Two Types of New Natural Materials for Fruit Vinegar in *Prunus* Plants

Han Zhao¹, Xiaoxing Zhou², Ying Luo¹, Yanli Huang³, Tana Wuyun¹, Fangdong Li¹ and Gaopu Zhu^{1,*}

¹Non-timber Forestry Research and Development Center, Chinese Academy of Forestry, and China Paulownia Research and Development Center, Zhengzhou 450003, China

²Administrative Office, Chinese Academy of Forestry, Beijing 100091, China

³Henan Province Institute of Landscape Planning and Design Company Limited, Zhengzhou 450045, China

Corresponding Email: poog502@163.com

Abstract. To increase *Prunus armeniaca* × *P. sibirica* and *P. domestica* × *P. armeniaca* added value; three natural fruit vinegars were designed. The results showed the nutrition of *Prunus domestica* × *P. armeniaca* cultivar Fengweimeigui vinegar (T1) had high minerals and microelements, especially the Ca and Mg reached to the 150.00mg/L, 85.40 mg/L, respectively; the vinegar of *Prunus armeniaca* × *P. sibirica* cultivar Zhongren No.1 (T2) not only have rich Na (2800.00 mg/L), P (123.00 mg/L), but also have plentiful amino acid that content reached to 200.08 mg/L. However, the mixture vinegar (T3) with pulps from *Prunus domestica* × *P. armeniaca* and *Prunus armeniaca* × *P. sibirica* had the middle nutrient contents, but the property was balanced. We therefore conclude that solid fermentation is a suitable method to preserve nutrients and value-added for *Prunus* plants fruit, and three types vinegars are suitable for different age people, and the difference nutrient contents and typical characteristic indicate that three vinegars are competitive products in market.

1 Introduction

In general, for fruits, there are nourishing but short shelf life, for nuts, the pulps used discarded. For examples, fruits *Prunus domestica* × *P. armeniaca* cultivar Fengweimeigui is rich nutrient [1-2], but the shelf life only lasting 5-7 d; the pulps of nuts *Prunus armeniaca* × *P. sibirica* cultivar Zhongren No.1 have organic acid, Ca, K, Fe and Se [3] but the pulps is inedible because of sour and bitter. With the food structure development, human interest in the health benefits of functional foods is increasingly. Meanwhile, the farmers hope to add agricultural raw materials value. The both of them expectations are consistent and suitable for future economic trend. For these reasons, we developed the new, functional and special products will help stronger the body and economic recovery. Microbial fermentation have been efficient biocatalysts to make the functional foods, this is a suitable method to solve above problems [3-7]. However, fruits vinegar is not only used as a seasoning but also play important roles, such as antioxidant, digestive, lipid lowering effects, and regulations of blood-pressure, these results in the vinegar can resist or assist cure the imbalanced fat or excess energy intake harm [8-10]. In this paper, based on solid fermentation method to produce fruit vinegar and improve residuum utilization ratio have been explored.

2 Materials and methods

2.1 Sample collection

Fully ripened and healthy (without diseases and insect pests) *Prunus domestica* × *P. armeniaca* cultivar Fengweimeigui and *Prunus armeniaca* × *P. sibirica* cultivar Zhongren No.1 fruits, whether big or small, were selected from garden of the Experimental Site of Non-timber Forestry Research and Development Center, Chinese Academy of Forestry, Yuanyang County, China, during June 2013 (day temperature 28±2℃, night temperature 25±2℃) (Figure 1). The three treatments were designed including T1, T2 and T3. The T1 and T2 are the pure *Prunus armeniaca* × *P. sibirica* cultivar Zhongren No.1, *Prunus domestica* × *P. armeniaca* cultivar Fengweimeigui, and the T3 is the mixture between *Prunus armeniaca* × *P. sibirica* cultivar Zhongren No.1 and *Prunus domestica* × *P. armeniaca* cultivar Fengweimeigui with weight is 1:1 (w/w) ratio because the pulps carbohydrate of *Prunus armeniaca* × *P. sibirica* cultivar Zhongren No.1 was lower, but the *Prunus domestica* × *P. armeniaca* cultivar Fengweimeigui was higher.

2.2 Fermentation process

The idea was solid fermentation. The total included seven stages (Figure 1). First, fruits were cleaned and dried. Second, the fruits were put a closed room and use ultraviolet disinfection with 8 h~12 h. Third, the fruits were crushed with machine and became pulp, meanwhile, the seeds was separated with pulp. Fourth, alcoholic fermentation stage including four steps (Figure 1). (a) Based on the preliminary experiment, the weight of saccharose with 2:5 (w/w) was added. (b) The *Saccharomyces cerevisiae* was added and the ratio is 0.2 g/100ml. (c) The pulps were stirred every 6 h interval until the saccharose were melted (about 3 times). (d) A stationary culture was conducted for 3 days at 35 °C in constant-temperature culture medium. The fifth stage, static acetic acid fermentation with three steps. (a) Acetic bacteria were added and the content reached to 1.0mg/100ml (w/v). (b) Fermentation at higher temperature at 33 ± 2℃ last 5 days. (c) Fermentation at constant lower temperature at 25±2℃ last 45 days. After fermentation, the filtration and sterilization was operation. Finally, the bottles were filled with vinegars. The procedure for making fruits vinegars is list in figure 1.

Fig. 1. Procedure for making fruit vinegars.

2.3 Composition and content analysis

The composition and content of amino acid, minerals and microelements, juice pH value and biochemical constituents (total sugar, total fat, total protein and ethanol) were analyzed based on GB/T 5009.124-2003 (China), GB/T 14924.12-2001 (China) and Ref. (Amerine et al., 1980; Zhu et al. 2015).

2.4 Data analysis

The experimental layout was a complete randomized plot with three replicates of five sampled per treatment. The data collect with Microsoft Office Excel 2013 software and the statistic analysis of variance analysis use Duncan's multiple range tests with DPS v6.05 software. Significance was accepted at $p\leq0.05$.

3 Results and analysis

3.1 The content different of major components

Table 1. The proximate composition of main nutrition apricot vinegars (mg/L).

Treat ment	Protein	Fat	Sugar	Fe	Mg	Na	Zn	Ca	P	pH
T1	0.12±0.02aA	0.01±0.00a	<u>138.00±1.70aA</u>	<u>3.30±0.16aA</u>	<u>85.40±2.90aA</u>	2600.00±14.84bB	<u>1.10±0.05aA</u>	<u>150.00±3.40aA</u>	63.70±2.73aA	<u>3.25±0.02a</u>
T2	<u>0.52±0.02cC</u>	0.02±0.01a	76.00±1.90cC	—	50.40±1.41cC	<u>2800.00±5.21aA</u>	0.64±0.04cB	108.00±2.75cB	<u>123.00±2.59bB</u>	3.14±0.05a
T3	0.18±0.01bB	0.02±0.00a	108.00±2.30bB	2.60±0.17bB	78.40±1.98bB	2600.00±6.08bB	0.74±0.06bB	143.00±2.43bA	68.20±2.56bB	3.19±0.01a

Note: values are means ± SD (n=5). Means in columns without letters in common differ significantly ($p<0.05$). ND = not detected.

In this study, all the treatments, the contents of protein and fat were lower, but the sugars 138.00 mg/L, 76.00 mg/L and 108.00 mg/L, respectively were higher and the different reached to the significantly (Table 1).

Table 2. The proximate content of essential amino acid in Fengweimeigui wine (mg/ L).

Treatm ent	Lys	Trp	Phe	Met	Thr	Ile	Leu	Val	Total
T1	1.8±0.04bB	—	1.84±0.03bB	0.16±0.01a	1.11±0.03b	0.82±0.03bB	0.65±0.05cC	1.86±0.09bB	8.24±0.78bB
T2	2.58±0.05aA	—	2.26±0.07aA	0.17±0.01a	—	1.78±0.05aA	2.08±0.05aA	3.36±0.06aA	12.23±0.55 aA
T3	1.52±0.03cC	—	1.56±0.06cC	0.16±0.00a	—	0.77±0.04bB	0.81±0.03bB	1.72±0.05cB	6.54±0.43cC

Note: values are means ± SD (n=5). Means in columns without letters in common differ significantly ($P<0.05$). ND = not detected.

Table 3. The proximate content of non-essential amino acid in vinegars (mg/ L).

Trea tmen t	Asp	Ser	Gln	Gly	Ala	Cys	Tyr	His	Arg	Pro	Total
T1	1.32±0.05cC	1.83±0.06cC	1.10±0.06bB	0.36±0.04cC	4.40±0.40cC	1.03±0.0a	0.70±0.00bB	0.62±0.00bB	0.34±0.00bB	1.31±0.02cC	13.01±0.09cC
T2	44.56±3.51aA	9.48±0.09aA	4.54±0.57aA	1.94±0.08aA	29.64±1.10aA	1.14±0.0a	1.24±0.05aA	1.60±0.04aA	0.65±0.03aA	93.06±3.95aA	187.85±6.77aA

T3	10.02±0.08bB	2.61±0.13bB	1.18±0.04bB	0.56±0.06bB	7.12±0.10bB	1.02±0.01a	0.78±0.02bB	0.62±0.01bB	0.32±0.00bB	17.52±1.55bB	41.75±2.33bB
----	--------------	-------------	-------------	-------------	-------------	------------	-------------	-------------	-------------	--------------	--------------

Note: values are means ± SD (n=5). Means in columns without letters in common differ significantly (P<0.05). ND = not detected.

In minerals and microelements part, T1 has the highest contents Fe (3.30 mg/L), Mg (85.40 mg/L), Zn (1.10 mg/L) and Ca (150.00 mg/L) shown that the vinegar included abundant mineral materials, and the characteristic constituent is the highest Mg and Ca contents (Table 1). Treatment T2 has the highest contents protein (0.52 mg/L), 2800.00 mg/L Na and 123.00 mg/L P, so the characteristic constituent are Na and P contents that these was difference than T1 (Table 1). However, Treatment T3 falls in between (Table 1).

3.2 The content different of essential amino acid

The total content of essential amino acid was lower among three treatments, and the amino acid Trp was not found in this paper (Table 2). The total content of essential amino acid from highest to lowest at different treatments was T2, T3 and T1. Treatment T1, have the only amino acid Thr (1.11 mg/L) and lowest total essential amino acid. Treatment T2 have the highest total essential amino acid (12.23 mg/L), and the components of amino acid Lys (2.58 mg/L), Phe (2.26 mg/L), Ile (1.78 mg/L), Leu (2.08 mg/L) and Val (3.36 mg/L) also has highest and the difference reached very significant Table 2). The T3 falls in the between except amino acid Leu and total essential amino acid (Table 2).

3.3 The content different of non-essential amino acid

The content tendency of total content of non-essential amino acid shown the same rule with essential amino acid, the contents from highest to lowest was T2>T3>T1 (Table 3), but the every constituents were significant difference. Treatment T2, not only have the highest total content but also have the highest constituents (44.56 mg/L Asp, 9.48 mg/L Ser, 4.54 mg/L Gln, 29.64 mg/L Ala, 1.24 mg/L Tyr and 0.65 mg/L Arg), especially in the content of amino acid Pro that reached to the 93.06 mg/L, the higher over 71, 5.3 times, respectively. And the next is the Asp, the difference reached to the 33.8, 4.5 times, respectively. So, the contents of amino acid Pro and Asp were the typical compositions in T2.

4 Conclusion and discussion

We have developed three new vinegar types. Vinegar prepared from *Prunus armeniaca* × *P. sibirica* cultivar Zhongren No.1 (T1) fruit pulp is a novel beverage rich minerals and microelements, especially in contents of Fe, Mg, Zn and Ca, so we putative that the content minerals Ca is the typical characteristic. Vinegar prepared from *Prunus domestica* × *P. armeniaca* cultivar Fengweimeigui (T2) fruit pule is a novel beverage rich amino acid (200.08 mg/L), especially in non-essential amino acid (187.85 mg/L), and this is the typical characteristic. But treatment T3, the contents of minerals, microelements and amino acids fall in between T1 and T2, the characteristic is mild and the nutrient is balanced.

In this study, the vinegars of proteins, fats and non-essential amino acid were lower than kernel-apricot vinegar, but the essential amino acid was significant higher, especially amino acid Lys, Phe, Met, Leu and Val, meanwhile, the amino acid Thr, Ile, Gln and Arg were only found in apricot vinegars [3], the results showed that the fermenting method was importance factor for nutritional ingredient separation from fruits pulp. Compared with apple vinegar, the essential amino acid was significant lower, but non-essential amino acid including the Ser, Ala and Pro were higher [11], especially the amino acid Pro (Table 3, 93.06 mg/L) was the over 180 times than apple vinegar (0.50 mg/L). Compared with persimmon vinegar, the amino acid was significant higher than persimmon vinegar [12], and the amino acid Cys was not found.

Acknowledgments

This work was supported by the Program of Research and Demonstration of Key Technology of High-efficient Production in Kernel-apricot and Almond under Grant No. 2013BAD14B02.

References

1. L.L. Lei, Study on the reproductive biology of *Prunus domestica* × *armeniaca* ‘fengweimeigui’, M.S. Thesis, Chinese Academy of Forestry, Beijing, China (2013).
2. G.P. Zhu, H. Zhao, X.X. Zhou, M.P. Liu, Y.L. Huang, T.N. Wuyun, F.D. Li, *Prunus domestica* × *P. armeniaca* cultivar Fengweimeigui: A New Natural Material for Fruit Wine, Adv. J. Food Sci. Technol. **10**(4), 277-280 (2016).
3. Y. Fan, Studies on the brewing techniques of apricot for kernel flesh vinegar and its health-care function, M.S. Thesis, Northwest A&F University, Yangling, China (2008).
4. S.M. Araújo, C.F. Silva, J.J.S. Moreira, N. Narain, R.R. Souza, Biotechnological process for obtaining new fermented products from cashew apple fruit by *Saccharomyces cerevisiae* strains, J. Ind. Microbiol. Biotechnol. **38**, 1161–1169 (2011).
5. T.S. Suryanarayanan, N. Thirunavukkarasu, M.B. Govindarajulu, V. Gopalan, Fungal endophytes: an untapped source of biocatalysts, Fungal Diversity **54**, 19–30 (2012).
6. Y. Jiang, S. Lin, L. Zhang, P. Yu, Upgrading the Fermentation Process of Zhejiang Rosy Vinegar by Purebred Microorganisms, Advances in Microbiology **3**, 297-301 (2013).
7. Z. Nie, Y. Zheng, H. Du, S. Xie, M. Wang, Dynamics and diversity of microbial community succession in traditional fermentation of Shanxi aged vinegar, Food Microbiology **47**, 62-68 (2015).
8. J. Qui, C. Ren, J. Fan, Z. Li, Antioxidant activities of aged oat vinegar in vitro and in mouse serum and liver, Journal of the science and food agriculture **90**, 1951-1958 (2010).
9. World Health Organization, Obesity and overweight, Available from <http://www.who.int/mediacentre/factsheets/fs311/en/> (2015).
10. C.H. Chou, C.W. Liu, D.J. Yang, Y.H. Samuel, Y.C. Wu, Chen, Amino acid, mineral, and polyphenolic profiles of black vinegar and its lipid lowering and antioxidant effects in vivo, Food Chemistry **168**, 63-69 (2015).
11. H.T. Zhang, X.L. Liu, Development and amino acid analysis of apple cider vinegar drink. Journal of Shandong Institute of Light Industry **24**(1), 41-44. (2010) (in Chinese).
12. X.L. Luo, Y. Yang, S.M. Lu, C.L. Zhang, The impact of fermentation modes on sensory and nutritional quality of persimmon vinegar, Food Science, Available from <http://www.cnki.net/kcms/detail/11.2206.TS.20160108.1651.052.html> (2016) (in Chinese) (to be published online).