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REVIEW PAPER

A REVIEW OF PROGRESS IN CURRENT RESEARCH ON CHINESE FLOWERING CABBAGE (*BRASSICA CAMPESTRIS* L. SSP. *CHINENSIS* VAR. *UTILIS* TSEN ET LEE)*

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Abstract

Chinese flowering cabbage (*Brassica campestris* L. ssp. *chinensis* var. *utilis* Tsen et Lee) is an important leafy vegetable species, which originates from Guangdong province in southern China. There is a variety called purple Chinese flowering cabbage (*Brassica campestris* L. ssp. *chinensis* L. Makino var. *purpurea* Bailay), which is popular in the Yangtze River basin, e.g. in Wuhan and Sichuan provinces. This manuscript is a review of recent studies on the nutritional value, breeding methods and factors affecting the yield of Chinese flowering cabbage. This vegetable is rich in glucosinolates, polyphenols, amino acids, fatty acids, soluble sugar and vitamin C. It also exhibits some antioxidative activity, e.g. the TEAC value was 16.93 μmol Trolox g^{-1} and the FRAP value was 12.01 μmol Fe(II) g^{-1} in total. Controlling the Cd level in Chinese flowering cabbage is important due to the fact that it can easily accumulate Cd in its edible leaves and flowering stems. To reduce the effect given by Cd, foliar spray with trace elements had been studied. Moreover, nitrogen fertilizer, biofertilizer and several cultivation methods have been implemented to improve the yielding and nutritional value of Chinese flowering cabbage. Depending on the conditions, fertilisation increased the yield from 19.1% to 168%, whereas the fresh weight of a single plant varied from 0.835 kg to 1.683 kg and the average yielding in the field ranged from 7.857 t ha^{-1} to 19.1 t ha^{-1}. In the last part of this paper, we reviewed the different breeding methods that have been used to develop new varieties of Chinese flowering cabbage meeting specific requirements, such as selecting a hybrid with kale to enrich the genotype, increase the resistance or discover a specific bolting gene. In brief, Chinese flowering cabbage has the potential for future research and commercial market.

Keywords: Chinese flowering cabbage, nutritional value, yield, breeding.

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INTRODUCTION

Chinese flowering cabbage (*Brassica campestris* L. *ssp. chinensis var. utilis* Tsen et Lee), aka 'Caixin' in Mandarin Chinese, or 'Choy sum' in the Cantonese dialect, is popular not only in its original Guangdong province but also throughout China due to its extensive adaptation to the climate. Some modified cold-resistant cultivars have been grown in northern China (Wang et al. 2019). Chinese emigrants spread Chinese flowering cabbage to other countries and it became known all over the world Li et al. 2011). This vegetable was exported from China to Japan in the 1920s, then to North America and Australia (He et al. 2000). In 2002, the cultivated area in Guangzhou city reached 200 hectares and occupied 60% of the total area of vegetable plantations. Guangdong province sends $7 \cdot 10^5$ kg vegetables to Hong Kong daily, 70% of which was Caixin (Yang et al. 2002). However, Chinese flowering cabbage is still unknown to the Europeans. Research has started on the possibility of growing Chinese flowering cabbage in Poland (Hołubowicz et al. 2016).

The optimal temperature for the growth of Chinese flowering cabbage leaves is 20-25°C, and for the flower stalk formation it is 15-20°C (Song et al. 2012*a*). It takes 32-35 days from sowing to harvest and 80-90 days for seeds to mature. The short growing period results in high values of the multiple cropping index (Peng et al. 2015). Throughout the long history of Chinese flowering cabbage, many varieties have been formed and new cultivars are still produced and tested (Ou et al. 2008). Early, middle and late types of Chinese flowering cabbage are distinguished, depending on the time of growth and adaptability to the cultivation season. For example, 'Youlü Cutai Caixin' and 'Youlu 501 Caixin', which were developed by systematic breeding, are early maturity cultivars of Chinese flowering cabbage (Li et al. 2010, Huang et al. 2011). They can be grown in Guangdong province in spring, summer and autumn owing to their tolerance to flood and heat. The green and purple types of Chinese flowering cabbage are distinguished, depending on the colour of leaves and stems. The green type of Chinese flowering cabbage is commonly grown in the south of China and Southeast Asia throughout the year owing to mild winters in those regions. Guangdong province has the largest cultivated area and is the biggest supplier of the vegetable (Li et al. 2011). The purple flowering cabbage (*Brassica campestris* L. ssp. *chinensis* L. Makino var. *purpurea* Bailay) is grown in the provinces north of Guangdong province, e.g. in Sichuan, Hubei and Wuhan (Wang et al. 2014, Hołubowicz et al. 2016). For example, 'Xianghongcaitai No. 1', which is suitable for the Yangtze River basin, is cultivated in summer-autumn and early autumn-winter. There are enormous differences in temperature between the north and south of China, which is the main reason why Chinese flowering cabbage spread. Li et al. (2012) measured the heat tolerance of six Chinese flowering cabbage cultivars at semi-lethal temperature (LT50) and the survival rate of seeds. The results showed that the heat tolerance of the six cultivars decreased in the following order: 'Sijiu-19 Caixin', 'Sijiu Huang Caixin', 'Youlv 50 Tian Caixin', 'Youlv 501 Caixin', 'Youlv 701 Caixin', 'Teqing Chixin 4'. There was a significant positive correlation with the survival rate of seeds during high stress in the field. It could be used as the Chinese flowering cabbage heat resistance evaluation index.

NUTRITIONAL CONTENT AND BIOLOGICAL VALUE OF CHINESE FLOWERING CABBAGE

Leaves with young flower stalks are the edible parts of Chinese flowering cabbage. The size of the stalks, leaf stems, and inflorescences are important morphological characteristics of the economic value of Chinese flowering cabbage (Huang et al. 2017). There are particularly important vegetables for the human diet in the *Brassicaceae* family (e.g. cabbage, Chinese cabbage, brussels sprouts, broccoli, cauliflower, kale). Brassica vegetables have been proved to contain glucosinolates (GLSs). In comparison with non-bulbous Chinese cabbages, Chinese flowering cabbage has certain differences in the content of volatile substances. Esters, alcohols and phenols were preliminarily identified as volatile flavour substances – a major factor that contributes to the aroma of Chinese flowering cabbage (Yuan et al. 2019*a*). Therefore, more and more scholars focus on vegetables of the *Brassicaceae* family, which have a high content of major antioxidants and putative anticarcinogenic compounds, including vitamin C, carotenoids and glucosinolates.

Like other vegetables of the *Brassica* genus, Chinese flowering cabbage is not only a valuable source of GLSs, polyphenols and vitamin C, but it is also rich in amino acids and other chemical compounds (Yuan et al. 2019*b*). Every 100 g of the edible part of Chinese flowering cabbage provides 89 kJ energy. It has the following chemical composition (g 100 g^{-1}): N – 511.7; K – 55.88; P – 49.16; Ca – 86.18; Mg – 8.593; Na – 35.67; Fe – 2.882; Zn – 1.088; Mn – 0.334; Cu – 0.186; Ni – 0.021; Pb – 0.119; Cd – 0.002; Cr – 0.008. The edible parts of Chinese flowering cabbage also contain 17 types of amino acids, 9 types of saturated fatty acids and 4 types of unsaturated fatty acids (Yang et al. 2002). The nutrients of Chinese flowering cabbage include: water (93.5%), ash (1.1%), crude protein (2.15%), etc. It contains flavonoids (1.73 mg g^{-1}), rutin (0.14 mg g^{-1}) and vitamin C (52.16 mg 100 g^{-1}). In addition, Chinese flowering cabbage has high ability to absorb selenium (Mo et al. 2006), which is a beneficial element for consumers.

Glucosinolates (GLS) are biologically active compounds found in plants of the *Brassicaceae* family, including broccoli, cabbage, cauliflower and Chinese flowering cabbage. The total GLS content in purple Chinese flowering cabbage was 50-70 mg 100 g^{-1} FW, which was higher than the total GLS content in Chinese cabbage, 14-35 mg 100 g^{-1} (Chen et al. 2008*a*). The GLS content varies in different organs of Chinese flowering cabbage. He et al. (2000) found the highest GLS content in inflorescences (569.3 μmol 100 g^{-1} FW), followed by stems (153.1 μmol 100 g^{-1} FW) and leaves (45.38 μmol 100 g^{-1} FW). Apart from GLS, more than 71 phenolic components have been tentatively identified in the edible parts of Chinese flowering cabbage by means of the liquid chromatography-mass spectrometry (LC-MS) profiling method, e.g. kaempferol 3-O-diglucoside-7-O-glucoside derivatives, isorhamnetin 3-O-glucoside-7-O-glucoside hydroxycinnamoyl gentiobioses, 3-O-diacyltriglucoside-7-O-glucosides of kaempferol and quercetin (Lin, Harnly 2010).

The antioxidative capacity of Chinese flowering cabbage can be determined by measurement of the Trolox equivalent antioxidant capacity (TEAC), ferric reducing antioxidant power (FRAP) assay, di(phenyl)-(2,4,6-trinitrophenyl) iminoazanium (DPPH) assay. The TEAC value of Chinese flowering cabbage was 16.93±0.38 μmol Trolox g^{-1}, whereas the FRAP value was 12.01±0.82 μmol Fe(II) g^{-1} in total. The phenolic content amounted to 0.02-8.16 mg GAE g^{-1} in the hydrophilic fraction, 4.83-15.11 mg GAE g^{-1} in the lipophilic fraction, and 4.99-23.27 mg GAE g^{-1} in total (Deng et al. 2013).

DETERMINANTS OF NITROGEN CONTENT

The leaf content of N can be influenced by many different factors. Song et al. (2012*a*) stated that the colour of shading nets (grey, red, black and blue) significantly changed the N content in Chinese flowering cabbage by changing the radiation spectrum. The N content in the leaves of Chinese flowering cabbage varied according to the shading net colour in the following way: grey – 52.7±0.2 mg kg^{-1}, red – 53.2±0.1 mg kg^{-1}, black – 57.0±0.1 mg kg^{-1}, blue – 57.1±0.1 mg kg^{-1}. These values were higher than in the control group – 49.6±0.2 mg kg^{-1}. The N content in the stems of Chinese flowering cabbage varied according to the shading net colour as follows: grey – 41.6±0.1 mg kg^{-1}, red – 40.1±0.3 mg kg^{-1}, black – 38.7±0.1 mg kg^{-1}, blue – 48.5±0.2 mg kg^{-1}. These values were also higher than in the control group – 37.5±0.2 mg kg^{-1} (Song et al. 2012*a*). In fact, this experiment revealed that the different colour of lights influenced the N content of flowering Chinese cabbage. However, there are no more references focusing on the biochemical or photochemical reason to explain how the light influences the N content in the case of this species of cabbage. Therefore, it would be interesting for the future studies to focus more on the interaction between the N content and photosynthesis of flowering Chinese cabbage. The content of nitrate-N (-N) and ammonium-N (-N) is also significant for nutrition. According to the European Food

Safety Authority report, lower levels of nitrite tend to be found in seeds and tubers, whereas higher levels occur in leaves. The control of nitrite, and also nitrate levels is vital in the cultivation of Chinese flowering cabbage, since the leaves are its edible part. The accumulation of nitrite in Chinese flowering cabbage is influenced by the form of N and the absorption of other mineral elements. When NO^-_3 is the only available source of N in a nutrient solution, the absorption of K and Cl are the main factors influencing nitrate accumulation. However, when the ratio of NO^-_3 and NH^+_4 NH^+_4 in a nutrient solution is 7:3, the absorption of P, K, Ca, Mg, S, Cl, Mo all influence NO^-_3 accumulation in Chinese flowering cabbage (Ai et al. 2003). Cao et al. (2010) proved that foliar treatment to Chinese flowering cabbage with glycine could significantly reduce the content of NO^-_3.

DETERMINANTS OF NUTRIENTS CONTENT

Some nutrients are counted as important nutritional value and scholar conducted experiments to discover what factors can influence those nutritional compounds. For example, the NH^+_4 and NO^-_3 ratios in the growth media also influenced the level of nutritional compounds of Chinese flowering cabbage. As the NH^+_4 proportion in a nutrient solution of the hydroponic model of Chinese flowering cabbage increased, so did the soluble sugar content in the stem, the soluble protein content in the leaves and the free amino acid content in the productive organs of Chinese flowering cabbage, but the vitamin C content decreased (Song et al. 2012*b*). The soluble sugar content could also be significantly improved by foliar application of amino acid, glycine, Gly2 (Cao et al. 2010). Additionally, the vitamin C level in the edible parts of Chinese flowering cabbage could be enhanced with microbial fertilisers and manure (Jin et al. 2011). The content of vitamin C could be increased by 8.6-17.1% by applying a refined organic fertiliser, or by 8.6% by treatment with fluid fertilisers at an amount of 40L 667 m^{-2} (Jian et al. 2004, Yu et al. 2009).

THE INFLUENCE OF CD, SE AND SI ON THE NUTRITIONAL VALUE

Cadmium (Cd) is a toxic heavy metal, which can enter the human body from soil through the food chain and damage the kidneys and bones. Chinese flowering cabbage can easily uptake Cd from polluted soils (Qiu et al. 2011*a*). Silicon (Si) and selenium (Se) are generally considered to be elements contributing to plants' resistance to abiotic stresses, especially in heavy-metal stressed environments. Se alleviates the toxicity of Cd by increasing the activity of antioxidative enzymes and the efficiency of the glutathione and ascorbate (GSH-AsA) cycle. Si mitigation not only increases the activity of antioxidative enzymes in Chinese flowering cabbage, but it may also involve other mechanisms (Wu et al. 2017). Moreover, the foliar combinations of Si and Se increased the antioxidant enzyme activities of SOD, CAT and APX in Chinese flowering cabbage, especially at high Cd dosage (Wu et al. 2018). In addition, soil phosphorus (P) significantly affects the Cd uptake and translocation of Chinese flowering cabbage via the processes involved in lepidocrocite-bound Cd mobilisation to the cell wall fraction and by forming Cd-phosphate complexes (Qiu et al. 2011*b*, Yang et al. 2019). Soil Fe and Al oxides were found to be the most relevant factors for the transfer of Cd from the soil to Chinese flowering cabbage in the Pearl River Delta (PRD). This area in the south of China has high content of Fe oxide and Al oxide in soils (Liu et al. 2018). Therefore, it is feasible to apply a pollution-safe cultivar (PSC) strategy in the cultivation of Chinese flowering cabbage to cope with Cd contamination (Qiu et al. 2011*a*). The use of low-Cd cultivars (Lubao70) combined with P supply may effectively reduce the risk of Cd contamination (Qiu et al. 2011*b*).

To sum up, these studies proved that the elements in the root zone significantly influence the leaf mineral content and nutritional value of Chinese flowering cabbage. The nutritional compounds, such as soluble sugar, vitamin C and amino acid, can be influenced by organic fertilizer application or foliar spraying with amino acid. This knowledge can be used to balance fertilisation so as to obtain high quality Chinese flowering cabbage and avoid the contamination of surface soil and groundwater.

DETERMINANTS OF YIELD

As the varieties of Chinese flowering cabbage differ in maturity, morphology, yield and quality, they should be carefully selected to meet production targets (Song et al. 2011). The nutritional value and yield of Chinese flowering cabbage are influenced by various factors, such as soil, climate, fertilisation and plant genotype. This section is a review of the factors that could influence the yield of Chinese flowering cabbage.

Various fertilisers have been tested on Chinese flowering cabbage to improve the yield. Nitrogen fertiliser increased the yield of flowering Chinese cabbage by 41.80%. The yield of purple Chinese flowering cabbage tended to increase at first, but then it decreased as the fertiliser dose increased (Xie et al. 2011). Therefore, in order to balance the economic benefit and quality, Xie et al. (2011) proposed that the optimal level of nitrogen was 440-490 kg ha^{-1}. A biochemically controlled release of urea nitrogen (containing 30% of N) fertiliser coating with four types of materials (named PDU, PHU, PS_2U, PS_5U, which were developed by the Research Center of New

Fertilizer and Resource of South China Agriculture University) was examined by Peng et al. (2006). They found that the controlled-release nitrogen fertilisers significantly increased the yield of Chinese flowering cabbage by 19.10-28.20%, as compared with the same 30% nitrogen level of urea (Peng et al. 2006).

It is necessary to balance nitrogen and other nutrients in a fertilisation schedule. Li et al. (2009) obtained the highest yield and quality of Chinese flowering cabbage when they applied ammonium nitrogen with an adequate proportion of N:P:K=3:1:1.2. Chen et al. (2010) pointed out that there was a parabolic relationship between the yield of Chinese flowering cabbage and available phosphorus in latosolic red soil. The researchers recommended a P content of 54.60-87.80 mg kg^{-1} as reasonable. In hydroponic cultivation, when the optimal proportion was N:P_2O_5:K_2O:Cl= 0.49:1.49:1.16:0.23 (dose amount: 20.64, 9.94, 24.56, 37.01 g m^{-2}), the highest yield of Chinese flowering cabbage was noted, i.e. 7.857 t ha^{-1} (Shu et al. 2007).

Also other agents and fertilisers have been tested on Chinese flowering cabbage to improve the yield. *Trichoderma* fungi are excellent biocontrol agents, which promote plant growth, enhance resistance, and improve soil. Ji et al. (2020) tested *Trichoderma* biofertiliser, which was a mixture of *T. harzianum*, *T. asperellum*, *T. hamatum*, and *T. atroviride* at a spore concentration of 2.56 $\cdot$ 10^9 mL^{-1}. The biofertiliser was applied in the experimental plot at a dose of 10 L m^{-2}. The yield of Chinese flowering cabbage improved by 37.4%, the height – by 24.4% and the fresh weight – by 41.7%. The biofertiliser enhanced the tolerance of Chinese flowering cabbage to environmental stresses. It also adjusted the soil environment by providing inorganic N and P and reducing harm to the plants. When Chinese flowering cabbage was treated with a microbial fertiliser (total N 3.67%) and a manure fertiliser mixed with chicken ordure and pig ordure, its yield ranged from 85.1% to 106.7% of the yield of the control group, which had been treated with the same level of inorganic nitrogen. The microbial fertiliser may indeed have elevated the height of Chinese flowering cabbage plants (Jin et al. 2011). 5 kg of refined organic fertiliser increased the yield of two Chinese flowering cabbage cultivars ‘Meiqing no. 1’ and ‘Baoqing 40 days’ by 29.1-40.6% (Cao et al. 2004). When a fluid fertiliser consisting of urea, phosphoric acid and potassium chloride was applied at a dose of 599.7 L ha^{-1} in soil cultivation, the yield increased by 9.3% and amounted to 1.91 t ha^{-1}, as compared with the solid fertiliser treatment (Yu et al. 2009). The seaweed fertiliser treatment increased the yield effectively, as compared with the peanut residue and common compound fertiliser (Wang et al. 2009). The treatment of Chinese flowering cabbage with an optimal amount of organic fertiliser (110.0 t ha^{-1}) and maize cob biochar (8.5 t ha^{-1}) increased the yield by 43.5% and nitrogen uptake by 47.6%, as compared with the yield of Chinese flowering cabbage which had not been treated with the organic fertiliser and maize cob biochar (Wang et al. 2019). The study showed that the K content in different biochars was the key determinant of the yield of Chinese flowering cabbage. When the available K content in biochar was 0.66-7.47 g kg^{-1}, the application of 60 g kg^{-1} biochar increased the soil pH from 4.77 to 5.26-6.15, whereas the yield of Chinese flowering cabbage increased from about 112% to 168% (Huang et al. 2018).

Foliar spraying is an effective method of improving the yield of Chinese flowering cabbage. The foliar application of amino acids, especially glycine (Gly2) at a dose of 200 mg kg^{-1}, improved the yield and quality of Chinese flowering cabbage and reduced the content of nitrate by about 85.03% (Cao et al. 2010). Concentrate spraying may be linearly correlated with the accumulation of selenium in Chinese flowering cabbage. The selenium accumulation could be improved by increasing the number of sprayings and decreasing the concentration and adjusting pH (Mo et al. 2006). The spraying of the leaves and stem of Chinese flowering cabbage with diluted photosynthetic bacteria agent (PBA) 100 times increased the yield (19.4%), nutrient absorption and quality, as compared with the control group (Peng et al. 2012). Similarly, Chen et al. (2008*b*) sprayed Chinese flowering cabbage with a type of liquid fertiliser OPEL HA202. The yield increased by 41.4% and amounted to 0.834 kg plant^{-1} on average. Yu et al. (2011) sprayed late Chinese flowering cabbage with Special Plant Nutritional Element (SPNE) once or twice and compared the effects. The experiment showed that the biological yield of the plants sprayed twice was 101.5% higher than the yield of the plants sprayed once. The yield of the plants sprayed once was 58.91% higher than in the control group. The yield of individual plants sprayed twice, once and of the unsprayed plants amounted to 1.683 kg, 1.327 kg, and 0.835 kg plant^{-1}, respectively.

The cultivation method may also improve the yield of Chinese flowering cabbage. Song et al. (2012a) observed that blue and red shading nets increased the fresh weight of aerial parts by 9% and 44.1% respectively, whereas silver and black nets decreased it by 12.7% and 48.5%. The use of an insect-proof net with the pore size of 0.710 mm for the cultivation of Chinese flowering cabbage in summer effectively prevented different pests, reduced the amount of pesticide used, improved the yield, increased the plant height, internode length, the content of soluble sugar and decreased the nitrite content (Miao et al. 2013, Chen et al. 2014). The size of the flower stalk is of key importance to the yield of Chinese flowering cabbage. Low temperature and gibberellin (GA) treatments may accelerate the bolting time, stem elongation, and flowering time of Chinese flowering cabbage (Song et al. 2019). In order to improve the yield, it is important for producers to dissect the regulatory mechanism of bolting and flowering.

CHINESE FLOWERING CABBAGE BREEDING

The species type of Chinese flowering cabbage is one of fundamental factor that influences the yielding or nutritional value, and the breeding efforts have produced more new species. Therefore, we briefly reviewed some breeding methods in this section. Chinese flowering cabbage is mainly produced by long-term breeding from easy bolting materials of Chinese leaf vegetables, which results in a narrow pool of genetic resources (Wei et al. 2018*a*). As a results, other methods of Chinese flowering cabbage breeding have been applied, such as interspecific hybridisation, genetic breeding, systematic breeding, mutation breeding, heterosis, tissue culture, molecular marker-assisted selective breeding, and resistance and quality breeding (Huang et al. 2017, Wei et al. 2018*a*,*b*).

Distant hybridisation or interspecific hybridisation can be applied in breeding to enrich the narrow genetic background of Chinese flowering cabbage as well as a hybrid variety with ideal agronomical traits. Generally, distant hybridisation is an important way of creating genetic variation and it can synthesise parental advantages or create heterosis, promote intergenic exchanges and the formation of new species. Wei et al. (2018*a*) selected one Chinese flowering cabbage variety and three Chinese kale varieties to make hybrids. They proved that the phenotypes of the initial generations of allopolyploids were not stable, which means that the differences between parental combinations and different generations were significant. Another interspecific hybridisation experiment was conducted on Chinese flowering cabbage and broccoli (Wei et al. 2018*b*). It showed that the parental traits were separated in the hybrids and some traits tended to shift from Chinese flowering cabbage to broccoli. The hybrids gained new traits and high levels of nutritional components. In order to improve the resistance of Chinese flowering cabbage '60-tian Caixin' to Turnip mosaic virus (TuMV), the hybrid was backcrossed with the high-resistance variety (Chiheiye Chinese cabbage, *Brassica campestris spp. Pekinensis*). The resistance of the hybrids increased, but disease-resistant offspring was not obtained after two generations of systematic selection (Zheng et al. 2003). These studies not only increased the available genetic resources of Chinese flowering cabbage, but also gave the theoretical foundation for the segregation of traits of the *Brassica* genome.

Genetic breeding could give insight into the molecular mechanisms of stalk development in Chinese flowering cabbage, which contributes to a new theoretical basis for stalk vegetable breeding. Huang et al. (2017) identified 11,514 differentially expressed genes (DEGs) in the three stages (seedling, bolting, and flowering) of stalk development. He made a functional analysis, which revealed that these DEGs significantly enriched plant physiological processing such as hormone signal transduction, cell cycle progression, and the regulation of flowering time. Shi et al. (2012) constructed a cDNA-AFLP-based linkage map of Caixin by using an F2 population from a cross of the parents of early flowering and late flowering Caixin. The linkage map consisted of 4 linkage groups, including 67 loci and spanning 334 cM with an average genetic distance of 4.99 cM. It provided reliable genetic information on Chinese flowering cabbage. Ahmed et al. (2019) showed that most of the identified miRNAs were downregulated in heat treatment by high throughput sequencing and the miRNAs played a significant role in stress adaptation and tolerance of Chinese flowering cabbage. Xiao et al. (2015) found that the BrcuFLC gene was gradually upregulated in the developmental stages. BrcuFVE levels were similar, with the highest values noted in the flowers. The highest transcription levels of BrcuFLC were found in the leaves and stems, whereas the highest BrcuFRI levels were noted in the roots. Xiao et al. (2012) also explained the bolting of specific genes in Chinese flowering cabbage by using cDNA-AFLP technology.

Systematic breeding methods have been used to breed varieties of Chinese flowering cabbage for a long time. At present, the cultivars bred with these methods and authorised by the Guangdong Province 12 Variety Appraisal (the department authorising vegetable varieties) include ‘Sijiu-19 Caixin’, ‘Chixin-2’, ‘Chixin-29’, etc. (Li et al. 2011). Systematic breeding directly selects breeding groups or target traits on the basis of differences in the performance between the offspring of the plant and the original population, which results in a long breeding time. Furthermore, continuous selection of a single plant will cause inbreeding and inferior viability.

Liao et al. (2003) applied ^{60}Co-γ rays to irradiate the seeds and stems of Chinese flowering cabbage. The researchers combined it with an *in vitro* culture technology and found that the right irradiation dose for the seeds was about 200 Gy, for the germinated seeds – 50-100 Gy, and for the cultured stem tips – 40-70 Gy. Zhang et al. (2010) sent the seeds of two Chinese flowering cabbage cultivars ‘Youlv 50’ and ‘Youlv 80’ into space by satellite. After inducing some mutation in space, they were then planted on the Earth. After direct breeding for 5-6 generations, the results of the amplification with 16 random primers showed that there was genetic variation between all the mutant lines of the two cultivars and the intraspecific variation between 3 mutant lines of ‘Youlv 80’ was greater than that of ‘Youlv 50’. In addition, Niu et al. (2019) conducted a study to establish an efficient microspore culture protocol for Zengcheng Chinese flowering cabbage, a *Brassica* vegetable variety, in the city of Zengcheng, Guangdong Province, China (Liu et al. 2009). Niu et al. (2019) pointed out 1 μM was the optimum concentration of VcNa (vitamin C sodium salt, VcNa) for microspores of Zhengcheng Chinese flowering cabbage that would improve the rates of direct plant regeneration and accelerate the breeding process.

CONCLUSION

Chinese flowering cabbage (*Brassica campestris* L. ssp. *chinensis* var. *utilis* Tsen et Lee) is a rich source of glucosinolates, polyphenols, amino acids, fatty acids, soluble sugar and vitamin C. It also exhibits some antioxidative activity. This biological composition could be influenced by the level of plant nutrition in the root zone. Nitrogen fertilisation is a vital factor influencing the yield of these plants. Moreover, a balanced use of P, K and other elements may also affect the yield. Organic fertilisation may improve the yield, but it varies according to the current condition. Other cultivation methods such as a colour net, insect net and plant hormone, have also been applied to improve the yield. The right Chinese flowering cabbage cultivars should be chosen to avoid Cd accumulation in plants. Se and Si may affect plants' resistance to abiotic stresses, especially those induced by heavy metals. A new genetic technology was introduced in Chinese flowering cabbage breeding in order to meet the market requirements, such as changing the bolting time, increasing stress resistance, and providing genetic information on Chinese flowering cabbage. The scientific interest in this vegetable is increasing and it has a huge potential to be thoroughly studied in the future.

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