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Qualities of Watermelon Juice during Shelf-life

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Abstract. The watermelon juice was treated by the ultra-high temperature and pasteurization, respectively. The quality and aroma of the pasteurized juice were evaluated during the storage at 37 ℃ for 6 d. The pasteurization was effective to maintain the total microbial counts of the watermelon juice within the limits for 6 d. Altogether 30 volatile compounds were identified in the unpasteurized juice with the aldehyde (70.6 %) as the main component. The typical volatiles of the ultra-high temperature were reduced from 52.1 % to 29.4 % during the storage.

Introduction

Watermelon juice is sensitive to the heat, oxygen, light, ion, and etc. [1-4]. Various processing methods such as the high pressure treatment gives less adverse effects on aroma and color of the watermelon juice [2, 3]; the high pressure carbon dioxide treatment holds the original properties by inactivating the polyphenoloxidase, peroxidase, and pectin methylesterase [5]; the pulsed electric field treatment holds the ((*Z*)-6-nonenal, 1-nonanol and (*Z*)-3-nonen-1-ol) content of the watermelon juice for 21 d [1] and maintains the antioxidant capacity [6]respectively. However, the mentioned techniques were all involved in intermittent production with the high running cost and limited production capacity.

Similarly, Ultra-high temperature (UHT) treatment inactivates spoiling micro-organisms [7], enhances the stability of the orange juice during the storage at 10 ℃ [7], and maintains the phenolics content of apricot nectars [8]. However, the qualities of the watermelon juice pasteurized by UHT had not been evaluated during the storage.

Therefore, the aim of the present study is to evaluate the effectiveness of UHT and Pasteurization on the qualities and aroma of the juice watermelon juice was stored at 37 ℃ for 1 week.

Material and Methods

Processing of the Watermelon Juice

Mature watermelon (*Citrullus lanatus* var. Jingxin No.3) was purchased from a local fruit market. The fruits were round with regular stripes and weighted about 3~4 kg per fruit. The flesh of the fruits was red with a soluble solid content of 11.5~13.5 % (SSC

was measured using a refractometer (PAL-α, ATAGO, Japan) calibrated with distilled water).

The fruits were peeled and squeezed in a juicer (make: Philips) after stored at 4 ℃ for 24 h (HR1861, Philips Co. Beijing, China). The juice was mixed with complex food additive including arboxymethylcellulose sodium, ascorbic acid, xanthan gum, ethylene diamine tetraacetic acid, carminum, sodium pyrophosphate and etc [9]. The mixture was fully stirred and adjusted to the pH 4.1 with the citric acid (1mol/L), and adjusted soluble solid content to 8.0 with the high fructose corn syrup (4502504-01, Fresh Juice Industry (Kunshan) Co. Ltd.). The formulated juice was homogenized at 50 MPa (NS101L2K, GEA, Parma, Italy). The juice was pasteurized by Pasteurization and UHT respectively. Specifically, the Pasteurization treatment heated the juice at 60 ℃ for 30 min, and the UHT treatment heated the juice at 135 ℃ for 2 s.

The pasteurized juice was stored at 37 ℃ for 6 d. The qualities and aroma of the UHT was evaluated at 1st, 3rd , and 6th d, which nominated as the UHT1, UHT3, and UHT6. The juice before pasteurization was considered as the Unpasteurized.

Total Flora Counts

Juice was serially diluted, plated in total count agar for total flora counts. The plates were incubated at 30 ℃ for 48 h and counted manually.

Electronic Nose Analysis

The aroma of the watermelon juice was compared by the electronic nose (PEN2, Airsense Analytics GmbH, Schwerin, Germany). The sample of 2 mL was put in the testing tube. And then the electronic sensor was put into the testing tube to collect the results for 60 s.

GC-MS Analysis and Identification of Volatiles

The volatiles of the sample were performed on an Agilent 6890 gas chromatograph coupled to an Agilent 5973I mass selective detector (Agilent Technologies, Palo Alto, CA). The volatile compounds were separated on a DB-Wax column (30 m × 0.25 mm i.d., 0.25 μm film thickness, Agilent Technologies).

Volatiles were identified by comparison of their mass spectra and retention times with those of authentic standards, or by comparison of Kovats' retention indexes and mass spectrum. The K.I.s were calculated from the retention times of C6–C40 n-alkanes followed the recently method.[10]

Statistical Analysis

Analysis of variance (ANOVA) was used to compare mean differences of the results. If the differences in mean existed, multiple comparisons were performed using Duncan's Multiple Range Test. All analysis were conducted using SPSS for Window Version 19. All experiments were done in triplicates or more.

Results and Discussion

Total Microbial Counts of Watermelon Juice

The effect of storage time on total microbial counts of the watermelon juice is shown in Fig. 1. The initial count of the Pasteurization and UHT was lower than 2.0 Log CFU/mL. Subsequently, the total microbial count of each treatment was enhanced with the storage time. The total microbial count of the Pasteurization and UHT reached 2.6 and 5.6 Log CFU/mL, respectively, on the 6th d. Therefore, the

Pasteurization was effective to maintain the microbial count of the watermelon juice.

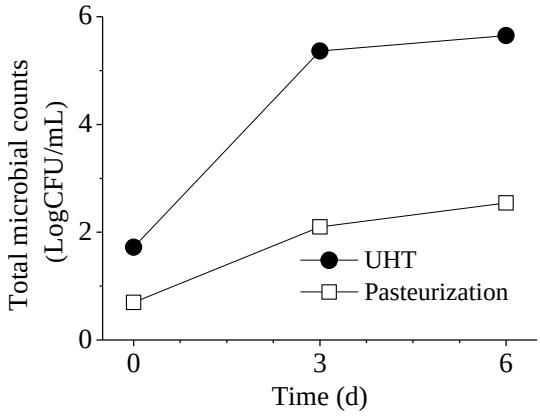

Figure 1 Effect of storage time on total microbial counts of the watermelon juice

Aroma of the Watermelon Juice

The pasteurized juice was stored at 37 ℃ and the aroma of the pasteurized juice was compared by the sensor array of 10 electrodes in the electric nose during the storage (Fig. 2). The dimensions of electrical responds were reduced by the principal component analysis. The main component 1 and 2 contributed 93.43 % and 4.17 % for the total watermelon aroma, respectively. The main component 1 represented the main aroma of the watermelon juice. The area of the Unpasteurized had no overlap with the stored watermelon juice. Consequently, the aroma of the UHT1, UHT3, and UHT6 was different to that of the unpasteurized juice. Interestingly, the aroma of the berry juice pasteurized by the UHT is well maintained [11], while the heating at 90 ℃ for 28 s leads to a significant aroma change of the apple cider [12].

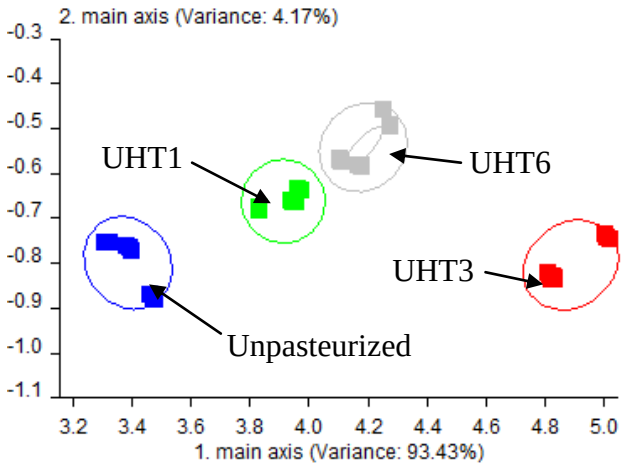

Figure 2 Effect of storage time on aroma of the watermelon juice

Volatiles of the Watermelon Juice

Total 30, 28, 25, and 28 volatiles were tentatively assigned in the unpasteurized, UHT1, UHT3 and UHT6, respectively (Table 1). The aldehyde, alcohol, ketone, alkane, and ester constituted 70.6 %, 15.8 %, 9.24 %, 4.42 %, and 0.26 %, respectively, in the unpasteurized watermelon juice. The acid was not found in the unpasteurized watermelon juice. Consequently, the aldehyde was the main component in unpasteurized watermelon juice.

Table 1. Volatile contents (%) of the watermelon juice during storage

Type	Volatile	Unpasteurized	UHT1	UHT3	UHT6
Alkane	Tetradecane	0.65	-*	-	-
	2-Pentylfuran	3.08	5.52	-	-
	1-Hexadecene	0.69	1.05	-	-
Subtotal		4.42	6.57	0	0
Alcohol	1-Nonanol	-	-	-	3.81
	(3Z)-3-Nonen-1-ol	3.42	2.3	1.73	0.72
	(E)-2-Nonen-1-ol	4.31	3.07	2.4	1.9
	(3E,6Z)-3,6-Nonadien-1-ol	-	-	2.5	1.95
	Phenethyl alcohol	3.06	4.04	5.23	3.98
	2-Methyl-1-propanol	0.99	-	-	-
	Hexyl alcohol	0.93	0.18	2.53	1.1
	3-Methyl-1-butanol	0.19	-	3.64	-
	2-Ethylhexanol	0.37	-	1.56	-
	2-Octanol	1.04	-	-	-
	Capryl alcohol	-	-	-	2.2
	Geraniol	0.25	-	-	-
	2-Hexyloctanol	-	0.69	-	-
	1-Octen-3-ol	-	-	1.49	3.25
	Dodecenol	-	0.33	-	-
	(2E)-2-Undecen-1-ol	-	-	-	0.25
	Dodecyl alcohol	0.47	-	-	-
	1-Tridecanol	0.8	2.77	2.02	1.43
	1-Pentadecanol	-	0.57	-	-
	1-Hexadecanol	-	0.53	-	-
	1-Nonadecanol	-	0.3	-	-
Subtotal		15.83	14.78	23.1	20.59
Aldehyde	1-Nonanal	8.45	9.18	6.85	2.81
	(2E)-2-Nonenal	10.1	9.22	8.56	7.35
	(E,Z)-2,6-nonadienal	25.8	22.59	18.7	10.9
	2-Hexenal(E)	4.32	4.21	2.93	1.05
	Octanal	5.21	3.22	-	-
	(E)-2-Octenal	0.83	-	-	0.15
	(E)-Hept-2-enal	1.23	-	-	-
	Decyl aldehyde	6.08	5.87	-	-
	2-Undecenal	-	-	5.13	8.25
	(E)-2-Dodecenal	7.65	6.07	-	-
	Tetradecanal	-	0.66	0.51	0.49
	Pentadecanal	0.58	0.89	1.03	-
Subtotal		70.25	61.91	43.71	31
Ketone	3-Hydroxy-2-butanone	1.47	-	-	-
	6-Methyl-5-hepten-2-one	3.97	2.95	5.74	-
	6,10-Dimethyl-5,9-undecadien-2-one	2.83	5.31	4.32	3.18
	2-Dodecanone	-	-	1.46	-
	2-Pentadecanone	0.33	2.46	3.9	-
	2-Nonadecanone	0.64	-	-	-
Subtotal		9.24	10.72	15.42	3.18
Acid	Nonanoic acid	-	-	4.85	10.01
	Acetic acid	-	-	1.68	4.09
	2-Methyl butyric acid	--	-	-	8.97
	Hexanoic acid	-	-	2.52	6.31
	Octanoic acid	-	-	3.23	7.51

Table 1, cont. Volatile contents (%) of the watermelon juice during storage

Subtotal		0	0	12.28	36.89
Ester	Isopropyl palmitate	-	0.46	-	-
	Dodecyl Acetate	-	-	-	0.16
	Diisobutyl phthalate	0.26	2.51	5.49	4.48
	Dimethyl phthalate	-	-	-	2.67
	Octyl Formate	-	0.22	-	-
	Heptyl forMate	-	-	-	0.9
	Allyl hexanoate	-	2.83	-	0.13
Subtotal		0.26	6.02	5.49	8.34

*: not detected.

Remarkably, the aldehyde content of the unpasteurized, UHT1, UHT3, and UHT6 was 70.6 %, 61.9 %, 43.7 %, and 31.0 %, respectively. The aldehyde was believed to be the main aroma of the watermelon juice. The aldehyde content reduced significantly during the storage, while the alcohol, acid, and ester content of the juice were enhanced during the storage.

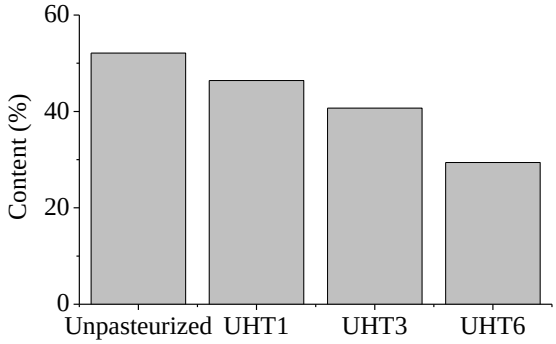

Figure 3 Effect of storage on typical volatiles of the watermelon juice

The C9 alcohol and aldehyde are the key aroma of the watermelon juice. The 1-Nonanol, (E)-2-Nonen-1-ol, (3Z)-3-Nonen-1-ol, (3E,6Z)-3,6-Nonadien-1-ol, 1-Nonanal, (E,Z)-2,6-Nonadienal, and (2E)-2-Nonenal were designated as the typical volatiles of the watermelon in the watermelon juice. The content of the typical volatiles of the unpasteurized, UHT1, UHT3, and UHT6 was 52.1 %, 46.4 %, 40.7 %, and 29.4 %, respectively (Fig. 3). Hence, the watermelon aroma of the pasteurized watermelon juice was reduced with the storage time.

Acknowledgement

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Reference

[1] I. Aguiló-Aguayo, M. Montero-Calderón, R. Soliva-Fortuny, O. Martín-Belloso, Changes on flavor compounds throughout cold storage of watermelon juice processed by high-intensity pulsed electric fields or heat, J. Food Eng. 100 (2010) 43-49.

[2] Q. Liu, R.-F. Wang, B.-B. Zhang, X.-Y. Zhao, D. Wang, C. Zhang, Protein secondary structure changes of watermelon juice treated with high hydrostatic pressure by FTIR spectroscopy, J. Food Process Eng. 37 (2014) 543-549.

[3] C. Zhang, B. Trierweiler, W. Li, P. Butz, Y. Xu, E. C. Rüfer, Y. Ma, X. Zhao, Comparison of thermal, ultraviolet-c, and high pressure treatments on quality parameters of watermelon juice, Food Chem. 126 (2011) 254-260.

[4] M. Feng, K. Ghafoor, B. Seo, K. Yang, J. Park, Effects of ultraviolet-C treatment in Teflon® -coil on microbial populations and physico-chemical characteristics of watermelon juice, Innov. Food Sci. Emerg. Technol. 19 (2013) 133-139.

[5] Y. Liu, X. Hu, X. Zhao, H. Song, Combined effect of high pressure carbon dioxide and mild heat treatment on overall quality parameters of watermelon juice, Innov. Food Sci. Emerg. Technol. 13 (2012) 112-119.

[6] G. Oms-Oliu, I. Odriozola-Serrano, R. Soliva-Fortuny, O. Martin-Belloso, Effects of high-intensity pulsed electric field processing conditions on lycopene, vitamin C and antioxidant capacity of watermelon juice, Food Chem. 115 (2009) 1312-1319.

[7] B. K. Tiwari, C. P. O' Donnell, K. Muthukumarappan, P. J. Cullen, Ascorbic acid degradation kinetics of sonicated orange juice during storage and comparison with thermally pasteurised juice, LWT Food Science and Technol. 42 (2009) 700-704.

[8] W. Huang, X. Bi, X. Zhang, X. Liao, X. Hu, J. Wu, Comparative study of enzymes, phenolics, carotenoids and color of apricot nectars treated by high hydrostatic pressure and high temperature short time, Innov. Food Sci. Emerg. Technol. 18 (2013) 74-82.

[9] Y. B. Wang, Y. Ma, X. Zhao, C. Zhang, Qualities and aroma of watermelon juice during storage at 4 oC, Advances in Biological Sciences Research (ABSR), volume 4.

[10] X. Tang, H. He, Y. Liu, X. Zhao, Identification of aroma compounds in watermelon juice by SPME-GCMS, Acta Hort. 944 (2012) 183-191.

[11] I. Dalmadi, K. Polyak-Feher, J. Farkas, Effects of pressure-and thermal-pasteurization on volatiles of some berry fruits, High Pressure Res. 27 (2007) 169-171.

[12] G. G. Rye, D. G. Mercer, Changes in headspace volatile attributes of apple cider resulting from thermal processing and storage, Food Res. Int. 36 (2003) 167-174.