Analysis of nutritional components of the fruits of *Pyracantha angustifolia* and *Pyracantha fortunaeana*

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 Abstract. In order to understand the difference of nutritional components between two species of *Pyracantha* Roem fruits in Sichuan Province, the contents of total sugar, Vc, protein, crude fibre, pectin, polyphenol and 12 kinds of main mineral elements in the fruits were determined by using the mature fruits of *Pyracantha angustifolia* and *Pyracantha fortunaeana* as material. The results showed that the basic nutrients of *P. angustifolia* and *P. fortunaeana* were complete. Except for crude fiber, other nutrients of *P. angustifolia* were higher than those of *P. fortunaeana*. The contents of 12 kinds of mineral elements in the two plants were abundant, and the contents of potassium (K), calcium (Ca), magnesium (Mg), zinc (Zn) and manganese (Mn) as beneficial mineral elements in *P. angustifolia* were higher than those of *P. fortunaeana*, while the contents of cadmium (Cd), chromium (Cr), nickel (Ni) and lead (Pb) as heavy metals in *P. fortunaeana* were higher than those of *P. angustifolia*. To sum up, the nutrient value of the fruits of *P. angustifolia* is higher than that of *P. fortunaeana*, which has more potential for exploitation and utilization.

1. Introduction

*Pyracantha* Roem is an evergreen shrub of Rosaceae, a total of 10 species, of which there are 7 species in China. The resources of wild genus in southwest China are abundant and concentrated [1-2]. *Pyracantha angustifolia* and *Pyracantha fortunaeana* are mainly distributed in Hubei Province, Yunnan Province, Sichuan Province, Tibet and other places in China, growing in the sunny slopes or on the roadside, with an altitude of 280-3000 m. The young leaves of *P. angustifolia*, the peduncle and the tube are covered with white fluff, the leaves are mostly narrow and oblong, and the whole edge. The leaves of *P. fortunaeana* are obovate and apex obtuse or dimpled, sometimes shortly pointed [1]. The plants of *Pyracantha Roem* can grow well even on barren sandy soil, with strong ability of drought resistance and wind prevention and sand fixation, and wide adaptability, which have important ecological value [3]. The fruits of *Pyracantha Roem* contain nutrients such as amino acids, soluble sugars, vitamins, mineral elements, fatty acids, proteins, starches, pectin and dietary fibre and other nutrients [4-9]. The roots, leaves and fruits of *Pyracantha Roem* all have medicinal value and health function, which help to enhance the human’s immunity, anti-oxidation and spleen-nourishing and digestion [10]. At present, the fruits of *Pyracantha Roem* have been used to develop foods such as fruit juice, fruit wine and preserved fruit, as well as other additives such as pigments and pectin, and are widely used in medicine, food, cosmetics and other industries [11-14].

The fruits of *Pyracantha Roem* replace food and have a long history of more than 1,700 years in China. Researchers in China have studied the specific nutrients of *P. fortunaeana* for the first time since the 1980s [2]. At present, there are reports on the related nutrients of *Pyracantha Roem* in Guizhou Province, Guangxi Province, Hubei Province, Xiangxi Autonomous Prefecture and other
areas in China [15-20], but there are few studies on the nutrient composition of *Pyracantha* Roem in Sichuan Province. The *P. angustifolia* and *P. fortunaeana* are rich in germplasm resources, with high fruit setting rates and bright color, which remain to be developed and utilized. In this experiment, six kinds of basic nutrients: total sugar, Vitamin C (Vc), protein, mineral elements, crude fibre, pectin, polyphenol and twelve kinds of main mineral elements: potassium (K), sodium (Na), calcium (Ca), magnesium (Mg), zinc (Zn), manganese (Mn), iron (Fe), copper (Cu), cadmium (Cd), chromium (Cr), nickel (Ni), and lead (Pb) were determined by using the mature fruits of *P. angustifolia* and *P. fortunaeana* in Sichuan Province, which provided the science basis for the exploitation and utilization of the germplasm resources of *Pyracantha* Roem in Sichuan.

2. Materials and methods

2.1 Experiment materials

From October to November in 2016, the fruits of *P. angustifolia* (orange-red) were collected in Xichang National Customs Park, Sichuan Province (at an altitude of 1530 m, N: 27°52'; E: 102°14'). The fruits of *P. fortunaeana* (red) were collected in Caoke Township, Shimian County, Ya'an City, Sichuan Province (at an altitude of 1860m, N:29°22'; E:102°02'). Select some of the fresh fruits with high quality and 9 ripening from 4 to 5 trees, and bring them back to the laboratory for preservation, for the analysis of the nutritional components of the fruits.

2.2 Experiment methods

Basic nutrients: Vc was determined by 2, 6-dichlorophenol indophenol method; total sugar was determined by anthrone colorimetry method; protein was determined by Coomassie Brilliant Blue G-250 method; pectin was determined by gravimetric method; polyphenols were determined by ferrotaric acid colorimetry [21]. Mineral elements: remove the seeds from the fresh fruits, after drying the fruits to constant weight in 100°C to 105°C, and then grind after 60 mesh. Related mineral elements were determined by flame atomic absorption spectrophotometry [22]. The experiment was repeated three times and averaged.

2.3 Statistical Analyses

SPSS 22.0 was used to analyse the significant difference between the nutrient components of *P. angustifolia* and *P. fortunaeana*. The datas in the table are indicated by the average ± standard deviation, and the difference is significant in different lowercase letters (p < 0.05).

3. Results

3.1 Basic nutrients of *P. angustifolia* and *P. fortunaeana*.

There were six kinds of basic nutrients in both of *P. angustifolia* and *P. fortunaeana*, but the contents of different nutrients were different (Table 1). Besides the crude fibre, the other basic nutrients in the fruits of *P. angustifolia* were higher than those of *P. fortunaeana*. Among them, the contents of sugar, pectin and polyphenol in *P. angustifolia* were significantly higher than that of *P. fortunaeana*, but the difference of Vc and protein contents did not reach a significant level. The pectin content in the fruits of *P. angustifolia* was 13.89 times (p < 0.05) than that of *P. fortunaeana*, and the polyphenol content was 2.54 times (p < 0.05) than that of *P. fortunaeana*. The Vc, sugar and protein contents of *P. angustifolia* were higher than that of *P. fortunaeana*, respectively: 3.69 % (p < 0.05), 10.96 % (p > 0.05), and 1.51 % (p > 0.05). In terms of crude fibre content, the crude fibre content in *P. fortunaeana* was 41.02% (p < 0.05) higher than that of *P. angustifolia*, and the difference was significant.

3.2 Mineral nutrients of *P. angustifolia* and *P. fortunaeana*.

There were 12 kinds of mineral elements in the fruits of *P. angustifolia* and *P. fortunaeana* (Table 2). However, the content of each element was different in the fruits of the two plants. Among the two
species of Pyracantha Roem, the K content of P. angustifolia was 14.71 % (p < 0.05) of P. fortunaeana. At the same time, Na content of P. angustifolia fruits was 37.77 % (p < 0.05) lower than that of P. fortunaeana. In addition, the contents of Ca, Mg, Zn and Mn in the beneficial mineral elements of the human body were higher than those of P. fortunaeana fruits, which were 10.86 % (p < 0.05), 23.64 % (p < 0.05), 22.22 % (p < 0.05) and 29.69 % (p < 0.05), respectively. In the case of Cu and Fe contents, the fruits of P. angustifolia were lower than those of P. fortunaeana: 18.18 % (p < 0.05) and 7.75 % (p > 0.05). In terms of heavy metals, the contents of Cd, Cr, Ni and Pb in P. fortunaeana were significantly higher than those in P. angustifolia. The contents of Cd, Cr and Ni in P. angustifolia were higher than those in P. fortunaeana: 11.80 % (p < 0.05), 27.05 % (p < 0.05), and 30.77 % (p < 0.05), respectively, while the Pb content in P. angustifolia was 8.29 times (p < 0.05) than that of P. fortunaeana.

4. Discussions

The fruits of P. angustifolia and P. fortunaeana were rich in Vc, sugar, protein, pectin, mineral elements, and other nutrients, all of which have high edible value. Among them, Vc, potassium, calcium, iron, zinc, copper and other contents have reached the requirements of processing them into food and pharmaceutical processing and production. Vc is a strong antioxidant in the body, which can directly interact with oxidants to protect other substances from oxidative damage. Vc can also reduce the risk of gastric cancer and prevent...
cardiovascular diseases [23]. The recommended intake of Vc in China is 100 mg/d, that is, the amount of Vc in the extract of about 200 g of P. angustifolia and P. fortunaeana can meet the daily intake requirement of the human’s life.

K, as an essential constant element of human body, plays an active role in maintaining nerve and muscle excitability, protecting human cardiovascular, preventing heart disease, and participating in intracellular glucose and protein metabolism [23]. The fruits of P. angustifolia with high K and low Na nutritive proportion were more conducive to the metabolism of sugar and protein in cells compared with P. fortunaeana, so as to effectively reduce the probability of cardiovascular disease.

As an important component of bones and teeth in the body, Ca can promote enzyme activity in the body, participate in cell metabolism, and maintain cell membrane permeability. The content of Ca in the fruits of P. angustifolia and P. fortunaeana were 36.36 mg/100g and 40.74 mg/100g, respectively. Therefore, as two supplementary foods for Ca, these two kinds of Pyracantha Roem fruits are recommended.

Iron is one of the main raw materials for the synthesis of hemoglobin. When iron is deficient, it cannot synthesize enough hemoglobin, causing iron deficiency anemia. The intake of a small amount of iron in the human body can have a blood-filling effect. The iron content of P. angustifolia and P. fortunaeana is 3.45 mg/100g and 3.74 mg/100g, respectively, which can be recommended as natural iron supplement.

Zn has a major role in the body's immune system and defense functions, and is a key factor in promoting growth and development, maintaining normal taste and olfaction to promote appetite [24]. Cu is mainly found in the organs and tissues in the form of enzymes, which can also maintain normal hematopoietic function and the integrity of the nervous system, and is related to the body's immune function. The contents of Cu and Zn in fruits of P. angustifolia were 0.18 mg/100g and 0.36 mg/100g, respectively, while the contents of Cu and Zn in fruits of P. fortunaeana were 0.22 mg/100g and 0.28 mg/100g, respectively, which can be used as natural food for supplement Cu and Zn.

Ni, Pb, Cd, and Cr are detected in both the fruits of P. angustifolia and P. fortunaeana, which are initially believed to be due to the presence of Ni, Pb, Cd, and Cr in the soil. The heavy metal elements in the soil where the P. fortunaeana was growing are still to be further detected. At present, studies have shown that P. fortunaeana can absorb the heavy metal arsenic (As), showing the basic characteristics of heavy metal hyperaccumulator plants [25]. Therefore, it may be possible to use this feature of P. fortunaeana for the restoration of heavy metals in the soil as a phytoremediation material.

5. Conclusions
In summary, the fruits of P. angustifolia and P. fortunaeana have complete and rich nutrition and high edible value. The overall comparison of the basic nutrients in the fruits of two species of Pyracantha Roem showed that the fruits of the P. angustifolia have higher value in terms of its nutritional utilization than that of the fruits of P. fortunaeana, and have greater development potential in food processing. In the case of mineral elements beneficial to human health, both P. angustifolia and P. fortunaeana can be used as supplementary foods to supplement mineral elements. In order to make full use of this wild resource and popularize them as an industry, more components and other nutrients of the fruits of P. angustifolia and P. fortunaeana should be analysed, and further research on processing technology should be carried out.

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References
[1] Chinese Flora Editorial Board of the Chinese Academy of Sciences, Flora of China (Science Press, Beijing, 1974)
[2] J. T. Teng, Y. H. Cheng, J. P. Xue, W. Sheng. Journal of Huaibei Normal University (Natural Science) 38, 43 (2017)
[3] R. F. He. Agriculture and technology 34, 128 (2014)
[4] J.F. Liu, Y.P. Zhang, G.Y. Zhang. Shandong Medical Journal 51, 37 (2011)
[5] Yuan C, Wang C, Bu Y, Xiang T, Huang X, Wang Z, Yi F, Ren G, Liu G, Song F. Immunology Letters 133, 14 (2010)
[6] Y. F. He, Y.B. Huang, Y. M. Li, M. Y, C. R. Yin, Y. Q. Liao, Y. Zou, Z. Su., Journal of Anhui Agri. Sci. 46, 177 (2018)
[7] P. X. Li, G.H. Mao, T. Zhao, Y. Zou, Y. N. Ren, S. Q. Bai, X. Y. Wu, L. Q. Yang, Food Science 34, 116 (2013)
[8] D. Wang. Journal of Chinese Institute of Food Science & Technology, (2010)
[9] C. F. Zhao,D. J. Lei, G. H. Song, H. Zhang, H. Xu, L. J. Yu. Food Chemistry 169, 484(2015)
[10] J. Zeng, R. Yang, Y. J. Li, T. Chen, J. Y. Yan, J. Li, S. X. Li. Hunan Journal of Traditional Chinese Medicine 32, 226 (2016)
[11] C. L. Jiang, Y. Zhuang, D. G. Zhu, C. Chen, W.Li. China Brewing 32, 80 (2013)
[12] S. A. Yang, Z. H. Shi. Food Res. Dev. 31,103 (2010)
[13] R. R. He, W. X. Li, Y. F. Li, Y. B. Li. Chinese Journal of Experimental Traditional Medical Formulae 17, 184 (2011)
[14] H. Zhang, Y. T. Mao, M. X. Ma, K. Ma, M. L. Wang, G. C. Tao. China Brewing 36, 177 (2017)
[15] G. F. Xie, X. S. Zhou, K. H. Wei, Q. L. Luo, Z. G. Liu. Journal of Food Science and biotechnology 36, 642 (2017)
[16] L. Wang, Q. F. Chen. Journal of Kaili University 34, 64 (2016)
[17] Y. Fu. Journal of Anhui Agri. Sci. 42, 1782 (2014)
[18] S. B. Liu, B. L. Yi, K. Li, X. J. Jiang. Chinese Wild Plant Resources 26, 58 (2007)
[19] J. Tian, L. Wang, Q. F. Chen. Journal of Henan Agri. Sci. 40, 109 (2011)
[20] W. Li, C. Chao, Y. T. Zhang, L. Yan, K. J. Mo. Food Science 29, 207 (2008)
[21] Z. K. Wang. Principles and techniques of plant physiological and biochemical experiments (Version 2) (Higher Education Press, Beijing, 2006)
[22] S. D. Bao. Soil agriculturalization analysis.: (China Agriculture Press, Beijing, 2000)
[23] L. X. Kuang, J. Y. Nie, Z. X. Li, Y. L. Wu, Z. Yan, Y. Cheng, D. K. Guan. Scientia Agricultura Sinica 49, 3993 (2016)
[24] R.Wang, R. Q. Xiong, Z. J. Zhang, P. Z. Chen, Q. P. Fan. Hubei Agricultural Sciences 54,184 (2015)
[25] B. Bi, G. X. Li, J. P. Shao, Z. H. Zhang. Journal of West China Forestry Science 44, 105 (2015)