Effects of cooking methods on the amino acid and mineral contents in the buds of *Aralia elata*

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**ABSTRACT**

*Aralia elata* buds contain many nutrients and have pleasant taste as well as unique flavor. However, there is currently no information regarding the effects of cooking methods on the nutrient contents. Boiling, steaming and stir-frying were used, and their influences on the amino acid and mineral contents were evaluated. Our results showed that boiling did not change the amino acid contents relative to the raw buds, but steaming and stir-frying significantly decreased amino acid contents. In addition, steaming increased the majority of the mineral contents, but the mineral contents decreased with the other cooking methods. The results suggest that boiling benefits the retention of amino acids, and substantial amounts of amino acids and minerals can be lost during stir-frying. Therefore, stir-frying is not an appropriate cooking method for retaining nutrients in *Aralia elata* buds compared with other cooking methods and is not recommended for preparing buds for human consumption.

**Efectos de diferentes métodos de cocción en el contenido de aminoácidos y minerales en los capullos de *Aralia elata***

**RESUMEN**

Los capullos de *Aralia elata* contienen muchos nutrientes y tienen un sabor agradable y único. Sin embargo, actualmente no existe información sobre los efectos que tienen los distintos métodos de cocción en su contenido nutritivo. En este estudio, los capullos fueron hervidos, preparados al vapor y salteados para posteriormente evaluar el efecto de estos tres métodos de cocción en su contenido de aminoácidos y minerales. Los resultados obtenidos dan cuenta de que, en comparación con los capullos crudos, cuando fueron hervidos no cambió su contenido de aminoácidos; no obstante, al ser preparados al vapor o salteados se redujo significativamente su contenido de aminoácidos. Además, cuando fueron preparados al vapor aumentó el contenido mineral, pero éste disminuyó al emplearse los otros dos métodos de cocción. Los resultados también sugieren que hervir los capullos potencia la retención de aminoácidos, mientras que saltearlos hace que pierdan cantidades sustanciales de aminoácidos y minerales. Por lo tanto, en comparación con los otros métodos, el salteado no constituye un método de cocción apropiado para retener los nutrientes en los capullos de *Aralia elata*, por lo que no se recomienda para la preparación de capullos destinados al consumo humano.

1. Introduction

*Aralia elata* (Miq.) Seem is a shrub of the Araliaceae family that is widely distributed in northeastern China (Heilongjiang, Liaoning and Jilin provinces), far eastern Russia, Japan and Korea (Wang et al., 2014). This plant is economically important, and its root and bark have long been used as antirhythmic, antihypertensive and antiarthritic agents in traditional Chinese medicine (Li & Lu, 2009; Xu, Yang, & Zhu, 1997). In addition, the buds of *Aralia elata*, locally called ‘ci lao ya’, contain many nutrients, including proteins necessary for human health, carbohydrates, vitamins and plant fiber. *Aralia elata* buds are also a popular ingredient in many Chinese dishes because of their good taste and unique flavor (Zhang et al., 2013). For these reasons, increasing attention is being paid to this plant.

Most previous phytochemical investigations of *Aralia elata* mainly focused on triterpene saponins in the root bark and leaves (Liu et al., 2011; Kuang et al., 2013; Ma, Zhang, Cai, Li, & Ni, 2013; Zhang, Peng et al., 2013) or studied its biological activities, such as its anticancer, anti-oxidative, anti-myocardial ischemia and anti-inflammatory properties (Nhiem et al., 2011; Zhang, Lu et al., 2013; Zhang, Peng et al., 2013; Otsuka et al., 2014; Wang et al., 2014). However, there is little information regarding its other chemical components, such as minerals and amino acids (Cui, Li, & Zhang, 1992), especially within the buds. Although not all the minerals are essential (some are even toxic) and also not all the amino acids are essential, these two components are still particularly important with regards to nutritional values. Minerals are inorganic compounds that are essential for the growth and development of the human body. Mineral deficiencies in diets can cause problems in both mental and physical development, particularly in children, the elderly and lactating or pregnant women (Hussain, Larsson, Kukatne, & Johansson, 2010;
Kayodé, Linnemann, Hounhouigan, Nout, & van Boekel, 2006). In addition, amino acids are the building blocks of protein, and protein accounts for at least 18% of an individual’s body weight, hence the saying ‘there is no life without amino acids’.

In northeastern China, the buds of *Aralia elata* are sometimes eaten raw, but they can also be cooked before consumption using various methods, including boiling, stir-frying and steaming. In general, boiling is mainly used when preparing dumplings or soup, stir-frying is often used to cook scrambled eggs with the buds, and steaming is used when preparing them for use in salads. It has been shown that domestic cooking methods can affect the chemical compositions of vegetables to a certain extent, which affects their nutritional value (Xu et al., 2014). For example, stir-frying and microwave heating lead to a higher retention of the bioactive components in peppers (Chua et al., 2008); sous vide cooking results in an increased content of antioxidant compounds in broccoli (*Brassica oleracea* var. *Avenger*) (Dos Reis, de Oliveira, Hagen, Jablonski, & Flôres, 2015). Therefore, it is also important to determine the retention of nutrients in *Aralia elata* buds with each of these cooking methods. To the best of our knowledge, no information is available on the effects of cooking treatments on the amino acid and mineral contents of *Aralia elata* buds. The aim of this work was to investigate how cooking (boiling, steaming and stir-frying) affects these two components compared with raw *Aralia elata* buds.

### 2. Materials and methods

#### 2.1 Plant materials

Buds of *Aralia elata* were collected from Greater Hinggan in Heilongjiang Province of China in May 2016 (121°12′ E, 50°10′ N and an average elevation of 1250 m). The samples were taxonomically identified by Prof. Zhenyue Wang of the Heilongjiang University of Chinese Medicine, and the buds (nearly 4 kg) were then maintained on ice and transported to the laboratory.

#### 2.2 Cooking treatment

Three different cooking methods were tested in this research: boiling, steaming and conventional stir-frying. Uncooked buds were used as the control group. We selected these three methods because they are the commonly used methods for cooking *Aralia elata* buds. Approximately 1 kg of buds was subjected to each cooking method. Before the cooking treatment, the samples were washed three times in tap water and then drained.

- **Boiling treatment:** the sample was boiled in an aluminum vessel in water (5:1 of water: sample proportion) at a temperature of 100°C for 10 min.
- **Steaming treatment:** the sample was placed in a steam vessel with 300 mL of water for 15 min. (final temperature is 95°C).
- **Stir-frying treatment:** a minimum amount of cooking oil (3–5 g) was placed in a frying pan (diameter of 32 cm) and heated to 130°C on an electric hot plate (Jiuyang Company, 1200 W, 220 V) for 4 min.

All of the cooking conditions were optimized in preliminary experiments for each treatment. For all of the cooking methods, the minimum time for the buds to reach tenderness as well as adequate palatability and taste was used. Each treatment was performed in triplicate. After cooking, the moisture contents were 91.8%, 90.2% and 86.6% in the boiling, steaming and stir-frying treatments, compared to the raw buds of 89.5%. All the samples were then cooled on ice and used for the following experimental processes.

#### 2.3 Analysis of the amino acid content

The amino acid composition was determined after hydrolysis of the samples with 6 N HCl at 110°C for 24 h in vacuum-sealed glass tubes according to the procedure described by Davies and Thomas (1973). The samples were then analyzed by ion-exchange chromatography on a Biochrom 30 automatic amino acid analyzer (Biochrom Ltd, Cambridge, UK) using lithium citrate buffers as eluents and a ninhydrin post-column reaction system. The amino acids were identified and quantified by comparing the peak profiles of the products with standard amino acid profiles. The following amino acid standards were purchased from Sigma-Aldrich (St. Louis, MO, USA): aspartic acid (Asp); threonine (Thr); serine (Ser); glutamic acid (Glu); glycine (Gly); valine (Val); methionine (Met); isoleucine (Ile); tyrosine (Tyr); phenylalanine (Phe); lysine (Lys); histidine (His); arginine (Arg); proline (Pro); leucine (Leu); alanine (Ala) and cysteine (Cys). All values were reported as the mean of three replicate determinations.

#### 2.4 Analysis of the mineral content

The determinations of the concentrations of all of the minerals were conducted with an ICP-OES instrument (PerkinElmer, Optima 8300, USA). The operating conditions of the ICP-OES equipment were as follows: 14 L min⁻¹ plasma gas flow rate, 0.2 L min⁻¹ auxiliary gas flow rate, 0.55 L min⁻¹ nebulizer gas flow rate, 1200 WRF power, and 1.5 mL min⁻¹ sample flow rate. All elements were detected in the axial mode. The analytical wavelengths (nm) were as follows: Ca (422.673), Mg (285.213), Cr (267.716), Cu (327.393), Fe (238.204), Mn (257.610), Ni (231.604), Co (240.7), Sr (407.771), and Zn (206.200). An ICP-OES multi-element standard containing Ca (0.1–62.5 mg L⁻¹), Mg (0.1–62.5 mg L⁻¹), Mn (0.1–12.5 mg L⁻¹), Co (0.1–12.5 mg L⁻¹), Ni (0.1–12.5 mg L⁻¹), Sr (0.1–12.5 mg L⁻¹), Fe (0.1–12.5 mg L⁻¹), Cu (0.1–12.5 mg L⁻¹) and Zn (0.1–12.5 mg L⁻¹) was prepared. Cr was prepared as a series of single element standards with 0.1 mg L⁻¹ to 12.5 mg L⁻¹. The concentrations of all of the elemental standards were obtained through five-fold serial dilution with 1% nitric acid.

#### 2.5 Statistical analysis

The data were analyzed by one-way analysis of variance (ANOVA). The significance level was set to \( P < 0.05 \), and principal component analysis (PCA) was performed using SPSS version 17.0 and CANOCO 4.5 software (Microcomputer Power, USA).
3. Results and discussion

3.1 Effects of the cooking methods on the amino acid contents

The moisture content of the Aralia elata buds ranged from 86% to 92%, increasing slightly after boiling and steaming treatments, but significantly decreasing after stir-frying treatment. Some other plants of the moisture content such as broccoli, cauliflower and Mediterranean vegetables were also shown this changed trend (dos Reis et al., 2015; Ramírez-Anaya, Samaniego-Sánchez, Castañeda-Saucedo, & Villalón-Mir, 2015).

The amino acid contents of raw and cooked buds of Aralia elata are presented in Table 1. The data showed that aspartic acid, glutamic acid and leucine acid were the dominant amino acids in the raw buds, and these were found in concentrations of 29.2 mg/g, 36.0 mg/g and 31.6 mg/g, respectively. The contents of the remaining amino acids were substantially lower. Similar results have also been reported by other researchers (Cui et al., 1992), who also found that aspartic acid and leucine acid were found at relatively high contents compared with other amino acids. However, glutamic acid was not detected in their research. The main reason for this might be the different experimental materials used in the studies. In addition, cysteine, methionine and histidine were the amino acids found at the lowest concentrations, specifically 3.1 mg/g, 7.0 mg/g and 7.8 mg/g, respectively.

The data shown in Table 1 clearly notes no significant differences in any of the amino acids between the raw and boiled buds (P < 0.05), with the exception of cysteine. The cysteine content of the boiled buds was 16.1% higher than that of the raw buds (P < 0.05). The concentrations of all amino acids in the steamed and stir-fried buds were decreased significantly compared with those in the raw buds (P < 0.05), which may due to that there was a reaction between a carbonyl compound (reductive carbohydrate) and an amino compound called Maillard reaction (dos Reis et al., 2015). However, there were no significant differences between the amino acid contents of the steamed and stir-fried buds (P > 0.05). Decreases in the amino acid contents of bean seeds by cooking methods have also been reported previously (Slupski, 2010). However, the amino acid contents in peanuts and cowpeas increased when prepared by traditional methods.

The contents of the 17 amino acids in the buds were then evaluated by principal component analysis (PCA) (Figure 1). The first component accounted for 60% of the variance in the data, and the second principal component accounted for 21.3% of the variance. The plot of the correlation coefficients between the amino acids and principal components was in the plane of the first two principal components. From Figure 1, we could clearly see that the cooking method of steaming was found greatly affected on the amino acids of Asp, Pro, Tyr, Met, Glu and Leu. In addition, Phe, Thr and Gly were found to be greatly affected by stir-frying. The results obtained with boiling appeared aggregated and similar to the CK treatment, indicating that the amino acid contents were minimally affected by this cooking method except Ala and His (Figure 1).

3.2 Effects of the cooking methods on the mineral contents

Little data on the influence of different cooking methods on the mineral contents of Aralia elata buds were available, even though mineral contents are an important component of nutritional value. The contents of Mn, Fe, Cu, Zn, Sr, Ca, Mg, Cr, Co and Ni of raw and cooked Aralia elata buds are presented in Table 2.

The Ca content in raw buds was 3818 μg/g, which was the highest among all of the mineral contents. Steaming significantly increased the Ca content to 4212 mg/g (P < 0.05), but boiling (3582 mg/g) and stir-frying (2878 mg/g) decreased the Ca content. Additionally, Zn and Mg had relatively high contents compared with the other minerals, which were 2875.2 mg/g and 1095.4 mg/g, respectively. Also, steaming significantly increased the Zn content to 3035.2 mg/g, and boiling significantly increased the Mg content to 1222 mg/g (P < 0.05). With respect to the contents of Mn, Fe, Cu and Sr, steaming was still the most effective way to increase the levels of these minerals (P < 0.05). We also found that stir-frying led to the lowest mineral contents. Moreover, the Cr, Co and Ni contents were very low, and none of the cooking methods affect the contents of these minerals.

These minerals are necessary for the regulation of various functions in the human body. For example, Ca and Mg are important for bone health; Fe is the most vital component of hemoglobin; Mn and Zn are responsible for regulating the activities of many enzymes; and Cu plays an important role in hematopoiesis (Taskaya, Chen, Beamer, Tou, & Jaczynski, 2009). In this research, we found that the buds of Aralia elata had high levels of some important minerals such as Ca, Mg and Zn. Thus, the buds of Aralia elata have important nutritional benefits for humans.

Previous studies have reported that culinary methods can lead to considerable changes in mineral contents (Barampama & Simard, 1995). However, these changes (either higher or lower than the raw material contents)

Table 1. Amino acid contents (mg/g) in raw and cooked buds of Aralia elata.

| Amino acids | Raw       | Boiled    | Steamed   | Stir-fried |
|-------------|-----------|-----------|-----------|------------|
| Asp         | 29.2 ± 0.8a | 28.9 ± 1.9a | 24.2 ± 0.6b | 23.3 ± 1.7b |
| Thr         | 15.4 ± 0.2a | 15.5 ± 1.1a | 12.6 ± 0.2b | 12.1 ± 0.9b |
| Ser         | 16.1 ± 0.1a | 16.1 ± 0.9a | 12.9 ± 0.3b | 12.5 ± 0.9b |
| Glu         | 36.0 ± 0.4a | 36.3 ± 2.3a | 29.0 ± 0.6b | 27.7 ± 2.2b |
| Gly         | 15.4 ± 0.2a | 15.2 ± 1.1a | 12.6 ± 0.2b | 11.9 ± 0.9b |
| Ala         | 18.6 ± 0.3a | 18.8 ± 1.3a | 14.6 ± 0.6b | 13.6 ± 1.1b |
| Cys         | 3.1 ± 0.3b  | 3.6 ± 0.2a  | 2.9 ± 0.1b  | 2.9 ± 0.2b  |
| Val         | 21.9 ± 0.2a | 21.7 ± 1.3a | 17.5 ± 0.5b | 16.8 ± 1.3b |
| Met         | 7.0 ± 0.6a  | 7.0 ± 0.2a  | 6.4 ± 0.3b  | 5.9 ± 0.4b  |
| Ile         | 19.1 ± 0.4a | 19.1 ± 1.2a | 15.4 ± 0.3b | 14.7 ± 1.0b |
| Leu         | 31.6 ± 0.5a | 31.8 ± 2.1a | 25.3 ± 0.9b | 23.7 ± 1.9b |
| Tyr         | 11.8 ± 0.5a | 12.2 ± 0.7a | 10.1 ± 0.3b | 9.4 ± 0.3b  |
| Phe         | 17.6 ± 0.1a | 17.3 ± 1.2a | 14.6 ± 0.8b | 13.4 ± 1.0b |
| Lys         | 23.3 ± 0.8a | 23.5 ± 1.5a | 17.9 ± 0.5b | 17.4 ± 1.9b |
| His         | 7.9 ± 0.1a  | 7.9 ± 0.4a  | 6.5 ± 0.2b  | 5.9 ± 0.3b  |
| Arg         | 20.7 ± 0.5a | 20.8 ± 1.4a | 16.3 ± 0.3b | 15.6 ± 1.1b |
| Pro         | 13.4 ± 0.2a | 13.5 ± 0.8a | 11.3 ± 0.3b | 10.9 ± 0.6b |

Notes: Results are means ± standard deviation of triplicates.
Different letters indicate significant differences among different cooking methods (P < 0.05).
Notes: Los resultados son las medias ± desviación estándar de tres ensayos. Las distintas letras indican diferencias significativas entre los métodos de cocción (P < 0.05).
mainly depend on the plant species, type of mineral and cooking method. For example, the Na contents in quinoa and buckwheat decreased with boiling, but boiling can increase the Na content above that of raw or steamed foods in other cases (Mota, Nascimento, Santos, Delgado, & Coelho, 2016). In addition, the lowest Zn value was found in steamed buckwheat, and the highest was found in boiled buckwheat. In our research, steaming can increase the contents of the majority of minerals to some extent. Boiling mainly increased the Fe and Mg contents. However, stir-frying can cause substantial losses in minerals, indicating that stir-frying is not appropriate for mineral retention relative to the other two cooking methods.

The contents of 10 minerals were evaluated by principal component analysis (PCA) (Figure 2). The first principal component accounted for 69.1% of the variance in the data, and the second principal component accounted for 18.9% of the variance. Mg and Fe contents were found to be greatly affected by the boiling treatment. Zn content was found to be greatly affected by the stir-frying. Unlike the amino acid findings, the results of steaming appeared to show the most aggregation, indicating that steaming had a minimal effect on the most mineral contents except Ca. Moreover, Cu content was the highest at the CK site (Figure 2). We then evaluated the combined results from the assays of the mineral and amino acid contents by principal component analysis (Figure 3). An eigenvalue of 99.3% was achieved using two PCs (PC1 = 83.7%, PC2 = 15.6%). The mineral and amino acid contents in raw buds were clearly distinguished from cooking methods (boiling, steaming and stir-frying). The results showed that cooking methods had a notable influence on changes in the mineral and amino acid contents compared with the raw buds.

Table 2. Mineral content (μg/g) in raw and cooked buds of *Aralia elata*.

| Minerals | Raw       | Boiled     | Steamed    | Stir-fried |
|----------|-----------|------------|------------|------------|
| Mn       | 33.8 ± 3.1a | 36.0 ± 2.5a | 34.2 ± 2.7a | 27.1 ± 3.6b |
| Fe       | 118.1 ± 3.9b | 136.6 ± 18.4b | 166.7 ± 13.5a | 123.5 ± 7.7b |
| Cu       | 37.7 ± 4.3a | 27.9 ± 3.8b  | 44.1 ± 5.4a  | 36.9 ± 3.2a  |
| Zn       | 2875.2 ± 8.3b | 2499.2 ± 13.8c | 3035.2 ± 5.5a | 2441.2 ± 12.3d |
| Sr       | 104 ± 3.6ab  | 91 ± 15.8bc  | 112.2 ± 11.6a | 97.4 ± 15.2c |
| Ca       | 3818.0 ± 9.9b | 3582.0 ± 8.7c | 4212.0 ± 9.4a | 2878.0 ± 5.4d |
| Mg       | 1095.4 ± 3.3b | 1222 ± 18.5a  | 1060.6 ± 16.7c | 908.8 ± 11.9d |
| Co       | 3.2 ± 0.0a   | 3.1 ± 0.0a   | 3.2 ± 0.1a   | 3.2 ± 0.0a   |
| Ni       | 0.4 ± 0.0a   | 0.3 ± 0.0a   | 0.4 ± 0.2a   | 0.2 ± 0.01a  |

Notes: Results are means ± standard deviation of triplicates. Different letters indicate significant differences among different cooking methods \( P < 0.05 \).

Notas: Los resultados son las medias ± desviación estándar de tres ensayos. Las distintas letras indican diferencias significativas entre los métodos de cocción \( P < 0.05 \).
In the present research, the effects of various traditional cooking methods, namely, boiling, steaming and stir-frying, on the mineral and amino acid contents in the buds of *Aralia elata* were explored. This manuscript provides the first report of the relationships between nutrient contents and cooking methods for *Aralia elata*. Our results clearly show that boiling benefits the amino acid contents compared with the raw, steamed or stir-fried buds of *Aralia elata*. In addition, mineral contents can be increased by steaming. However, stir-frying can cause significant losses in amino acids and minerals. Therefore, stir-frying is not an appropriate cooking method for retaining the nutrients of *Aralia elata* buds compared with the other two cooking methods and is not recommended for cooking buds suitable for human consumption.

**Disclosure statement**

No potential conflict of interest was reported by the authors.

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**References**

Barampama, Z., & Simard, R. E. (1995). Effects of soaking, cooking and fermentation on composition, in-vitro starch digestibility and nutritive value of common beans. *Plant Foods for Human Nutrition (Formerly Qualitas Plantarum)*, 48(4), 349–365.

Chuah, A. M., Lee, Y. C., Yamaguchi, T., Takamura, H., Li, J. Y., & Matoba, T. (2008). Effect of cooking on the antioxidant properties of colored peppers. *Food Chemistry*, 111(1), 20–28.

Cui, S. Y., Li, X. G., & Zhang, C. X. (1992). Chemical component of the *aralia elata* (Mia) Seem. *Journal of Jilin Agricultural University*, 14(3), 29–32, 94.
Davies, M. G., & Thomas, A. J. (1973). An investigation of hydrolytic techniques for the amino acid analysis of foodstuffs. Journal of the Science of Food and Agriculture, 24(12), 1525–1540.

dos Reis, L. C. R., de Oliveira, V. R., Hagen, M. E. K., Jablonski, A., & Flóres, S. H. (2015). Effect of cooking on the concentration of bioactive compounds in broccoli (Brassica oleracea var. Avenger) and cauliflower (Brassica oleracea var. Alphina F1) grown in an organic system. Food Chemistry, 172, 770–777.

Hussain, A., Larsson, H., Kuktaite, R., & Johansson, E. (2010). Mineral composition of organically grown wheat genotypes: Contribution to daily minerals intake. International Journal of Environmental Research and Public Health, 7(9), 3442–3456.

Kayodé, A. P., Linnemann, A. R., Hounhouigan, J. D., Nout, M. J., & van Boekel, M. A. (2006). Genetic and environmental impact on iron, zinc, and phytate in food sorghum grown in Benin. Journal of Agricultural and Food Chemistry, 54(1), 256–262.

Kuang, H. X., Wang, Z. B., Wang, Q. H., Yang, B. Y., Xiao, H. B., Okada, Y., & Okuyama, T. (2013). Triterpene glucosides from the leaves of aralia elata and their cytotoxic activities. Chemistry & Biodiversity, 10(4), 703–710.

Li, M., & Lu, W. (2009). Pharmacological research progress of Aralia elata. Medical Recapitulate, 20, 3157–3160.

Liu, Y., Liu, J., Liu, Z., Liu, Y., Liu, M., Jiang, J., & Xu, W. (2011). The antitumor effects of Araloside A extracted from the root bark of Aralia elata on human kidney cancer cell lines. African Journal of Pharmacy and Pharmacology, 5(4), 462–467.

Ma, Z. Q., Zhang, Y., Cai, C. K., Li, Q., & Ni, J. (2013). Two new triterpenoid saponins from the leaves of Aralia elata. Journal of Asian Natural Products Research, 15(8), 849–854.

Mota, C., Nascimento, A. C., Santos, M., Delgado, I., & Coelho, I. (2016). The effect of cooking methods on the mineral content of quinoa (Chenopodium quinoa), amaranth (Amaranthus sp.) and buckwheat (Fagopyrum esculentum). Journal of Food Composition and Analysis, 49, 57–64.

Nhiem, N. X., Lim, H. Y., Kiem, P. V., Minh, C. V., Thu, V. K., & Tai, B. H. (2011). Oleanane-type triterpene saponins from the bark of Aralia elata and their NF-kappa B inhibition and PPAR activation signal pathway. Bioorganic & Medicinal Chemistry Letters, 21, 6143–6147.

Otsuka, H., Gotoh, Y., Komeno, T., Ono, T., Kawasaki, Y., & Iida, N. (2014). Aralin, a type II ribosome-inactivating protein from Aralia elata, exhibits selective anticancer activity through the processed form of a 110-kDa high-density lipoprotein-binding protein: A promising anticancer drug. Biochemical & Biophysical Research Communications, 433(1), 117–123.

Ramírez-Anaya, P. J., Samaniego-Sánchez, C., Castañeda-Saucedo, M. C., & Villalón-Mir, M. (2015). Phenols and the antioxidant capacity of Mediterranean vegetables prepared with extra virgin olive oil using different domestic cooking techniques. Food Chemistry, 188, 430–438.

Slupski, J. (2010). Effect of cooking and sterilisation on the composition of amino acids in immature seeds of flageolet bean (Phaseolus vulgaris L) cultivars. Food Chemistry, 121(4), 1171–1176.

Taskaya, L., Chen, Y. C., Beamer, S., Tou, J. C., & Jaczynski, J. (2009). Compositional characteristics of materials recovered from whole gutted silver carp (Hypophthalmichthys molitrix) using isoelectric solubilization/precipitation. Journal of Agricultural and Food Chemistry, 57(10), 4259–4266.

Wang, M., Xu, X. D., Xu, H. B., Wen, F. C., Zhang, X. P., & Sun, H. (2014). Effect of the total saponins of Aralia elata (Milu) Seem on cardiac contractile function and intracellular calcium cycling regulation. Journal of Ethnopharmacology, 155(1), 240–247.

Xu, F., Zheng, Y. H., Yang, Z. F., Cao, S. F., Shao, X. F., & Wang, H. F. (2014). Domestic cooking methods affect the nutritional quality of red cabbage. Food Chemistry, 167, 162–167.

Xu, X. D., Yang, J. S., & Zhu, Z. Y. (1997). Advances in the studies of saponins from Aralia. Yao xue xue bao = Acta pharmaceutica Sinica, 32(9), 711.

Zhang, J., Lu, S. P., Wang, H. Y., & Zheng, Q. S. (2013). Protective role of Aralia elata polysaccharide on mercury(II)-induced cardiovascular oxidative injury in rats. International Journal of Biological Macromolecules, 59, 301–304.

Zhang, Y., Peng, Y., & Li, L. (2013). Studies on cytotoxic triterpene saponins from the leaves of Aralia elata. Food chemistry, 138(1), 208–213.