Effect of Dynamic High-Pressure Microfluidization Processing on the Nutritional Components and Antioxidant Activity of Chinese Jujube Juice

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***Abstract*—In this study, the effect of Dynamic High-Pressure Microfluidization (DHPM) on the nutritional components and antioxidant activity of Chinese jujube juice. The effect of DHPM pressure and pass number were also assessed. Juice was passed through DHPM at 40-200 MPa for one or three passes. Total phenolic, Vitamin C, soluble protein, polysaccharide, titratable acide content and antioxidant activity of the samples were evaluated through DHPM treatment. Results indicated that DHPM treatment exerted insignificant effect on all nutritional parameters of juice expect for polysaccharide and titratable acide, which demonstrated adverse change. In comparison of raw and DHPM treatment, these two showed no significant difference on total phenolic content and vitamin C content overall. Regarding to soluble protein, it was increased with pressure and pass number of DHPM, and remarkable enhancement was observed in DHPM. In case of polysaccharide, results of DHPM at 40-200 MPa were noticeably lower than control, except 80 MPa for three passes. Besides, DHPM showed remarkable reduction in titratable acid as compared to control. In addition, the • OH radical scavenging capacity could be maintained by DHPM, and the ABTS+ assay was enhanced obviously at 40-120 MPa. While, according to the DPPH assay, the juice antioxidant capacity has not noticeably altered by DHPM processing. In conclusion, DHPM treatment was beneficial to preserve the quality of Chinese jujube juice, suggesting DHPM technology is a potential alternative to conventional for application in Chinese jujube juice.**

***Index Terms*—Chinese jujube juice, dynamic high-pressure microfluidization, nutritional components, antioxidant activity**

I. Introduction

Chinese jujube (Ziziphus jujuba Mill.) is the fruit of tree belonging to the Rhamnaceae family and is widespread in Asia and southern Europe. It is native to China and has been cultivated for 4000 years [1], [2]. Chinese jujube is very popular with consumers. In recent years, the output of jujube in China has increased and accounted for a high proportion of the total production in the world [3]. The processing of jujube into juice not only can make the jujube products diversified, but also is an effective way to improve the economic efficiency.

Recently DHPM processes (high or ultrahigh pressure homogenization (HPH or UHPH)) are receiving a growing amount of interest. DHPM is an emerging and promising technique for continuous production of fluid foods, which involves in the mechanical effects of powerful shear, high frequency vibration, high velocity impact, instantaneous pressure drop and cavity effect [4]. The solution is pressurized and passed through two geometrically fixed microchannels at high velocity [5]. Compared with conventional high-pressure device, this technique can achieve the similar effects to the conventional valve homogenizer with much lower pressure, whereby the energy consumption is greatly reduced.

The overall objective of this investigation was to the effect of DHPM on the nutritional components and antioxidant activity of Chinese jujube juice. Of specific interest was the influence of different parameters of DHPM, including pressure and number of microfluidization pass, on the content antioxidant activity of total polyphenols, vitamin C, polysaccharide, soluble proteins and titratable acid, DPPH, ABTS+, and • OH.

II. Materials and Methods

A. Preparation of Jujube Juice

The preparation of jujube juice was carried out according to the previous method of with minor modifications [6]. Clean and cored Chinese jujube (500 g) was mixed with 2.5 L distilled water and pulped with beater. Subsequently, pectinase (1800 mg/L) was added into the pulp and the resulting mixture was kept in water bath (40 ℃) for 4 h. Afterwards, the jujube pulp was passed through colloid grinder for three times (20 μm) and through a filter press to obtain raw jujube juice. The sample was immediately used for further study.

B. DHPM Treatment

Jujube juice was passed through DHPM for one pass or three passes at 40 MPa, 80 MPa, 120 MPa, 160 MPa and

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200 MPa. Juice without any homogenization treatment was set as control. Three replicates were used for all experiments.

C. Total Phenolic Content (TPC) Determination

TPC determination was carried out with Folin－Ciocalteau method [7].

D. Vitamin C

The content of Vitamin C (Vc) was measured with spectrophotometric method as previously described by Degl'Innocenti, Guidi, Pardossi, and Tognoni [8].

E. Soluble Protein Content Determination

Coomassie Brilliant Blue method was employed to detect soluble protein content in jujube juice [9].

F. Polysaccharide Content

The content of polysaccharide was determined by phenol-sulfuric acid method according to Cuesta, Suarez, Bessio, Ferreira, and Massaldi [10] with some modifications.

G. Titratable Acid

Titratable acid in jujube juice was determined by neutralising all the titratable protons with 0.1 mol/L NaOH to a fixed pH (8.1) [11].

H. Antioxidant Capacity Determination

ABTS+, method described by Rea R [12], using a spectrophotometer; DPPH, method described by Wang H [13], with a little slight modifications; • OH, method carried out by Fan, Y.N [14].

III. RESULTS AND DISCUSSION

A. Total Phenolic Content (TPC)

According to the results shown in Fig. 1, TPC of control was determined as 0.873 mg/ml, where no significant difference was observed between all samples of DHPM treatment ($p>0.05$). It can be seen that TPC appeared to be comparatively resistant to the impact of processing, DHPM treatment did not affect TPC of Chinese jujube juice significantly.

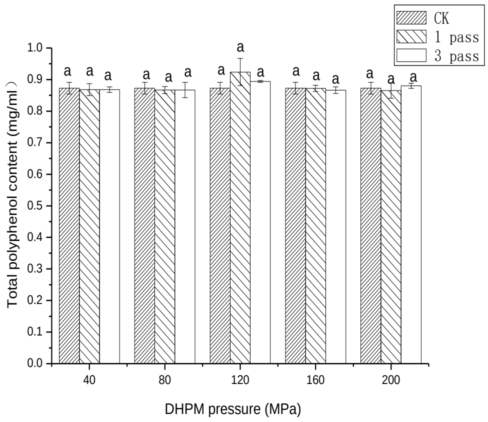

Figure 1. Total polyphenol content of Chinese jujube juice with different treatment, including untreated (dark shadow column), DHPM treated at 40 MPa, 80 MPa, 120 MPa, 160 MPa and 200 MPa for 1 (light shadow column) and 3 passes (colorless column).

B. Vitamin C Content

Effect of DHPM treated with different pressure and different times on Vc content of Chinese jujube juice were shown in Fig. 2. The values of control (0.133 mg/ml) and DHPM treatment, except for the one processed at 120 MPa for one pass, which were determined, and no remarkable change was observed. Meanwhile, DHPM treated for three passes samples at each pressure revealed lower Vc content than those treated for one pass, except for 120MPa. In the Process of DHPM treatment, samples were generated heat by the increase of pressure treatment, which made temperature of the samples were on the increase. Additionally, part of the water was evaporated, so Vc could be caused the change of the concentration. Ascorbic acid is an unstable compound, thus the milder the processing, the higher the ascorbic acid retention in juices [15].

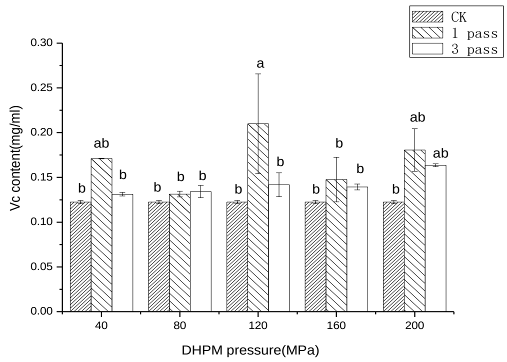

Figure 2. Vc content of Chinese jujube juice with different treatment, including untreated (dark shadow column), DHPM treated at 40 MPa, 80 MPa, 120 MPa, 160 MPa and 200 MPa for 1 (light shadow column) and 3 passes (colorless column).

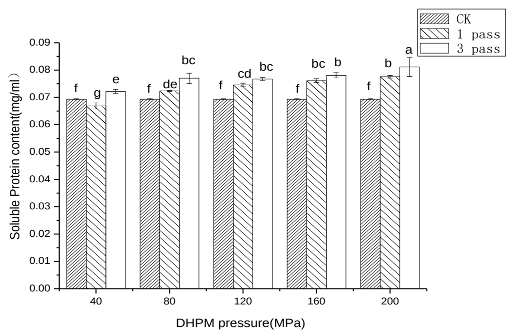

Figure 3. Soluble protein content of Chinese jujube juice with different treatment, including untreated (dark shadow column), DHPM treated at 40 MPa, 80 MPa, 120 MPa, 160 MPa and 200 MPa for 1 (light shadow column) and 3 passes (colorless column).

C. Soluble Protein Content (SPC)

As shown in Fig. 3, after passing through DHPM, the SPC increased with pressure and pass number in general. The result obtained at 40 MPa for one pass was comparable to that of control, but significantly lower than that of control samples. However, no significant difference was observed DHPM for three treated samples at 80-160 MPa. With the increase of pressure and pass number, all assayed samples treated with DHPM demonstrated noticeable enhancement in SPC compared with control samples. As is known in the literature, the force generated by DHPM may disrupt the cellular walls, allowing an accelerated mass transfer and enhanced solvent penetration into the cells [16]. In addition to the reason, we accept the possibility that the modification of protein structure and properties achieved by DHPM may also be a key factor leading to increased SPC.

D. Polysaccharide Content (PC)

Effect of DHPM treated with different pressure and different times on PC of Chinese jujube juice were shown in Fig. 4. According to ANOV results, no significant difference was observed DHPM treatment at 40-120 MPa for one or three passes, PC were comparable to that of control, while remarkable reduction was found at 160 and 200 MPa for one or three passes. Interestingly, adverse relationship was observed between raw and DHPM processed samples, where the former ones demonstrated noticeable improvement at 40-120 MPa, while insignificant difference was found at 160 and 200 MPa for both one and three passes. PC of DHPM treated at 160 MPa and 200 MPa were significantly decreased by approximately 32.1%, suggesting that DHPM at relatively higher pressure treatment caused adverse effect on PC of Chinese jujube juice. This was in good agreement with the report of Yang, Jiang, Wang, Zhao, and Sun [17], who applied high pressure to treat longan fruit pericarp.

E. Titratable acid Content (TAC)

Effect of DHPM treated with different pressure and different times on TAC of Chinese jujube juice were shown in Fig. 5. ANOV results showed that all tested DHPM samples except for that treated at 40 MPa for one pass exhibited remarkable reduction as compared to control samples, which were determined as 0.236%. These results indicated that DHPM treatment could result in reduction of TAC of Chinese jujube juice. However, the lowest TAC of 0.206% was found at 160 MPa for one pass, which was only reduced by 0.03% as compared with control (0.236%). In previous studies, Ma *et al* [18] reported that ultra high pressure might cause the enhancement of organic acid in rice wine by promoting hydrolysis and exchange of esters, or the oxidation of aldehydes and alcohols, while the reduction of some organic acid was possibly attributed to the esterification occurred between organic acids and alcohols.

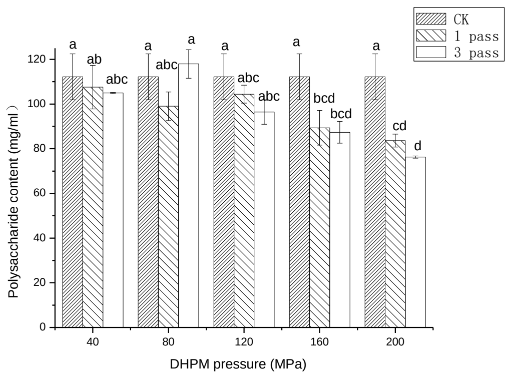

Figure 4. Polysaccharide content of Chinese jujube juice with different treatment, including untreated (dark shadow column), DHPM treated at 40 MPa, 80 MPa, 120 MPa, 160 MPa and 200 MPa for 1 (light shadow column) and 3 passes (colorless column).

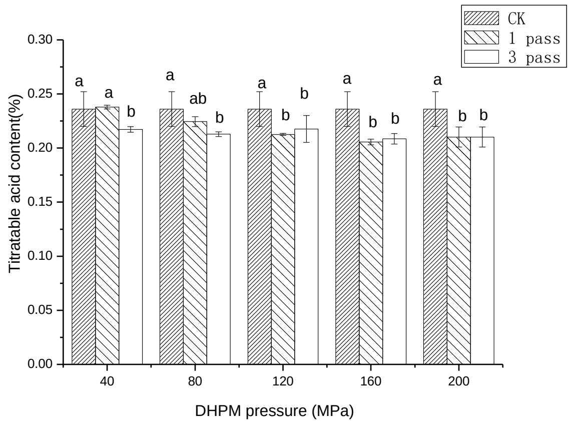

Figure 5. Titratable acid content of Chinese jujube juice with different treatment, including untreated (dark shadow column), DHPM treated at 40 MPa, 80 MPa, 120 MPa, 160 MPa and 200 MPa for 1 (light shadow column) and 3 passes (colorless column).

F. Relationship Among Total Phenolic,Vc and the Antioxidant Capacity

Effect of DHPM treated with different pressure and different times on antioxidant capacity, total polyphenol and Vc content of Chinese jujube juice were shown in Fig. 6. As a result, the index was concluded that DHPM treatment did not alter the antioxidant activity of the concentrate significantly, which showed a similar behavior with TPC and Vc of Chinese jujube juice. Phenolic compounds exhibit strong antioxidant activity, they have been shown in many studies to contribute significantly to the total antioxidant capacity. And also, there have been strong correlations between total phenolics and antioxidant capacity [19]. Additionally, Pearson correlation coefficient between TPC and ABTS+ radical scavenging capacity for Chinese jujube juice was found as 0.629 ($p < 0.05$) which was consistent with the published literature. Positive correlation between DPPH and ABTS+ was also found (0.641, $P<0.05$).

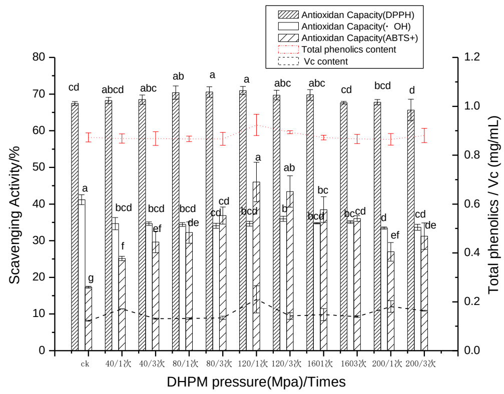

Figure 6. Antioxidant capacity ,total polyphenol and Vc content of Chinese jujube juice by DHPM with different treatment at three antioxidant indices, including DPPH (dark shadow column),· OH (colorless column), ABTS+ (light shadow column) .

IV. CONCLUSION

In order to study the influence of DHPM on the quality of Chinese jujube juice. The parameters of control and DHPM treated samples were determined. Results of this study allow one to conclude that samples were well characterized in terms of their sensory properties, demonstrating that DHPM was maintained or increased, the TPC, SPC, Vc and antioxidant capacity of Chinese jujube juice . DHPM treatment does not disturb the nutritional components except for the polysaccharide and TAC in the juice. Relatively high correlation between TPC and antioxidant capacity of the processed samples was detected. In regard to SPC, it was increased with pressure and pass number of DHPM, and results were remarkably higher than control. However, DHPM gave noticeable fall to polysaccharide as compared to raw samples. In case of TAC, it was remarkably reduced by DHPM when pressure was higher than 40 MPa. This suggests that DHPM treatment was beneficial to keep or enhance the quality of Chinese jujube juice. In conclusion, DHPM technology is a potential alternative to conventional high-pressure treatment for application in Chinese jujube juice.

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