Analysis on nutritional components of the fruits in three population of Sichuan *Pyracantha fortunaeana*

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Abstract. The fruits of wild *Pyracantha fortunaeana* were taken from Sichuan Mianyang, Ya'an Shimian and Hanyuan, and the main nutrients were determined by selecting the fruits with vermeil and orange-red. The results showed that the content of Vc (10.36~45.30mg/100gFW) in the fruit of *P. fortunaeana* was very rich, and the K content of mineral elements was 145.36~195.78mg/100g, the Ca content was 76.56~166.02mg/100g, and the Mg content was 6.94~16.29 mg/100g. Among them, the content of Cu, Fe, Mn and Zn which had health care effects were high, which were extremely valuable for development and utilization. In the comparison of the nutrient content of *P. fortunaeana* in the same population, the orange-red fruit had greater development potential than the vermeil fruit, while under the same fruit color and different populations, Mianyang's *P. fortunaeana* fruit was richer in nutrients. In general, Mianyang population was better than other two populations of *P. fortunaeana*, and the development prospect of Pyracantha fruit was quite good, which could be widely used in edible, medicinal and garden ecological greening.

1.Introduction

*Pyracantha* Roem is an evergreen wild shrub belonged to sub-family Maloidae of Rosaceae family in plant taxonomy, and there are 10 species of this genus. There are 7 species found in China, and 4 species are common. The most widely distributed and largest reserves are *P. fortunaeana*. *P. fortunaeana* is distributed in more than 10 provinces such as southeast, southwest and northwest of China \[1\] at an altitude of 500~2800m.

*P. fortunaeana* fruit has orange-yellow, vermeil or orange-red fruit, fruiting period from September to December \[2\]. *P. fortunaeana* fruit contains a variety of amino acids, soluble sugar, vitamins, mineral elements, fatty acids, protein, starch, pectin and dietary fiber. For example, the essential amino acids of the human body are as high as 43% of the total amino acids \[3\], have a high nutritional value. The fruit of *P. fortunaeana* can also be used as a medicine, and the *P. fortunaeana* fruit extract can also be used for skin care products. In addition, *P. fortunaeana* is also an important natural pigment \[4, 5\], pectin \[6\], processed food \[7\] and feed resources. *P. fortunaeana* is not only a plant with three effects of food, medicine and ornamental, but also has an important ecological value \[8\] because of its wide adaptability and strong ability to resist wind and sand fixation.

The fruits of wild *P. fortunaeana* in three areas of Mianyang, Hanyuan and Shimian, which were the same grade of maturity of the fruit of vermeil and orange-red *P. fortunaeana*, were used as the materials. The contents of the main nutrients in the fruit of the same fruit color of different populations and the different fruit color of the same population were determined and analyzed. Understand the effects of different growth conditions on the main nutrients of wild *P. fortunaeana* fruits and the changes of nutrient content of fruits in different fruit colors, and obtain the basic information of the
main nutrients of wild *P. fortunaeana* plants in Sichuan, in order to further protect the wild *P. fortunaeana* resources and follow-up effective development and utilization provide theoretical references.

2. Materials and Methods

2.1 Materials

From October to November 2017 in Youxian District, Mianyang City, Sichuan Province (802.9~542m, N:31°32'; E:104°41'~104°46'), Niaba Mountain, Hanyuan County, Ya'an City (1882~1885m, N:29°36'; E:102°37'), Caoke Township, Shimian County, Ya'an City (1342~2011m, N:29°04'~29°23'; E:102°00'~102°29'), the fruit collection of *P. fortunaeana* was carried out. Each sample was collected from 4-5 collection sites of each population, and 4-5 *P. fortunaeana* fruits with the same maturity were collected from each collection site. The fresh samples were immediately put into the ice box and sent back to the freezer for storage. The pulp of *P. fortunaeana* with the seeds removed were dried in an oven at 60 °C for 24-48 h, crushed and passed through a 60 mesh sieve in a dry box for use. Except for the fresh fruits selected by VC, all the other indexes were determined by dry powder. The composition of each sample was measured in three parallel ways.

2.2 Methods

Vitamin C content was determined by the 2, 6-dichloroindophenol method, and the method was specifically carried out by referring to D.M. Zhang [9]. The content of Ca, Mg, Fe, Ni, Mn, Cu and Zn was determined by atomic absorption spectrometry. The content of K and Na were determined by atomic emission spectrometry, and the content of Cr, Pb and Cd were determined by graphite furnace method. Total sugar was determined by an fluorenone sulfuric acid colorimetric method [10]. Protein content was determination by GB/T5009.3-2003 Kjeldahl distillation. Pectin content determined by calcium pectate method [11]. Cellulose content was determination by reference to GB/T5009.10-2003 method. Polyphenol content was determination by ferrous tartrate colorimetric method [12].

3. Results and Discussion

3.1 Basic nutrient content of fruit

3.1.1 Basic nutrients of different colors fruits of the same population

The basic nutrient composition of different color fruits of Mianyang population is shown in Table 1. The results showed that except for polyphenols, the content of each nutrient component of Mianyang population orange-red *P. fortunaeana* fruits was higher than that of vermeil fruits. The F value test showed that Vc, protein, total sugar and polyphenol were significantly different.

| Basic nutrients | Vermeil fruits | orange-red fruits | F value(*=significantly significant,**=extremely significant) |
|-----------------|----------------|------------------|-------------------------------------------------------------|
| Vc(mg/100g FW)  | 44.97          | 45.30            | 600.25*                                                     |
| Protein(%)      | 3.03           | 3.74             | 1890.37*                                                   |
| Total sugar(%)  | 4.83           | 5.59             | 248.72*                                                    |
| Cellulose(%)    | 3.63           | 4.18             | 82.50                                                      |
| Pectin(%)       | 2.15           | 2.42             | 68.34                                                      |
| Polyphenol(%)   | 1.52           | 1.28             | 863.00*                                                    |

The basic nutrient composition of different color fruits of Shimian population is shown in Table 2. Table 2 showed that the contents of other nutrients in orange-red fruits were higher than those in vermeil fruits except cellulose, protein and polyphenols. F test results showed that the difference in Vc and cellulose was extremely significant, and the difference in protein, total sugar and polyphenol was significant.
Table 2. The basic nutrient composition of different color fruits of Shimian population

| Basic nutrients       | Vermeil fruits | orange-red fruits | F value(*=significant,**=extremely significant) |
|-----------------------|---------------|-------------------|------------------------------------------------|
| Vc(mg/100g FW)        | 10.36         | 11.43             | 17173.49**                                      |
| Protein(%)            | 2.25          | 1.86              | 2281.50                                        |
| Total sugar(%)        | 4.85          | 5.86              | 3825.37*                                       |
| Cellulose(%)          | 5.60          | 3.27              | 40716.74**                                     |
| Pectin(%)             | 2.56          | 2.67              | 216.00                                         |
| Polyphenol(%)         | 2.10          | 1.08              | 853.00*                                        |

3.1.2 Basic nutrients of different populations of P. fortunaeana

Comparison of the basic nutritional components of 3 populations of vermeil P. fortunaeana in Mianyang and Ya'an Shimian and Hanyuan is shown in Table 3. The contents of protein and Vc in fruit of vermeil P. fortunaeana were decreasing gradually. The contents of other nutrients were the lowest in Hanyuan except cellulose and pectin, and the cellulose content(5.60%) in Shimian populations of P. fortunaeana was higher than the other 2 groups. The Vc content of the fruit of Miyang(44.79mg/100g FW) P. fortunaeana was the highest in the 3 populations, which was 4.3 times as high as that in Shimian population (10.36mg/100g FW), and 4.4 times the Vc content of the Hanyuan population (10.18mg/100g FW).

Table 3. Comparison of basic nutritional components of vermeil P. fortunaeana fruit in different populations

| Basic nutrients | Mianyang population | Shimian population | Hanyuan population |
|-----------------|---------------------|--------------------|--------------------|
| Vc(mg/100g FW)  | 44.97 aA            | 10.36 bB           | 10.18 bB           |
| Protein(%)      | 3.03 aA             | 2.25 bB            | 1.99 cC            |
| Total sugar(%)  | 4.83 aA             | 4.85 aA            | 4.58 bB            |
| Cellulose(%)    | 3.63 cC             | 5.60 aA            | 3.73 bB            |
| Pectin(%)       | 2.15 cC             | 2.56 aA            | 2.37 bB            |
| Polyphenol(%)   | 1.52 bB             | 2.10 aA            | 1.43 bB            |

The basic nutritional components of orange-red P. fortunaeana in 2 populations of Mianyang and Shimian are compared and analyzed in Table 4. The protein content of the orange-red P. fortunaeana fruit in Mianyang (3.74%)was 2 times as high as that in Shimian, and the content of Vc in Mianyang(45.30mg/100gFW) P. fortunaeana was the highest in the 3 populations, which was 3.9 times that of Shimian population (11.43mg/100gFW). F test showed that the contents of total sugar, pectin and polyphenols in the two populations were significantly different, and the differences in Vc, protein and cellulose content were extremely significant.

Table 4. Comparison of basic nutritional components of orange-red P. fortunaeana fruit in 2 populations of Mianyang and Shimian

| Basic nutrients | Mianyang population | Shimian population | F value(*=significant,**=extremely significant) |
|-----------------|---------------------|--------------------|------------------------------------------------|
| Vc(mg/100g FW)  | 45.30               | 11.43              | 36477506.92**                                   |
| Protein(%)      | 3.74                | 1.86               | 53016.00"                                      |
| Total sugar(%)  | 5.59                | 5.86               | 1093.49*                                       |
| Cellulose(%)    | 4.18                | 3.27               | 12421.50"                                      |
| Pectin(%)       | 2.42                | 2.67               | 937.49*                                        |
| Polyphenol(%)   | 1.28                | 1.08               | 600.00*                                        |

3.2 The content of mineral elements in fruit

3.2.1 Contents of mineral elements in P. fortunaeana fruit of different fruit color in the same population

According to table 5, the contents of Ca, Fe, K, Mg and Na in the mineral elements of P. fortunaeana fruits in different color of Mianyang were extremely significantly different, and Pb and Zn were
significantly different. The contents of Cd, Cr and Pb met the requirements of the "limit of pollutants in food" issued by the Ministry of health that Cd was lower than 0.05mg/100g, Cr was lower than 0.5mg/100g, Pb was lower than 1mg/100g. Two fruit colored fruits have their own valuable value to the human body. The content of Ca in orange-red fruit had reached 166.02mg/100g, while the Mg content of the vermeil fruit had reached 13.05mg/100g.

Table 5. Comparison of mineral elements contents in different fruit color of Mianyang population (mg/100g)

| Elements | Vermeil fruits | orange-red fruits | F value(*=significant,**=extremely significant) |
|----------|----------------|-------------------|-----------------------------------------------|
| Ca       | 76.56          | 166.02            | 30011593.71**                                 |
| Cd       | 0.13           | 0.12              | 0.60                                          |
| Cr       | 0.17           | 0.18              | 1.50                                          |
| Cu       | 0.15           | 0.17              | 1.20                                          |
| Fe       | 3.29           | 2.13              | 20184.00**                                    |
| K        | 170.53         | 195.78            | 1366205.37**                                  |
| Mg       | 13.05          | 8.84              | 265861.49**                                   |
| Mn       | 0.25           | 0.27              | 6.00                                          |
| Na       | 6.76           | 5.20              | 73008.00**                                    |
| Ni       | 0.12           | 0.11              | 1.50                                          |
| Pb       | 0.39           | 0.18              | 661.50*                                       |
| Zn       | 0.53           | 0.22              | 1441.50*                                      |

The mineral elements contents of *P. fortunaeana* fruit in different colors of Shimian populations were shown in Table 6. Two kinds of *P. fortunaeana* fruit mineral elements K, Ca, Mg content was very rich, Zn, Cu, Mn and other beneficial mineral elements were also higher. Among them, the contents of Ca, Fe, Mg and Na in vermeil *P. fortunaeana* were higher than those of orange-red fruit. The contents of Cd and Pb were significantly different, the differences in Cr content were not significant, and the contents of Cd, Pb and Cr were obviously lower than the national standard.

Table 6. Comparison of mineral elements contents in different fruit color of Shimian population (mg/100g)

| Elements | Vermeil fruits | orange-red fruits | F value(*=significant,**=extremely significant) |
|----------|----------------|-------------------|-----------------------------------------------|
| Ca       | 136.36         | 129.48            | 710016.04**                                   |
| Cd       | 0.32           | 0.19              | 253.50*                                       |
| Cr       | 0.28           | 0.35              | 73.50                                         |
| Cu       | 0.22           | 0.18              | 24.00                                         |
| Fe       | 3.74           | 2.58              | 20184.00**                                    |
| K        | 149.92         | 145.36            | 311903.99**                                   |
| Mg       | 16.29          | 6.94              | 1311337.50**                                  |
| Mn       | 0.44           | 0.85              | 2521.50*                                      |
| Na       | 4.25           | 2.36              | 53581.50*                                     |
| Ni       | 0.51           | 0.44              | 73.50                                         |
| Pb       | 0.69           | 0.24              | 3037.50*                                      |
| Zn       | 0.28           | 0.22              | 54.00                                         |

3.2.2 Contents of mineral elements in *P. fortunaeana* fruit in different population

The contents of mineral elements in vermeil *P. fortunaeana* fruits from 3 populations of Mianyang, Shimian and Hanyuan are shown in Table 7. The contents of K and Na were the highest in Mianyang population, while the contents of Ca, Fe, Mg, Mn and Pb in Shimian populations were higher than those in other 2 populations.

Table 7. Comparison of mineral elements contents in different populations of vermeil *P. fortunaeana* fruits (mg/100g)

| Elements | Mianyang population | Shimian population | Hanyuan population |
|----------|---------------------|--------------------|--------------------|
| Ca       | 76.56 bB            | 136.36 aA          | 51.09 cC           |
| Cd       | 0.13 cC             | 0.32 aA            | 0.2 bB             |
The contents of mineral elements in orange-red fruits from 2 populations of Mianyang and Shimian are shown in Table 8. Except for Pb, Cr and Mn, the content of mineral elements in all the mineral elements in Mianyang was higher or equal to that of Shimian. It shows that Mianyang’s orange-red *P. fortunaeana* fruit was more beneficial to human mineral elements.

Table 8. Comparison of mineral elements contents in different populations of orange-red *P. fortunaeana* fruits (mg/100g)

| Elements | Mianyang population | Shimian population | F value(*=significant,**=extremely significant) |
|----------|---------------------|--------------------|------------------------------------------------|
| Ca       | 166.02              | 129.48             | 20027574.51**                                   |
| Cd       | 0.12                | 0.19               | 73.58                                          |
| Cr       | 0.18                | 0.35               | 433.5*                                         |
| Cu       | 0.17                | 0.18               | 1.5                                            |
| Fe       | 2.13                | 2.58               | 3037.5*                                        |
| K        | 195.78              | 145.36             | 38132649.73**                                  |
| Mg       | 8.84                | 6.94               | 54150.00**                                     |
| Mn       | 0.27                | 0.85               | 5046.00*                                       |
| Na       | 5.20                | 2.36               | 241968.00**                                    |
| Ni       | 0.11                | 0.44               | 1633.5*                                        |
| Pb       | 0.18                | 0.24               | 1633.5*                                        |
| Zn       | 0.53                | 0.28               | 0                                              |

4. Conclusions

The results of this experiment indicated that the 3 populations of *P. fortunaeana* in Mianyang, Shimian and Hanyuan had complete nutrient composition, rich in Vc and the content of macro mineral elements Ca, Mg and K, and Cu, Fe, Mn, Zn, etc. in trace mineral elements were high, which can meet the basic needs of the human body. The contents of Cd, Cr and Pb were significantly low.

The comparison results of the basic nutrients of different fruit colors in the same population showed that the content of the orange-red fruit was higher than vermeil fruit. The same fruit color of different populations showed that the basic nutrient content of the fruit of Mianyang population was higher. In the three populations, the Vc content was 10.36~45.30 mg/100 g, which was higher than that of S.Z. Liu [13] which was 9.84~13.49 mg/100 g in Xiangxi, which can meet the needs of the human body. The cellulose content was 3.27~5.60%, which was slightly higher than the cellulose content of 3.51% in Guixi and Qinling [10, 14], was lower than the content of 8.15% in Xiangxi [14]. The results of S.Z. Liu [14] showed that the protein and soluble sugar content of the fruit under the same population was lower in November than in March of the following year, indicating that the content of protein and soluble sugar in the fruit was proportional to the maturity. The experimental material was taken from October to November, and the protein content (1.86~3.74%) was low, which was lower than 4.14% of M.J. Liu [15], 5.32~7.13% of Xiangxi and 7.55% of Guixi reported by Z.L.Huang. The total sugar content (4.83~5.86%) was lower than that of Guixi and Qinling (8.24~11.68%) measured by Z.L. Huang. The pectin content was 2.15~2.67%, which was about twice as high as 1.32~1.1% measured by R.F. Deng [14] and 1.32% measured by X.J. Wang [16].
addition, a higher content of polyphenols has an antioxidant function and can be developed and utilized in health foods.

Comparing the content of mineral elements of different fruit color in the same population, the results showed that the contents of Ca, Mg and K of the two fruit colors were all high, which could meet the needs of the human body. Comparing different populations of *P. fortunaeana* with the same fruit color, the K content of vermeil fruit was the highest in Mianyang population, and the content of Ca and Mg was the highest in Shimian. In addition, the Zn content in Mianyang was the highest. The contents of K, Ca and Mg of orange-red fruit in Mianyang were higher than those in Shimian population, and the contents of Fe, Zn and Cu were equivalent.

In conclusion, *P. fortunaeana* fruit of Mianyang population had the highest nutrient content among the three populations, and the orange-red *P. fortunaeana* fruit had more development value than the vermeil fruit.

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