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Effect of Blanching on Dietary Fiber and Free Sugar Content of Vegetables

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ABSTRACT - Vegetables are rich sources of dietary fiber, which exhibit various health benefits. In the Republic of Korea, vegetables are consumed after cooking using different methods. However, they are most commonly eaten raw or blanched. In this study, chamnamul, sesame leaf, Fischer's ragwort, burdock root, and garlic stem from Korea were analyzed according to the Korean Food Code, and changes in dietary fiber content after blanching were compared. Blanching reduced the total dietary fiber (TDF) content in chamnamul (from 3.67±0.03 to 2.61±0.14 g/100 g), burdock root (from 4.95±0.40 to 3.89±0.10 g/100 g), and sesame leaf (from 4.32±0.12 to 3.65±0.17 g/100 g), but increased it in Fischer's ragwort (from 6.09±0.49 to 6.43±0.01 g/100 g) and garlic stem (from 4.52±0.35 to 5.09±0.04 g/100 g). Sucrose, glucose, and fructose were detected in the vegetables; however, sesame leaf did not have sucrose. Fresh burdock root had the highest sucrose content (1.71±0.07 g/100 g) whereas garlic stem had the highest glucose and fructose content (1.65±0.02 and 1.73±0.02 g/100 g, respectively) compared with other vegetables. Upon blanching, the free sugar content of vegetables decreased for all sugars except for sucrose, which increased in Fischer's ragwort (from 0.10±0.01 to 0.14±0.01 g/100 g) and garlic stem (from 0.76±0.00 to 0.83±0.01 g/100 g). These results can provide information on blanching-associated changes in the content of dietary fiber and free sugar in foods prepared using these vegetables.

Key words: Chamnamul, Sesame leaf, Garlic stem, Fischer's ragwort, Burdock root

Vegetables have been playing an important role in our diet. They contain vitamins, minerals, dietary fibers, and phytochemicals that could give various health benefits[1]. It is not easy to separate vegetables into different groups, but according to the U.S. Department of Agriculture (USDA), there are five categories of vegetables divided by their color (dark green, red, and orange), characteristics (starchy), beans and peas, and other vegetables[2]. Although they have different compositions of nutrients, one thing in common is that they are rich in dietary fiber[3].

The American Association of Cereal Chemists (AACC) states that dietary fiber is the parts of the plant that are edible, but indigestible, and are fermented in the large intestine. The method to analyze dietary fiber was developed by Prosky et al.[4]. Dietary fiber could be divided into soluble dietary fiber (SDF) and insoluble dietary fiber (IDF). Like their names, SDF dissolves in water and is known to be more fermented, and IDF does not dissolve in water and is less fermented[5]. IDF helps promote intestinal health, and SDF is known to help lower the speed of glucose absorption[6]. Aside from these benefits, high consumption of dietary fiber is known to reduce cardiovascular disease, normalize cholesterol levels, lower the incidence of type 2 diabetes, and more[7-9]. Because of these benefits, national agencies recommend intaking 20-30 g of dietary fiber daily[7].

Vegetables are also known to contain some carbohydrates which provide energy when consumed[10]. Digestible carbohydrates (starch and glycogen) should be digested into smaller-sized carbohydrates such as monosaccharides and disaccharides[11]. The monosaccharides are mainly consisted of glucose, followed by fructose and galactose, which are used as an energy source after consumed by animals. Sucrose, maltose, and lactose belong to disaccharides.

The Organization for Economic Co-operation and Development (OECD) data showed that South Korea is the second most vegetable-consuming country in 2019, as 99% of the population aged 15 years and over consumes vegetables, which is higher than the OECD average, 59.1%[12]. According to the Korea Agricultural Statistics Service (KASS), the annual consumption of vegetables per capita in 2021 was 149.5 kg[13].

Traditional Korean diet mainly consisted of vegetables, aside from eating them fresh, vegetables were consumed by

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using various cooking methods such as boiling, blanching, steaming, and baking. They were used for soup, kimchi, namul, and other kinds of dishes[14]. Namul is one of the most common Korean vegetable dishes, which is usually cooked by blanching or stir-frying vegetables[15]. It can be seen in almost every meal, which helps increase the vegetable intake in Koreans. Over time, the intake of vegetables has decreased due to the increase in meat intake, but recently the interest in dietary fiber has been increasing as more people think about health or the environment. Supplements are added to different kinds of foods to increase the intake of dietary fiber[5]. However, as the Korean traditional diet is known to be good for health, people eating vegetables in traditional Korean diets are increasing. Lee and Lee analyzed 54 kinds of raw vegetable foods commonly consumed in Korea[16]. Aside from those samples, Fischer's ragwort (*Ligularia fischeri*), chamnamul (*Pimpinella brachycarpa* Nakai), burdock (*Arctium lappa*) root, garlic (*Allium sativum*) stem, sesame (*Sesamum indicum*) leaf are some of the common vegetable used as side dishes in Korea. These vegetables are usually blanched and eaten as a form of namul. They may not be common in foreign countries, so there are not many studies about them.

Several studies showed that cooking changes the nutritional and dietary fiber content of vegetables. Cooking also alters the texture of vegetables by changing the fibrous components[17]. The nutritional and physicochemical values in vegetables may vary depending on the cooking method (steaming, boiling, frying)[18]. The difference between short-cooked, long-cooked, and raw vegetables (carrots, broccoli, okra, cabbage) of dietary fibers was analyzed by Matthee and Appledorf[19]. There are also studies about vegetables and legumes comparing the dietary fiber content by different cooking methods[20,21]. Some studies analyzed the dietary fiber content of raw and cooked chamnamul[22,23].

These show that there are studies showing the changes in dietary fiber in vegetables by different cooking statuses. However, there are not many studies showing the specific change of IDF, SDF, and total dietary fiber (TDF) or the free sugar content of blanched and raw vegetables. The changes in IDF, SDF, TDF, and free sugar before and after blanching Fischer's ragwort, chamnamul, burdock root, garlic stem, and sesame leaf were compared in this study to provide information for consumers wanting to know the specific content.

Materials and Methods

Sample preparation

Five kinds of vegetables, Fischer's ragwort, chamnamul, burdock root, garlic stem, and sesame leaf were procured from the Agricultural Science and Technology Institute of the Rural Development Administration (Wanju, Korea). All the vegetables were cultivated in South Korea. Garlic stem (chopped into 5-6 cm), Chamnmaul, and Fishcer's ragwort were blanched in boiling water for 1 min using a highlight electric stove (ERAB373E00PW, SK Magic, Seoul, Korea). Sesame leaf was blanched for 1 min using a highlight electric stove (ERAB373E00PW, SK Magic, Seoul, Korea), and drained for 10 s at speed 5 using a mini spin extractor (CFD-09G, Hanil, Bucheon, Korea). Burdock root was blanched for 3 min using a highlight electric stove (ERAB373E00PW, SK Magic, Seoul, Korea). The vegetable samples were then grounded and freeze-dried.

Analysis of TDF, IDF, and SDF

The AOAC Prosky method was used to analyze the SDF, IDF, and TDF content in the vegetable samples[4]. One g of each sample was weighed and placed in tall beakers. Fifty μL of α-amylase and 40 mL of pH 8.2 MES-TRIS buffer (Sigma-Aldrich, St. Louis, MO, USA) were added to each tall beaker with samples and stirred. The samples were placed in a water bath (C-WB3, Changshin science, Seoul, Korea) for 15 min at 100°C and were cooled down at room temperature. After the samples were cooled, 10 mL of distilled water and 100 μL of protease (Sigma-Aldrich, St. Louis, MO, USA) were added to the mixture and incubated in a water bath (C-WB3, Changshin Science, Seoul, Korea) for 30 min at 60°C. Then 5 mL of 0.561 N HCl was added, and using 6 N NaOH and 1 N HCl, the pH was adjusted to 4. After that, 300 μL of amyloglucosidase (Sigma-Aldrich, St. Louis, MO, USA) was added to the mixture, then incubated in a water bath (C-WB3, Changshin Science, Seoul, Korea) for 30 min at 60°C. For the filtration process, the Fritted crucible (PYREX®, Corning, NY, USA) containing 1 g of diatomaceous earth was prepared by adding 15 mL of distilled water while applying air suction, was used. The IDF was filtered and washed with 78% ethanol, 95% ethanol, then acetone while air suction was applied. The filtrate which contains the SDF was kept for analysis. For SDF, four volumes of 95% ethanol of the filtrate were added and incubated in the water bath (C-WB3, Changshin Science, Seoul, Korea) for 1 h at 60°C then filtered through a new set of crucibles and washed with 78% ethanol, 95% ethanol, then acetone. The crucibles were dried in a 105°C oven overnight, placed in a desiccator to cool down for 1 h, and weighed. TDF content was calculated by adding the SDF and IDF.

Preparation of standard sugar solution

The qualitative and quantitative methods of measuring sugar contents by the apparatus analysis of carbohydrates stated in the Korean food code was used to analyze the free sugar content of vegetable samples[24]. Fructose, glucose, galactose, sucrose, lactose, maltose, and raffinose were placed in a 60ºC dry oven for 12 h to be used as standard samples. The 1% standard solution was prepared by mixing 50 mL HPLC grade water (Fisher Scientific, Seoul, Korea) to 0.5 g of each standard and was diluted for use. The standard samples were diluted from 10,000 mg/kg to 7,000 mg/kg, 5,000 mg/kg, 2,500 mg/kg, 1,250 mg/kg, 625 mg/kg, and 312.5 mg/kg. HPLC grade water (Fisher Scientific, Seoul, Korea) was mixed with HPLC grade acetonitrile (Fisher Scientific, Seoul, Korea) up to 75%, filtered using a 0.22 μm filter (Pall Corporation, Ann Arbor, MI, USA) and mixed well by ultrasonication for 30 min to be used as a mobile phase. Each vegetable sample (5 g) was placed in a 50 mL colonial tube and mixed with 25 mL of 50% ethanol, then weighed. The tube was incubated in a water bath (C-WB3, Changshin Science, Seoul, Korea) for 25 min at 85ºC. After the tubes are cooled at room temperature, they were adjusted to the constant volume, of 25 mL. Lastly, the samples were filtered using a 0.45 μm syringe filter (Futecs, Daejeon, Korea) and kept in a glass vial.

Analysis of free sugar content using HPLC

The Korean food code was used to analyze the free sugar content of vegetable samples[24]. The High performance liquid chromatography (HPLC) analysis was performed using the condition shown in Table 1. The test solution was calculated using a calibration curve obtained by the peak area to obtain the concentration of sugar (mg/mL) in each standard solution and sample, then the sugar content (g/100 g) was calculated using the equation below.

$$\text{Sugar content}\left(\frac{\text{g}}{100\text{ g}}\right) = \text{S}\times\frac{\text{a}\times\text{b}}{\text{amount of sample (g)}}\times\frac{100}{1{,}000}$$

S: Concentration of sugars in the test solution; a: Total amount of the test solution; b: Dilution rate

Table 1. HPLC condition for analyzing free sugar content of vegetables

Item	Condition
Column	Asahipak NH2P-50 4E 4.6 mm ID×250 mm
Standard	Fructose, Glucose, Lactose, Sucrose, Raffinose, Maltose, Galactose
Detector	RI
Mobile phase	75% Acetonitrile
Flow rate	1.0 mL/min
Column temperature	35ºC
Injection volume	10 μL

Statistical analysis

The data collected from the experiment were analyzed by using SPSS (Statistical Package for Social Sciences, SPSS Inc., Chicago, IL, USA) to calculate the means and standard deviation[25]. All experiments were performed in duplicate. A probability (*P*) level of 0.05 was considered statistically significant.

Results and Discussion

Dietary fiber contents of raw vegetables

SDF, IDF, and TDF content of raw vegetables are arranged in Table 2. The TDF content of vegetables was 3.67±0.03 g/100 g in chamnamul, 6.09±0.49 g/100 g in Fischer's ragwort, 4.95±0.40 g/100 g in burdock root, 4.52±0.35 g/100 g in garlic stem, and 4.32±0.12 g/100 g in sesame leaf, respectively. Fischer's ragwort showed the highest TDF content among the vegetable samples, followed by burdock root, garlic stem, sesame leaf, and chamnamul. The vegetable with the most IDF was also Fischer's ragwort as 4.96±0.46 g/100 g. Burdock root contained the most SDF as 1.62±0.09 g/100 g.

The TDF of raw Fischer's ragwort ranged as 33.50 to 40.50 g/100 g in other studies[22,23]. A study about the burdock root stated that it contains 17.43±1.65 g/100 g of dietary fiber[26]. Sesame leaf, chamnamul, and garlic stem are known to have 36.90, 35.8, and 4.55 g/100 g of TDF[27-29]. The result of Fischer's ragwort, sesame leaf, and chamnamul in other studies showed a higher content of TDF compared to the result of this study because the samples were analyzed on a dry basis, which does not contain moisture, making other nutritional components higher than the wet basis. Through this, the study about garlic stem used a wet basis, showing similar results[27].

Dietary fiber change in blanched vegetables

Table 2 shows the TDF content of blanched vegetables. After blanching, the TDF changed to 2.61±0.14 in chamnamul, 6.43±0.01 in Fischer's ragwort, 3.89±0.10 in burdock root, 5.09±0.04 in garlic stem, and 3.65±0.17 in sesame leaf. The IDF decreased in chamnamul (2.26 to 2.01 g/100 g) and burdock root (3.33 to 2.68 g/100 g), but increased in Fischer's ragwort (4.96 to 5.86 g/100 g), garlic stem (3.33 to 3.39 g/100 g), and slightly in sesame leaf (2.81 to 2.88 g/100 g). The SDF also showed change, which decreased in all vegetable samples except for garlic stem, which increased from 1.19 to 1.70 g/100 g. These changes affected the TDF content, as the TDF of Fischer's ragwort (6.09 to 6.43 g/100 g) and garlic stem (4.52 to 5.09 g/100 g) increased, and chamnamul (3.67 to 2.61 g/100 g), burdock root (4.95 to 3.89 g/100 g), and sesame leaf (4.32 to 3.65 g/100 g)

Table 2. Dietary fiber contents in raw and blanched vegetables (Unit: g/100 g)

Vegetable	SDF		IDF		TDF	
	Raw	Blanched	Raw	Blanched	Raw	Blanched
Chamnamul	1.10±0.09[a]	0.59±0.14[b]	2.26±0.12[*]	2.01±0.01[*]	3.67±0.03[a]	2.61±0.14[b]
Fischer's ragwort	1.13±0.03[a]	0.57±0.04[b]	4.96±0.46[*]	5.86±0.05[*]	6.09±0.49[*]	6.43±0.01[*]
Burdock root	1.62±0.09[*]	1.21±0.11[*]	3.33±0.30[*]	2.68±0.21[*]	4.95±0.40[*]	3.89±0.10[*]
Garlic stem	1.19±0.14[a]	1.70±0.02[b]	3.33±0.21[*]	3.39±0.02[*]	4.52±0.35[*]	5.09±0.04[*]
Sesame leaf	1.51±0.29[*]	0.77±0.24[*]	2.81±0.41[*]	2.88±0.06[*]	4.32±0.12[a]	3.65±0.17[b]

Values are expressed as mean ± standard deviation. Means with different letters (a, b) of the corresponding dietary fiber type by the cooking status in the same type of vegetables are significantly different at $P<0.05$ based on independent T-test. The symbol (*) indicates there is no significant difference at $P>0.05$ based on independent T-test.
SDF: soluble dietary fiber, IDF: insoluble dietary fiber, TDF: total dietary fiber.

Table 3. Free sugar contents in raw and blanched vegetables (Unit: g/100 g)

Vegetable	Sucrose		Glucose		Fructose	
	Raw	Blanched	Raw	Blanched	Raw	Blanched
Chamnamul	0.27±.0.00[a]	0.20±0.01[b]	0.47±0.02[*]	0.40±0.00[*]	0.36±0.03[*]	0.27±0.02[*]
Fischer's ragwort	0.10±0.01[a]	0.14±0.01[b]	0.16±0.01[a]	0.11±0.01[b]	0.19±0.00[a]	0.13±0.01[b]
Burdock root	1.71±0.07[*]	1.51±0.05[*]	0.07±0.01[*]	0.06±0.00[*]	1.52±0.08[a]	1.16±0.05[b]
Garlic stem	0.76±0.00[a]	0.83±0.01[b]	1.65±0.02[a]	1.42±0.01[b]	1.73±0.02[a]	1.55±0.00[b]
Sesame leaf	N.D[1)*]	N.D[*]	0.04±0.01[a]	N.D[b]	0.03±0.00[a]	N.D[b]

Values are expressed as mean ± standard deviation. Means with different letters (a, b) of the corresponding dietary fiber type by the cooking status in the same type of vegetables are significantly different at $P<0.05$ based on independent T-test. The symbol (*) indicates there is no significant difference at $P>0.05$ based on independent T-test.
[1)] Not detected.

decreased. However, most of these changes of fibers in vegetables were not significantly different except for the SDF of chamnamul, Fischer's ragwort, and garlic stem. On the other hand, the TDF of chamnamul and sesame leaf had significant differences between blanched and fresh status.

The TDF, SDF, and IDF of a blanched Fischer's ragwort in a study by Kim et al. [30] were 32.83±0.65, 6.22±0.23, and 26.61±0.42 g/100 g, respectively. Blanched chamnamul showed a TDF content of 40.70±1.36 g/100 g from a study by Chae et al.[22].

The free sugar content of raw vegetables

Among 7 free sugar standard solutions, only glucose, sucrose, and fructose were detected in the vegetable samples (Table 3). When compared to each vegetable, the ones with the highest content of sucrose, glucose, and fructose were burdock root (1.71±0.07 g/100 g), garlic stem (1.65±0.02 g/100 g, 1.73±0.02 g/100 g), respectively. In the sesame leaf, only glucose (0.04±0.01 g/100 g) and fructose (0.03±0.00 g/100 g) could be detected. Among all vegetable samples, the garlic stem had the highest free sugar content, and the sesame leaf had the least.

In other studies, chamnamul is known to contain arabinose (0.10 g/100 g), galactose (0.10 g/100 g), glucose (3.90 g/100 g), fructose (0.10 g/100 g), and maltose (14.30 g/100 g) in a dry basis[23]. Fructose (7.56±1.27 to 118.72±0.85 mg%), glucose (286.32±22.27 to 3,395.09±924.85 mg%), and sucrose (21.61±0.40 to 98.40±6.01 mg%) were detected in Fischer's ragwort harvested in different time and conditions[31]. Dried burdock root had 8,826.53±98.34 mg% of fructose, 2,023.01 ±28.02 mg% of glucose, 1,125.57±3.84 mg% of sucrose and 1,266.73±13.69 mg% of maltose[32]. Sesame leaf contained sucrose (28.89 mg%), lactose (12.27 mg%), glucose (17.48 mg%), and fructose (28.91 mg%)[33]. For the garlic stem, only the total sugar content was studied, as 9.52±0.36 to 12.66±0.11 g/100 g[34]. The results of the free sugar content in each corresponding vegetable were different, but the cultivation area, harvesting date, and growing conditions could affect the nutritional contents in vegetables[31].

The free sugar content of vegetables after blanching

After blanching, the sugar contents in vegetables decreased except for sucrose in Fischer's ragwort (0.10±0.01 to 0.14 ±0.01 g/100 g) and garlic stem (0.76±0.00 to 0.83±0.01 g/100 g) (Table 3). For chamnamul, sucrose, glucose, and fructose decreased by almost 0.07 g/100 g, 0.07 g/100 g, and

0.09 g/100 g, respectively. Glucose and fructose decreased approximately 0.05 g/100 g and 0.06 g/100 g in Fischer's ragwort. Burdock root showed a decrease in sucrose (0.20 g/100 g), glucose (0.01 g/100 g), and fructose (0.36 g/100 g). In garlic stem, glucose and sucrose decreased by about 0.23 g/100 g and 0.18 g/100 g. However, in sesame leaf, no free sugar could be detected after blanching. The content of all the free sugar in Fischer's ragwort and garlic stem was significantly different, but chamnamul, burdock root, and sesame leaf showed a significant difference in each sucrose, fructose, glucose, and fructose, respectively.

There were no studies about the free sugar in blanched 5 kinds of vegetables. This may be the low free sugar content even in fresh vegetables. Thus, the comparison could not be done with other studies.

Through this study, it can be known that blanching affects the dietary fiber and free sugar contents of Fischer's ragwort, chamnamul, burdock root, garlic stem, and sesame leaf. TDF contents decreased in chamnamul, burdock root, and sesame leaf after blanching, but could also be increased in Fischer's ragwort and garlic stem. Especially, blanching reduced the free sugar content in sesame leaf. The following results and the nutritional value of the 5 kinds of vegetables could be provided to consumers, which could help them decide which vegetables to eat at what stage of cooking.

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국문요약

채소는 여러 건강상의 이점을 주는 식이섬유를 다량 함유하고 있다. 채소는 국내에서 다양한 형태로 섭취되고 있으며, 특히 생으로 먹거나 나물의 형태로 가장 많이 섭취되고 있다. 나물은 여러 조리 방법이 있는데, 가장 흔한 방법은 데치고 무치는 형식이다. 한국에서 나물로 흔히 섭취되는 국내산 참나물, 깻잎, 곰취, 우엉, 마늘쫑을 데친 후, 데친 채소와 생 채소를 한국 식품공전에 따라서 식이섬유와 유리당을 분석하고 비교하였다. 참나물, 우엉뿌리와 깻잎은 데친 후에 총 식이섬유가 감소하였으나, 곰취와 마늘쫑은 각각 6.09±0.49에서 6.43±0.01 g/100 g 과 4.52±0.35 에서 5.09±0.04 g/100 g으로 증가하였다. 유리당 분석 결과, 깻잎을 제외한 채소들에서 sucrose, glucose와 fructose가 검출되었으며, 깻잎은 sucrose가 검출되지 않았다. 분석한 채소들 중에서 sucrose 함량이 가장 높은 채소는 우엉 뿌리 (1.71±0.07 g/100 g) 였으며, glucose와 fructose는 각각 1.65±0.02 와1.73±0.02 g/100 g로 마늘쫑이 가장 높게 나타났다. 채소를 데친 후, 곰취 (0.10±0.01 에서 0.14±0.01 g/100 g)와 마늘쫑 (0.76±0.00 에서0.83±0.01 g/100 g)에 함유된 sucrose를 제외한 다른 유리당 함량은 전부 감소하였다. 이 연구를 통해 채소를 데치면 채소에 함유된 유리당과 식이섬유의 함량이 증가하거나 감소할 수 있다는 것을 나타낼 수 있다. 또한, 이러한 영양 정보를 통해 소비자들에게 어떠한 조리 상태의 채소를 섭취할지 선택할 때에 도움을 줄 수 있을 것이다.

Conflict of interests

The authors declare no potential conflict of interest.

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References

1. Slavin, J.L., Lloyd, B., Health benefits of fruits and vegetables. *Adv. Nutr.*, **3**, 506-516 (2012).
2. United States Department of Agriculture and U.S. Department of Health and Human Services, (2023, February 6). Dietary Guidelines for Americans, 2020-2025. Retrieved from https://www.dietaryguidelines.gov
3. Slavin, J.L., Carbohydrates, dietary fiber, and resistant starch in white vegetables: links to health outcomes. *Adv. Nutr.*, **4**, 351–355 (2013).
4. Prosky, L., Asp, N.G., Furda, I., DeVries, J.W., Schweizer, T.F., Harland, B.F., Determination of total dietary fiber in foods and food products: collaborative study. *J. Assoc. Off. Anal. Chem.*, **68**, 677-679 (1985).
5. Dhingra, D., Michael, M., Rajput, H., Patil, R.T., Dietary fibre in foods: a review. *J. Food Sci. Technol.,* **49**, 255-266 (2012).
6. Perry, J.R., Ying, W., A review of physiological effects of soluble and insoluble dietary fibers. *Nutr. Food Sci.*, **6**, 476-481 (2016).
7. Buil-Cosiales, P., Toledo, E., Salas-Salvadó, J., Zazpe, I., Farràs, M., Basterra-Gortari, F.J., Diez-Espino, J., Estruch, R., Corella, D., Ros, E., Marti, A., Gómez-Gracia, E., Ortega-Calvo, M., Arós, F., Moñino, M., Serra-Majem, L., Pintó, X., Lamuela-Raventós, R.M., Babio, N., Gonzalez, J.I., Fitó, M., Martínez-González, M.A., Association between dietary fibre intake and fruit, vegetable or whole-grain consumption and the risk of CVD: Results from the PREvención con DIeta MEDiterránea (PREDIMED) trial. *BJN to Br. J. Nutr.*, **116**, 534-546 (2016).
8. Dias, J., Nutritional quality and health benefits of vegetables: A review. *Food Nutr. Sci.*, **3**, 1354-1374 (2012).
9. Pop, C., Suharoschi, R., Pop, O.L., Dietary fiber and prebi-

otic compounds in fruits and vegetables food waste. *Sustainability*, **13**, 7219-7236 (2021).

10. Bach Knudsen, K.E., Lærke, H.N., Jørgensen, H., 2013. Carbohydrates and carbohydrate utilization in swine, 1st ed. Wiley-Blackwell, Hoboken, NJ, USA, pp.109–137.
11. Navarro, D.M.D.L., Abelilla, J.J., Stein, H.H., Structures and characteristics of carbohydrates in diets fed to pigs: a review. *Animal to Anim*., **10**, 39-55 (2019).
12. OECD, (2022, February 11). Health at a Glance 2021: OECD Indicators. Retrieved from https://www.oecd-ilibrary.org/social-issues-migration-health/health-at-a-glance-2021_ae3016b9-en
13. Korea Agricultural Statistics Service. (2022, December 21). Annual consumption of vegetables per person. Retrieved from https://kass.mafra.go.kr/statHtml/statHtml.do?orgId=114&tblId=DT_114_015_B129&conn_path=I2
14. Cho, M.S., A study of intakes of vegetables in Korea. *J. Korean Soc. Food Cult*., **18**, 601-612 (2003).
15. Kim, S.H., Kwon, D.Y., Shin, D.H., *Namul*, the driving force behind health and high vegetable consumption in Korea. *J. Ethn. Foods*, **7**, 1-12 (2020).
16. Lee, K.S., Lee, S.R., Analysis of dietary fiber content in Korean vegetable foods. *Korean J. Food Sci. Technol.,* **25**, 225-231 (1993).
17. Rodríguez, R., Jiménez, A., Fernández-Bolaños, J., Guillén, R., Heredia, A., Dietary fibre from vegetable products as source of functional ingredients. *Trends Food Sci. Technol*., **17**, 3-15 (2006).
18. Miglio, C., Chiavaro, E., Visconti, A., Fogliano, V., Pellegrini, N., Effects of different cooking methods on nutritional and physicochemical characteristics of selected vegetables. *J. Agric. Food Chem.,* **56**, 139-147 (2008).
19. Mattheé, V., Appledorf, H., Effect of cooking on vegetable fiber. *J. Food Sci*., **43**, 1344–1345 (2006).
20. Fabbri, A., Crosby, G., A review of the impact of preparation and cooking on the nutritional quality of vegetables and legumes. *Int. J. Gastron Food Sci*., **3**, 2-11 (2016).
21. Thed, S.T., Phillips, R.D., Changes of dietary fiber and starch composition of processed potato products during domestic cooking. *Food Chem*., **52**, 301-304 (1995).
22. Chae, H.S., Lee, S.H., Jeong, H.S., Kim, W.J., Antioxidant activity and physicochemical characteristics of *Pimpinella brachycarpa* Nakai with treatments methods. *Korean J. Food & Nut.,* **26**, 125–131 (2013).
23. Lee, J.J., Choo, M.H., Lee, M.Y., Physicochemical compositions of *Pimpinella brachycarpa*. *J. Korean Soc. Food Sci. Nutr.,* **36**, 327-331 (2007).
24. KFDA. (2022, February 7). 2022 Food code. Retrieved from https://www.mfds.go.kr/brd/m_211/view.do?seq=14685
25. SPSS, 2021. IBM SPSS statistics 28 brief guide. IBM Corporation, Armonk, NY, USA.
26. Moro, T.M.A., Pereira, A.P.A., Lopes, A.S., Pastore, G.M., Clerici, M.T.P.S., Retention of bioactive compounds and bifidogenic activity of burdock roots subjected to different processes. *Int. J. Gastron. Food Sci.,* **27**, 100448 (2022).
27. Choi, S.Y., Kim, S.C., Son, B.Y., Kim, K.T., Kim, M.H., Choi, Y.M., Cho, Y.S., Hwang, J.B., Oh, M.R., Oh, H.K., Comparison of dietary fiber and amino acid composition in frequently consumed vegetables and fruits. *Korean J. Food Cook Sci.,* **30**, 564–572 (2014).
28. Park, J.S., Lee W.J., Dietary fiber contents and physical properties of wild vegetables. *Korean J. Food & Nutr.,* **23**, 120-124 (1994).
29. Hwang, S.H., Kim, J.I., Sung, C.J., Analysis of insoluble (IDF) and soluble dietary fiber (SDF) content of common Korean foods consumed by Korean male college students. *Korean J. Nutr*., **29**, 278-285 (1996).
30. Jin, Y.X., Kim, H.Y., Kim, S.N., Lee, J.Y., Seo, D., Choi, Y., Comparison of nutritional compositions of green vegetables. *J. Korean Soc. Food Sci. Nutr.,* **46**, 592-599 (2017).
31. Cho, J.Y., Kim, S.H., Cho, I.K., Jeong, J.H., Park, J.K., Gim, D.W., Kim, Y.D., Huh, C.K., Analysis of quality characteristics of *Ligularia fischeri* cultivated in a greenhouse and an open field based on the harvest time. *Korean J. Food Preserv*., **26**, 49-58 (2019).
32. Hwang, D.J., Kim, J.S., Physicochemical properties of dried burdock (*Arctium Lappa* L.) powder in the peeling process. *J. East Asian Soc. Dietary Life,* **25**, 902-910 (2015).
33. Han, H.S., Park, J.H., Shoi, H.J., Son, J.H., Kim, Y.H., Kim, S., Choi, C., Biochemical analysis and physiological activity of perilla leaves. *J. Korean Soc. Food Cult*., **19**, 94-105 (2004).
34. Sim, H.J., Kang, M.J., Shin, J.H., Changes in the quality characteristics and chemical compounds of garlic shoots for blanching. *Korean J. Food Preserv*., **23**, 310-318 (2016).