples and carrots to improve the taste. Mr. Ray credits his morning glass of broccoli juice with halting the disease and his healing. The scans show that his cancer has stopped spreading and his recovery. This episode confirmed the study of Munday., *et al.* [70] of the inhibition of N-butyl-N-(4-hydroxybutyl) nitrosamine induced rat bladder carcinogenesis by broccoli sprouts that are a rich source of several isothiocyanates, an important group of breakdown products of glucosinolates. In another study Bhattacharya., *et al.* [71] observed also the inhibition of proliferation of bladder carcinoma cell lines *in vitro*, and in two rat bladder cancer models *in vivo* by allyl-isothiocyanate.

There are a lot of research that's focused on broccoli and the healing properties that this vegetable cole contains. Besides broccoli other *Brassicas* can be used for juice. The main *Brassicas* used are kales, Chinese cabbages and tronchudas. In United States many juicing companies offer juice-cleanse kale packages. Tronchudas and Chinese cabbages have superior juice production, less bitter flavor and equivalente nutritional value than kales. Besides *Brassicas* the detox juice usually have other vegetables (spinach, celery, parsley, coriander, fennel, cucumber, zucchini, carrots and ginger), or fruits (apples, kiwi, orange and lemon) to improve the taste and to have the maximum minerals and nutraceuticals [7]. The choice of vegetables and fruits for juice is made according to consumer preferences.

Brassica sprouts and micro-greens

Technically there are differences between sprouts and micro--greens. Sprouts are newly germinated seeds with immature cotyledons and tiny roots. They are harvested before the development of true leaves. When grown in dark conditions without soil and fertilizers, the seeds are fed solely with clean water and air. The nutrients are supplied by the seed embryo and cotyledons. When grown in light conditions the cotyledons are green. Sprouts are eaten as a whole plant including stem, root and immature cotyledons. Growing period is short, ranging from 3-7 days.

Micro-greens on the other hand are grown in soil or soil substrate with sunlight or grown light. Micro-greens have entirely expanded cotyledons and a pair of very small partly developed true leaves. Repeated rinsing is done to prevent spoilage. The ideal day lenght is between 12 and 16 hours. The growing period ranges from 7 to 14 days. At the time of harvest the micro-greens are cut above the roots and are eaten along with stem and true leaves but not the roots.

Brassica sprouts and micro-greens are nutritious and healthy food loaded with enzymes, bioavailable minerals, vitamins antioxidants and phytochemicals. There is no aliment in the earth higher in enzymes than sprouted seeds. To obtain the best benefits of enzyme combination and concentration, the sprouts need to be eaten when the enzyme activity is high which is generally, depending in the *Brassica* specie and cultivar, between two and seven days of sprouting.

Tribulato., *et al.* [72] made a study of health beneficial compounds in seeds and sprouts of 22 different crops of *Brassicaceae* including 7 *B. oleracea* (two broccoli, one Brussels sprouts, one kale and three savoy cabbages) and 3 *B. rapa* (all broccoletos) vegetables. The presence of every glucosinolates was detected in all the 10 *Brassica* vegetables in seed and sprouts at 0 days (90% of germination process) and after seven days, demonstrating the persistence of the glucosinolates following the germination process. Eleven glucosinolates were detected in the 10 *Brassicas*: glucoiberin, progoitrin, sinigrin, glucoraphanin, sinalbin, gluconapin and glucoerucin (all seven aliphatic); 4-hidroxyglucobrassicin, glucobrassicin, neo-glucobrassicin (all three indolic); and gluconasturtiin (aromatic). From those eleven glucosinolates detected only four, 4-hidroxyglucobrassicin, glucobrassicin, neo-glucobrassicin and gluconasturtiin were detected in all the 10 *Brassicas*. The glucosinolates sinalbin and gluconapin were only detected in the 3 broccoletos evaluated, but they do not have sinigrin, glucoraphanin and glucoerucin.

Vale., *et al.* [73] observed that *B. oleracea* sprouts of red cabbage, broccoli, Galega kale and tronchuda cabbage had a higher amount of aliphatic glucosinolates than indole glucosinolates (opposed to the profile stated for most of cole crops mature plants), being sinigrin, glucoiberin, glucoraphanin and progoitrin the major compounds in the sprouts. Galega kale sprouts had the highest glucosinolate amount, principally sinigrin and glucoiberin, which are known for their beneficial health effects. Tronchuda cabbage sprouts were notably rich in glucoraphanin, who was also one of the major glucosinolates in broccoli sprouts. Red cabbage exhibit a higher amount of progoitrin. Light exposure increment sprouts glucosinolate amount.

Consumption of sprouts of *Brassicas* are associated with reduced incidence or progression of various cancer diseases. Broccoli sprouts inhibit the growth of prostate cancer, urinary bladder cancer, ovarian cancer, breast cancer, lung cancer and skin tumors [7,74,75]. The broccoli sprouts at the age of 3 days contain 10-100 time more glucoraphanin than the mature counterpart [76] due to which even a small amount of broccoli sprouts reduces the risk of cancer [77]. The main sprouts of *Brassica* consumed are broccoli, cabbage, kohlrabi, broccoleto, turnip and tatsoi.

Looking for micro-greens in a research performed by Xiao., *et al.* [78] the red cabage micro-greens had 6 times more vitamin C and 40 times more vitamin E than their mature counterpart.

Brassicas as vehicle for selenium supplementation

As indicated selenium-enriched broccoli reduce colon cancer and mammary tumors [31,32]. Other distinct researches indicated an increase danger of cancer with low selenium diet [7]. Selenium deficiency in human diet are found in Northern Europe which may increase the risk of several diseases.

The ability of *Brassicas* to accumulate selenium can also be exploited as vehicle for nutrient supplementation. *Brassica* sprouts and micro-greens can be enriched in selenium using the method suggested by Bryszewska., *et al.* [79]. In this approach seeds are germinated using water with SeO2 addition. Piekarska., *et al.* [80] showed that *Brassica* sprouts of broccoli, green-white cabbage and mustard are very efficient in accumulating selenium, comparing with rye, when sprouts are sprinkled with water with 10 mg SeO_2/L during germination. In broccoli the increase was of 2.60 μg/g (control) to 400.11 μg/g dry weight (enriched), in white cabbage was 4.05 to 381.95 μg/g and in mustard 3.55 to 138.30 μg/g dry weight. Such *Brassica* sprouts may then be used to correct selenium content as a functional food.

Conclusions

Brassica vegetable crops are a unique and diverse group. They are highly nutritious and have unique flavor and taste. They are fundamental for balanced diets since they are good sources of dietary fiber, vitamin C, vitamin B6, vitamin K, minerals, and antioxidants glucosinolates and flavonoids, that exhibit antioxidant and anticarcinogen properties. They can accumulate considerable amounts of selenium when cultivate and grown on high-selenium content soils. Selenium may block and inhibit cancer by increasing immune activity and acting as an antioxidant. In this article we have highlight the nutritional and health benefits of vegetable *Brassicas*.

Since *Brassicas* are rich in glucosinolates and therefore good for health, we presented two real examples of new products from selection and breeding with high healthy glucosinolates content: "'Beneforté' a super healthy broccoli bred", and "Selection of baby turnips with high content of healthy glucosinolates".

We show also six examples of consumer attractive product concepts, delivering improved or high nutrition and health content, and products delivering convenience or ready-to-use that can stimulate *Brassicas* consumption: "Greens revolution with *Brassicas* baby leaf"; "Gluten free veggie wraps and rolls with flat shape white cabbage"; "Kohlrabi raw veggie sticks"; "Detox *Brassicas* juice"; "*Brassica* sprouts and micro-greens"; and "*Brassicas* as vehicle for selenium supplementtion".

Because each specie and cultivar of *Brassicas* have a particular and exclusive miscellany of minerals and nutraceuticals a high and bulky diversity of *Brassicas*, as well as of other vegetables, should be eaten to assure and provide all the nutritional and health benefits.

Conflict of Interest

Author has declared that no conflit of interest exists.

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