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Variation in Amino Acid Contents of Pale Green and Purple Kohlrabis (*Brassica oleracea* var. gongylodes)

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Vegetables from the brassicaceae family are among the most commonly grown vegetables worldwide. Kohlrabi contains health-promoting phytochemicals and has good levels of minerals. Here, we investigated amino acid contents variations in pale green and purple kohlrabis. Twenty-one different amino acids were found in varying proportions in pale green and purple kohlrabis. The levels of these amino acids varied widely between the pale green and purple kohlrabis. Purple kohlrabi contained higher amounts of 15 different amino acids, whereas pale green kohlrabi contained higher amounts of 6 different amino acids. Arginine was 3.2 times and histidine, tyrosine, leucine and aspartate were twice as high in purple kohlrabi than in pale green kohlrabi. Purple kohlrabi contained approximately 1.5 times more glutamate, threonine, cysteine, isoleucine and lysine compared with pale green kohlrabi. Considering the total amount, glutamine was the most dominating amino acid in both kohlrabis. The amount of glutamine was 1460.60 mg/100 g dry wt. in pale green kohlrabi types, which is 1.7 times the amount in purple kohlrabi. Alanine and norvaline were twice higher and methionine was 1.5 times higher in pale green kohlrabi than in purple kohlrabi. Our results show that both kohlrabis contain varying amounts of amino acids, suggesting that both kohlrabis are excellent, potential sources of amino acids in the development of food supplements.

Keywords: Amino acids, Pale green, Purple kohlrabis, *Brassica oleracea* var. gongylodes.

INTRODUCTION

Consumption of vegetables has beneficial health effects and this is well known all over the world. Members of Brassicaceae, which include many important vegetable crops such as cabbage, kale, Brussels sprouts, cauliflower, broccoli and kohlrabi, contain potent phytochemicals, glucosinolates and their breakdown products[1]. Kohlrabi is a cool weather plant and has an edible turnip-like swollen stem. Purple and pale green cultivars of kohlrabi are available. Similar to other members of the Brassicaceae, kohlrabi contains health-promoting phytochemicals such as isothiocyanates, sulforaphane and indole-3-carbinol, which protect against prostate and colon cancers[2,3]. Kohlrabi especially contains good amounts of many B-complex vitamins such as niacin, vitamin B-6 (pyridoxine), thiamin, pantothenic acid, which act as co-factors to enzymes during various metabolic processes inside the body. The plant also has good levels of minerals *e.g.*, copper, calcium, potassium, manganese, iron and phosphorus.

Awareness regarding food composition has increased among consumers and precise information beyond that available in food composition tables is often demanded. Information regarding amino acid composition is limited in such tables. The vital functions of amino acids include their role as building blocks of proteins; many researchers have reported the antioxidant effects of several amino acids[4-7].

Amino acids are needed in secondary plant metabolism and in the biosynthesis of compounds such as glucosinolates and phenolics, which play important roles in plant-environment interactions and human health[8]. Many amino acids exist in nature, although not all are necessary for human health. Approximately two dozen different amino acids are vital to human nutrition[9,10]. Kohlrabi is an important source of amino acids, but insufficient information exists regarding the composition of amino acids in different types of kohlrabi. The aim of this study was to investigate the content of amino acids in two types of kohlrabis, *i.e.*, pale green and purple kohlrabis.

EXPERIMENTAL

Seeds of both pale green and purple kohlrabi were collected from Asia Seed Co., Ltd (Seoul, Korea) and stored at 4 °C

until they were used. Both types of kohlrabi seeds were sown in the greenhouse to produce seedlings, which were transplanted to the experimental farm at Chungnam National University (Daejeon, Korea). Ten weeks after transplanting, both pale green and purple kohlrabi were harvested. Immediately after harvesting, the samples were freeze-dried at -80 °C for at least 72 h and then ground into a fine powder using a mortar and pestle for amino acid analysis.

Extraction and analysis of free amino acids: The amino acid extraction and analysis methods were performed as described by Kim *et al.*[11]. Amino acids were extracted from freeze-dried plant tissues (1 g) with 30 mL of 70 % ethanol at 80 °C for 20 min; this step was repeated three times. After evaporating the ethanol, the residual water phase (30 mL) was mixed with ethyl ether (30 mL) by using a separation funnel. After separation, the water phase was freeze-dried. The extract was resuspended in 3 mL of 0.02 N HCl and filtered using a 0.45 μm syringe filter.

The amino acids in the extract were identified using an amino acid analyzer (HITACHI L-8900, Japan) equipped with a HITACHI HPLC column packed with the ion-exchange resin No. 2622 PF (4.6 mm × 60 mm) and a UV detector (VIS1, 570 nm; VIS2, 440 nm). Wako L-8500 buffer solutions PF-1, PF-2, PF-3, PF-4 and RG were used. Twenty microliters of each sample was injected and identification was performed using the ninhydrin reagent set (Wako Chemical Inc., Japan). Sample preparation and analysis were repeated three times.

RESULTS AND DISCUSSION

The levels of amino acids in pale green and purple kohlrabi were determined and 21 different amino acids were found in varying proportions (Table-1). The amino acid content varied widely between the pale green and purple kohlrabis. Purple kohlrabi contained higher amounts of 15 different amino acids, whereas pale green kohlrabi contained higher amounts of 6 different amino acids. The level of arginine was 3.2 times higher in purple kohlrabi than in pale green kohlrabi. The amounts of histidine, tyrosine, leucine and aspartate were approximately double in the purple kohlrabi compared to the pale green kohlrabi. Furthermore, purple kohlrabi contained approximately 1.5 times higher levels of glutamate, threonine, cysteine, isoleucine and lysine than in the pale green kohlrabi. The levels of asparagine, serine, vitamin U, tryptophan and phenylalanine were also higher in purple kohlrabi (approximately 1.2 times higher) than in pale green kohlrabi.

On the other hand, pale green kohlrabi contained higher amounts of glutamine, alanine, γ-amino butyric acid (GABA), valine, methionine and norvaline than in purple kohlrabi. Considering the total amount, glutamine was the most dominant amino acid in both types of kohlrabis. The amount of glutamine was 1460.60 mg/100 g dry wt. in pale green kohlrabi, which is 1.7 times higher than that in purple kohlrabi. The amounts of alanine and norvaline were twice higher and methionine was 1.5 times higher in pale green kohlrabi than in purple kohlrabi. The levels of γ-amino butyric acid and valine were slightly higher in pale green than in purple kohlrabi.

Variation of amino acids in different cultivars of the same species has been reported previously and variation has been observed even in different parts of the same cultivar[12,13]. Kim *et al.*[12] observed variations in the amino acid levels among different tissues of green and red mustard cultivars and found that young leaf of green mustard cultivars contained 3.6, 1.3, 17.5 and 63.2 times higher total amino acid content than that in the stem, flower, seed and root, respectively. Young leaf tissue of red mustard cultivars contained 11.56, 1.1, 9.6 and 35.1 times higher total amino acid content than that in the stem, flower, seed and root, respectively, which is consistent with our results. Kim *et al.*[13] observed 21 different free amino acids in different plant parts of golden root (*Scutellariabaicalensis*), the levels of which varied widely between organs. Concentrations of proline in flower buds and flowers reported by Xue *et al.*[14] were significantly higher than in vegetative organs of *Brassica napus*. Kim *et al.*[11] found that among all the amino acids isolated from *Momordicacharantia*, arginine was present in remarkably high quantities while cysteine and methionine showed the lowest concentrations. Kim *et al.*[15] found varying amounts of different amino acids in *Aloe vera*, *A. saponaria* and *A. arborescens*. Similar results were observed in this study regarding variations of amino acid contents in pale green and purple kohlrabis.

TABLE-1
AMINO ACID CONTENT IN PALE GREEN AND PURPLE KOHLRABI (mg/100 g dry wt.)

Amino acid	Pale green kohlrabi	Purple kohlrabi
Aspartate	265.22 ± 4.20	465.25 ± 0.10
Glutamate	94.49 ± 6.91	139.03 ± 1.47
Asparagine	136.00 ± 1.49	167.34 ± 0.66
Serine	70.16 ± 0.61	80.90 ± 0.05
Vitamin U	7.09 ± 0.09	7.26 ± 0.02
Glutamine	1460.60 ± 114.16	852.19 ± 76.01
Histidine	4.15 ± 0.14	8.70 ± 0.21
Glycine	-	-
Threonine	39.78 ± 0.42	63.36 ± 0.14
Arginine	158.79 ± 0.97	506.35 ± 0.95
Alanine	192.18 ± 1.70	99.74 ± 0.25
γ-Amino butyric acid	102.99 ± 0.13	94.05 ± 0.10
Tyrosine	6.94 ± 0.04	14.12 ± 0.08
Cystine	7.83 ± 0.52	11.62 ± 0.26
Valine	91.02 ± 1.69	90.46 ± 0.27
Methionine	11.71 ± 5.31	7.92 ± 2.00
Norvaline	9.76 ± 4.50	5.00 ± 2.52
Tryptophan	6.83 ± 0.59	7.98 ± 0.31
Phenylalanine	9.29 ± 0.08	11.59 ± 0.02
Isoleucine	29.91 ± 0.41	43.20 ± 0.13
Leucine	11.36 ± 0.02	24.19 ± 0.01
Lysine	17.17 ± 0.29	25.85 ± 0.16
Total	2733.27 ± 84.92	2726.12 ± 71.25

Values represent the mean ± SD (n = 3)

Conclusion

Pale green and purple kohlrabi contain varying amount of amino acids, with purple kohlrabi containing higher amounts for 15 different amino acids and pale green kohlrabi containing higher amounts for 6 different amino acids. Cultivar-specific amino acid profiles have high potential as good source in the development of food supplements.

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