Impact of Processing on Flavor Volatiles and Physicochemical Properties of Pomegranate Juice

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Abstract: This study was undertaken to investigate the effect of pasteurization and concentration techniques on some physicochemical parameters, volatile flavor compounds and polyphenols composition of clear pomegranate juice and to evaluate the use of cut-back process for improving the quality of the juice concentrate. The results showed no marked changes could be observed in titratable acidity, total sugars and pH value, whereas ascorbic acid content and color parameters of the juice were affected by pasteurization. A total of 27 compounds were identified in fresh pomegranate juice: 7 monoterpenes, 6 esters, 5 aldehydes, 3 alcohols, 4 ketone, 1 ether and 1 alkane hydrocarbon. Concentration and pasteurization processes resulted in loss of the two major aroma compounds (Ethyl acetate and Ethyl propanoate) whereas pasteurization alone resulted in loss of one monoterpene (3-Carene). Pomegranate juice prepared by cut-back process retained all the 27 aroma compounds found in fresh juice but in slightly lower concentration. Twenty three phenolic compounds were identified and quantified in pomegranate juice. Pyrogallol was the predominating polyphenol in addition to varying concentrations of gallic acid, 4 Epi-catechin, 4-amino benzoic, protocatchouic, catechin, chlorogenic acid, chatechol, P-OH-benzoic acid, ellagic acid, P-coumaric acid and ferulic acid. Concentration process resulted in considerable increase in polyphenols concentration whereas pasteurization lowered its concentration to a great extent. The highest polyphenol concentration was found in pomegranate juice from cut-back process. It is to be concluded that cut-back process could be a promising process in producing better quality juice.

***Keywords*:** Pomegranate juice, concentrate, volatile compounds, polyphenols, cut-back process

INTRODUCTION

Pomegranate (*Punica granatum* L.) is a member of the Punicaceae family and is considered one of the oldest cultivated edible fruit. The annual world production of pomegranate fruit is estimated to be 3 million metric tons (Kahramanoglu and Usanmaz, 2016). Global demand to pomegranate is increasing due to its functional properties with nutritional and health benefits in the human diet (Caleb *et al.,* 2015). Pomegranate fruit and its juices are being widely promoted to consumers as one of the new "super food" capable of addressing a huge variety of health disorders (Johanningsmeier and Harris, 2011).

Pomegranate juice is the most popular and extensively studied pomegranate-based product (Carbonell-Barrachina *et al.,* 2012; Nuncio-Jauregui *et al.,* 2014).Pomegranate juice is defined as unfermented juice obtained from mature and sound fruit by mechanical processes and is preserved by physical means, such as pasteurization (AIJN, 2008). Processing of pomegranate juice has some negative effects on juice quality parameters (color and aroma). This effect was different depending on the processing operations used. Pasteurization and concentration of pomegranate juice had an impact on flavor volatiles, polyphenols composition, antioxidants activity, anthocyanin and vitamins (Alper *et al.,* 2005; Fischer *et al.,* 2011; Ashoush and Gadallah, 2012; Yousefi *et al.,* 2012; Koppel *et al.,* 2015). Fruit juices have been traditionally concentrated by multi-stage vacuum evaporation, resulting in a loss of fresh juice flavors, color degradation and a "cooked" taste due to the thermal effects (Jiao *et al.,* 2004).

The aroma of pomegranate juice had been attributed to the presence of various volatile compounds, including esters, alcohols, aldehydes, ketones, and terpenes, which provide a mixture of various "green", "woody", "earthy", "fruity", "floral", "sweet" and "musty" notes (Mayuoni-Kirshinbaum and Porat, 2014). Calín-Sánchez *et al.* (2011) reported that the overall liking of the juice was found to be related to the attribute of "fresh flavor" and "fresh odor" which in turn seemed to be due to the presence of some volatile compounds, mainly terpenes (α-pinene, β-pinene, β-myrcene, limonene and γ-terpinene). They identified a total of 18 compounds were found in pomegranate aroma profiles, including monoterpenes, aldehydes, alcohols, monoterpenoids and linear hydrocarbons. The most abundant compound was trans-2-hexenal, 3-carene, α-terpinene and α-terpineol. Impact of preharvest and postharvest factors on changes in volatile compounds of pomegranate products (Caleb *et al.,* 2015), the effect of method of extraction on volatile compounds (Zhiying *et al.,* 2016), and the effect of different maturity stages and growing locations on change in volatile compounds (Mphahlele *et al.,* 2016) have been extensively studied. The influence of pasteurization and concentration on volatile flavor compounds of clear pomegranate juice has not been thoroughly investigated.

One of the main constituents responsible for the functional properties of pomegranate juice, are phenolic compounds which act as chain breaking antioxidant because of their hydroxyl group scavenges reactive radicals (Halliwel, 2002). Pomegranate juice obtained by squeezing the whole fruit has the highest concentration of ellagitannins than any commonly consumed juice and contains the unique ellagitannin, punicalagin (Heber, 2011). According to Alper *et al.* (2005) the thermal treatment applied to pomegranate juice produced by different clarification methods affected their total phenol content.

Different technological approaches have been developed and implemented to overcome the negative effects of pasteurization and concentration of fruit juices (Shatta, 2006). Unpasteurized juices packaged in polyethylene bottles are now occupying a great segment of the fruit and vegetable juice market (Fellers, 2006). The shelf life of these juices depends primarily on storage temperature. Freeze concentration systems (FCS) are implemented in the fruit juice industry (Sanchez *et al.,* 2009). Freeze-concentrated fruit juices are characterized by high nutritional value and sensory quality due to low processing temperatures which alter undesirable chemical changes. Membrane processes such as membrane distillation (MD), reverse osmosis (RO), and pervaporation have been recognized as alternative membrane based separation and concentration processes in fruit juice (Cassano *et al.,* 2011; Kumar *et al.,* 2013). Sixty five years ago, cut-back process was developed to overcome the flavor deterioration of orange juice concentrate as a result of concentration by evaporation (Ashurst, 2013). The process is still in use today for the production of frozen concentrated orange juice (FCOJ). It involves adding fresh unpasteurized orange juice (called cut-back juice) to orange juice concentrate of 58˚ Brix before freezing to reduce its concentration to 42º Brix giving four-fold concentrated FCOJ. The later concentrate is packed in 350 mL enameled cans and for reconstitution amount of water equals 3 times the volume of the can is added. The cut-back process was not implemented, so far, for other fruit juices.

This study was undertaken to investigate the effect of pasteurization and concentration processes on volatile flavor compounds, polyphenols composition and some physicochemical properties of clear pomegranate juice and to evaluate the cut-back process for improving the quality of the reconstituted juice.

MATERIALS AND METHODS

Materials:

Pomegranate fruits (Manfaluti cultivar) were purchased from whole sale market (El-obour, Egypt) at commercially ripening stage.

Methods:

Preparation of pomegranate juice and concentrate:

Fresh pomegranate fruits were washed and cut into two halves. The arils were separated manually and juice was extracted using Braun Juice Extractor (Type: MP 50, Germany). The resultant turbid juice was centrifuged at 5000 rpm for 15 min. The obtained clear juice (Fresh Juice, F) was concentrated in a laboratory rotary vacuum evaporator rotating at 40ºC to final total soluble solids (TSS) of 60º Brix. Reconstituted Juice (R) was prepared from juice concentrate by adding the amount of water to bring the TSS of the juice to the level of the fresh juice (16.1º Brix). Pasteurization of fresh pomegranate juice (F1) and reconstituted juice (R1) was performed at 87ºC for 5 min (Alper *et al.,* 2005).

Preparation of pomegranate juice using cut-back process:

One volume of fresh unpasteurized pomegranate juice was added to 3 volume of pomegranate concentrate. The resultant concentrate (48.5º Brix) was packaged in polyethylene bags (each contained 100 ml), subjected to freezing at -18ºC and stored at the same temperature. For the preparation of the single strength juice two volumes of water (200 ml) were added to one volume of the frozen concentrate to obtain ready to drink juice of 16.1º Brix.

Physicochemical analysis

Pomegranate juices were analyzed for pH (Jenway pH meter, UK). Total soluble solids content were measured with an Abbe refractometer (Bellingham and Stanley Ltd.) at 20ºC with values being expressed as ºBrix. Titratable acidity was determined according to FSSAI (2012) by acid-base potentiometer (NaOH, 0.1 N up to a pH value of 8.1) and expressed as gram anhydrous citric acid per 100 ml juice, total sugars and ascorbic acid contents were determined according to AOAC (2005). Color was measured in juices using the CIE (Committee International d'Eclairage) L*, a*, and b* coordinates in a glass– sample cup using Hunter Lab Spectrophotometric colorimeter (Hunter Lab Color Flex EZ, USA). The instrument was calibrated by white, black and red tiles at illuminant D^{65} and 10˚ observer according to McLaren (1980). The L* value indicates lightness, a* value indicates redness to greenness and b* value indicates yellowness to blueness.

Extraction of volatile compounds

The aroma volatiles of pomegranate juices were isolated using a dynamic headspace system. The samples were purged for 3 hours with nitrogen gas (purity > 99.99%) at a flow rate of 100 ml/min. The headspace volatiles were swept into cold trap containing diethyl ether and pentane (1:1, v/v) and hold at –10ºC. The solvents containing the volatiles were dried over anhydrous sodium sulfate for one hour. The volatiles were obtained by evaporation of the solvents under reduced pressure (Güler, 2007).

Gas Chromatography (GC) analysis

Gas chromatography analysis was performed using Perkin Elmer Auto system equipped with flame ionization detector (FID). A fused silica capillary column DB-5 (60 m X 0.32 mm i.d) was used. The oven temperature was maintained initially at 50ºC for 10 min, then programmed from 50 to 180˚C at a rate of 3ºC/min. Helium was used as the carrier gas, at a flow rate 1.0 ml/min. The injector and detector temperatures were 220 and 250ºC, respectively (Abbas *et al.,* 2016).

Gas Chromatographic-Mass Spectrometric (GC-MS) analysis

Isolation, identification, and quantification of the volatile compounds were performed using a gas chromatograph (Hewllet-Packard (5890)/mass spectrometry Hewlett- Packard-MS (5970) and operated with the MS Workstation software. The GC-MS system was equipped with DB-5 column (Varian, Inc. Walnut Creek, CA; 60 m X0.25 mm X 1.0 mm film thickness). Column temperature began at 50ºC and held for 10 min, increased 3ºC per minute to 180ºC, and finally increased 10ºC per minute to 230ºC and kept at this temperature for 10 min. The constant column flow was 1 ml/min, using helium as carrier gas. The linear retention index (Kovatsindex, KI) values for unknowns were

determined based on retention time data obtained by analyzing a series of normal alkanes (C8-C22). Volatile components were positively identified by matching their KIs values and mass spectra with those of standards, also run under identical chromatographic conditions in the laboratory (Adams, 2007).

Determination of phenolic compounds

HPLC technique was used for the separation and quantification of phenolic compounds in pomegranate juices according to the method outlined by Mattila *et al.* (2000). The instrument (Agilent 1200 series, USA) was equipped with Zorbax column (4.6 x 250 mm) kept in column compartment at 35ºC. Gradient elution was employed with a mobile phase consisting of 5 mM H_3PO_4, pH 2.5 and acetonitrile at a flow rate of 1 ml/min. A Multi-wavelength detector set at 280 nm was used. All phenolic compounds were quantified using external standard method.

RESULTS AND DISCUSSION

Physicochemical properties

The main physicochemical properties of the studied pomegranate juices are presented in Table (1). Fresh pomegranate juice contained 0.92 g/100 ml titratable acidity, 11.30 g/100ml total sugars, 1.36 mg/100 ml ascorbic acid and pH value of 3.66. The CIE color coordinates of fresh juice were L* (12.59), a* (1.40) and b* (-0.20). These values are consistent with those observed by Valero *et al.* (2014). Pasteurization and concentration did not show pronounced effects on titratable acidity, total sugars and pH value. Pasteurization had a marked effect on the degradation of ascorbic acid. Lower ascorbic acid content was observed in pasteurized juice (F1) and reconstituted-pasteurized juice (R1) than fresh juice and juice from cut back process (C). A noticeable effect of pasteurization on color parameters of pomegranate juices was also exhibited. The pasteurized juices (F1 and R1) had the lowest L*, a* and b* values, indicating that thermal treatment during pasteurization had negative effect on color of pomegranate juice. Alper *et al.* (2005) stated that heat treatment significantly affected the color values of pomegranate juices. Vegara *et al.* (2013) found that pomegranate juice pasteurized at 90ºC for 5 seconds lost 22% of the red color (measured as absorbance at A_{520}). The primary color degradation in fruit juices containing anthocyanin (such as pomegranate juices) has been attributed to the degradation of monomers anthoyanins, polymerization and subsequent formation of brown pigments (Alighourchi and Barzegar, 2009). The improvement in color parameters and ascorbic acid retention of juice prepared by cut-back process compared to pasteurized juices is probably due to the inclusion of fresh pomegranate juice in the concentrate and to the fact that no further heat treatment was applied.

Table (1): Some physicochemical Properties of pomegranate juices

Parameter	F	F1	R	R1	C
Total Soluble Solids (ºBrix)	16.10	16.10	16.10	16.10	16.10
Titratable Acidity (g/100 ml Anhydrous citric acid)	0.92	0.89	0.94	0.90	0.95
Total sugars (g/100 ml)	11.30	11.43	11.39	11.46	11.38
pH value	3.66	3.61	3.63	3.64	3.64
Ascorbic acid (mg/100 ml)	1.36	0.91	1.22	0.98	1.27
Color coordinates					
L*	12.59	10.85	12.45	10.92	12.43
a*	1.40	1.21	1.38	1.28	1.41
b*	-0.20	-0.16	-0.21	-0.14	-0.21

F: Fresh Juice, F1: Pasteurized Juice, R: reconstituted Juice, R1: Pasteurized-reconstituted Juice, C: Juice from Cut Back Process

Flavor Volatiles

Results presented in Table (2) show that in fresh pomegranate juice (F) a total of 27 compounds were identified: 7 monoterpenes, 6 esters, 5 aldehydes, 3 alcohols, 4 ketone, 1 ether and 1 alkane hydrocarbon. Calín-Sánchez *et al.* (2011) and Melgarejo *et al.* (2011) reported respectively 18 and 21 different aromatic compounds in Spanish pomegranates. Twenty three volatile compounds were found in the juices extracted from Wonderful cultivar (Vázquez-Araújo *et al.,* 2011). On the other hand, Zhiying *et al.* (2016) identified a total of 36 volatile compounds in pomegranate juice using 3 different techniques for the extraction of the aromatic compounds.

Six esters (ethyl acetate, ethyl propanoate, isobutyl acetate, ethyl-2-methylbutyrate, ethyl-3-methylbutyrate and ethyl hexanoate) were identified in fresh pomegranate juice (Table 2). They constituted 31.45% of the total peaks area. Pasteurization of pomegranate juice did not markedly change the level of esters (32.6% of the total peaks area). Ethyl acetate and ethyl propanoate were the predominating esters. They

contribute to floral and fruity smell. Reconstituted pomegranate juice showed lower level of esters (9.82%) which was reduced to a value as low as 4.05% after pasteurization. This is mainly due to the loss of ethyl acetate and ethyl propanoate (Table 2). These results indicated that concentration is responsible for the low levels of esters identified in the juice. This effect is augmented when concentration is combined with pasteurization. On the other hand, pomegranate juice prepared by cut-back process retained high level of esters (23.71%) due to the addition of fresh juice to pomegranate concentrate.

Table (2): Flavor volatiles composition of pomegranate juices

Volatile compounds	KI[a]	F	F1	R	R1	C
Ethyl acetate	615	9.18	9.38	3.78	n.d	6.89
Ethyl propanoate	687	6.95	7.18	2.19	n.d	4.76
Isobutyl acetate	759	5.37	5.82	1.13	0.78	5.07
Hexanal	803	3.51	3.43	n.d	9.51	0.93
***trans*-2-Hexenal**	841	2.78	2.65	0.96	2.92	1.13
Ethyl-2-methylbutyrate	847	4.61	4.71	1.19	1.17	2.95
Ethyl-3-methylbutyrate	853	2.59	2.65	0.84	0.95	3.16
cis-3-Hexenol	857	15.08	14.29	5.45	10.37	13.76
α-Pinene	932	3.75	3.59	2.47	5.51	4.29
β-Pinene	965	5.82	4.52	3.18	9.14	5.18
1-Octen -3-one	976	1.95	1.90	0.06	0.08	3.19
β-Myrcene	988	3.64	3.62	1.24	1.29	1.38
Octanal	1001	0.81	0.79	1.13	6.71	2.65
3-Carene	1003	0.16	n.d	1.15	0.83	0.06
Ethyl hexanoate	1005	2.75	2.86	0.69	1.15	0.88
α-Terpinene	1012	1.84	1.16	0.73	0.79	5.02
1,8-Cineole	1027	0.67	0.59	1.25	0.04	7.35
Limonene	1029	2.45	2.37	3.89	11.37	3.28
Phenylacetaldehyde	1047	0.17	0.19	1.18	1.12	0.22
γ -Terpinene	1058	1.69	1.64	0.05	2.63	1.53
Fenchone	1084	2.44	2.51	1.26	0.38	6.13
Nonanal	1102	6.82	7.93	0.79	9.10	0.95
Camphor	1146	1.73	1.82	0.04	0.58	1.19
Terpinen-4-ol	1173	3.82	3.77	1.19	0.32	0.06
α-Terpineol	1189	1.45	1.42	3.71	0.82	2.64
Dodecane	1199	1.18	0.93	0.03	0.03	1.12
***β*-Damascenone**	1396	0.16	0.08	0.85	0.06	0.79

F: Fresh juice, F1: Pasteurized juice, R: reconstituted juice, R1: Pasteurized-reconstituted juice, C: Juice from Cut Back process,
[a]: Kovats Index

The obtained results are in agreement with Belitz *et al.* (2009) who reported that esters are significant aroma constituents of many fruits and plants and are synthesized only by intact cells, but during the processing of the plant material, esters are rapidly hydrolyzed and the fruity aroma flattens. Table (2) shows also that 3-carene was not detected in pasteurized juice. Among the identified alcohols cis-3-Hexenol was found in highest concentration, representing 15.08% of the total peaks area. It is characterized by an intense grassy-green odor of freshly cut green grass and leaves. Pasteurization did not affect the level of cis-3-hexenol, but concentration step had greater impact. Reconstituted juice contained the lowest level of this alcohol (5.45%), whereas juice from cut-back process retained high level (13.76%). Terpenes (α-pinene, β-pinene, β-myrcene,

limonene and γ-Terpinene, α-terpinene) are present in moderate concentration. They contribute to fresh flavor. Although reconstituted pasteurized juice (R1) showed the highest level of terpenes (31.50% of the total peaks area) but this is mainly due to the fact that the loss of the 2 esters was reflected proportionally on the other volatile compounds (such as α-pinene, limonine and nonanal). These results are in accordance with those reported by Nisperos-Carriedo and Shaw (1990). They found that unpasteurized and pasteurized single-strength juices not made from concentrate did not show marked changes in the profile of flavor component when compared to fresh juice. In contrast, pasteurized reconstituted juices from concentrate showed decreased acetaldehyde, methyl acetate, methyl butyrate and ethyl butyrate. Koppel *et al.* (2015) stated that the most differentiated juice was the reconstituted sample with fermented and brown flavors, while fresh, fresh frozen and pasteurized samples did not vary as much.

Phenolic compounds

A total of 23 phenolic compounds were identified in pomegranate juices, except pasteurized juice which contained 22 compounds (Table 3). Phenolic compounds of clear pomegranate juice consisted of 15 phenolic acids, pyrogallol, catechin, chatechol, epi-catechin, caffeine, resveratrol, oleuropein and coumarin. The major phenolic compounds identified and quantified in fresh pomegranate juice in deceasing order (as mg/100ml juice) were pyrogallol (36.39), catechin (9.12), chatechol (5.76) and protocatchuic acid (5.74). Mena *et al.* (2012) detected 21 phenolic compounds in pomegranate juice. The phenolic acids present in pomegranate juice were found to be divided into 2 groups: hydroxybenzoic acids, mainly gallic acid and ellagic acid and hydroxycinnamic acids, principally caffeic acid, chlorogenic acid, and p-coumaric acid (Poyrazoglu *et al.,* 2002).

Table (3): Phenolic compound contents of pomegranate juices

Phenolic compound	Concentration (mg/100 ml)				
	F	F1	R	R1	C
Gallic acid	1.22	1.44	1.37	1.40	2.00
Pyrogallol	36.39	15.98	52.58	40.81	58.70
4-Amino benzoic acid	0.57	1.20	0.45	1.01	1.10
Protocatchuic acid	5.74	7.00	5.26	4.76	8.52
Catechin	9.12	10.68	10.11	5.85	13.45
Chlorogenic acid	1.00	1.10	1.06	1.07	1.48
Chatechol	5.76	6.43	5.33	5.24	8.85
Epi-catechin	0.52	0.79	1.32	0.81	0.72
Caffeine	0.28	0.43	0.24	1.14	1.13
P-OH-benzoic acid	2.22	2.63	2.52	3.43	5.82
Caffeic acid	0.11	0.053	0.12	0.15	0.16
Vanillic acid	0.3	0.00	0.24	0.37	0.31
P-Coumaric acid	0.18	0.48	0.21	0.27	0.25
Ferulic acid	0.16	0.5	0.16	0.19	0.17
Iso-Ferulic acid	0.06	0.2	0.08	0.07	0.09
Resveratrol	0.02	0.06	0.01	0.02	0.03
Oleuropein	3.22	6.24	3.21	2.79	4.11
Ellagic acid	0.37	1.94	0.69	0.48	0.38
ρ-Coumaric acid	0.06	0.15	0.05	0.06	0.07
Benzoic acid	0.69	0.91	0.75	0.75	0.04
3,4,5-Triethoxy cinnamic acid	0.04	0.14	0.018	0.03	0.04
Coumarin	0.03	0.09	0.01	0.03	0.03
Salicylic acid	0.08	0.34	0.05	0.05	0.07
Total	68.09	58.58	85.83	67.65	102.24

F: Fresh juice, F1: Pasteurized juice, R: reconstituted juice, R1: Pasteurized-reconstituted juice, C: Juice from Cut Back process

Pasteurization caused pronounced decrease in phenolic compounds content. Phenolic compounds content in fresh pomegranate juice accounted for 68.09 mg/100 ml which was decreased to 58.58 mg/100 ml in pasteurized juice (Table 3). This is mainly due to reduction in pyrogallol concentration by 56.09%. According to Alper *et al.* (2005) the thermal treatment applied to pomegranate juice affected their total phenol amount. The effect of pasteurization on total phenol reduction was 7.1%. Mena *et al.* (2013) stated that pasteurization resulted in significant reduction (60%) of ellagic acid. On the other hand, concentration process resulted in higher content of total phenolic compounds in reconstituted juice (85.83 mg/100 ml) which upon pasteurization was reduced to 67.65 mg/100 ml. Pomegranate juice prepared from cut back process was characterized by the highest phenolic contents (102.24 mg/100 ml). Total phenolic content ranged from 58.8 to 255.1 mg/100ml of pomegranate juice (Gomez-Caravaca *et al.,* 2013).

CONCLUSION

In conclusion processing had an effect on pomegranate juice properties and the effect is different depending on the processing method. Pasteurization and concentration of pomegranate have an impact on ascorbic acid content, color parameters, Flavor profiles, as well as phenolic compounds. Cut-back process could be a promising technique in producing better quality juice.

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تأثير التصنيع على مركبات النكهة الطيارة والخواص الفيزيوكيمائية لعصير الرمان

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تهدف الدراسة إلى البحث في تأثير عمليتي البسترة وتقنية التركيز على بعض الخواص الفيزيوكيمائية، مركبات النكهة الطيارة والمركبات الفينولية وكذلك تقييم عملية إعادة القطع cut-back process على جودة عصير الرمان. أوضحت النتائج أنه لا يوجد تغير ملحوظ في الحموضة والمحتوى الكلي للسكريات ورقم الأس الهيدروجيني، بينما حدث تأثير في محتوى حمض الأسكوربيك وفي لون العصير نتيجة عملية البسترة. أوضحت النتائج أن عصير الرمان الطازج يحتوي على ٢٧ مركب رائحة طيارة في صورة ٧ مركبات تربينية، ٦ إسترات، ٥ ألدهيدات، ٣ كحولات، ٤ كيتونات، واحد ايثير وواحد هيدروكربون. أدت عمليتي البسترة والتركيز معا إلى فقد إثنان من مركبات الرائحة الهامة وهما الإيثايل استر والإيثايل بروبيونات، بينما أدت عملية البسترة بمفردها إلى فقد أحد المركبات التربينية. كما بينت النتائج أن عصير الرمان المحضر بعملية إعادة القطع احتوى على الـ ٢٧ مركب التي وجدت في العصير الطازج ولكن بنسب منخفضة نسبيا. بالنسبة للمركبات الفينولية فقد تم التعرف على ٢٣ مركب في عصير الرمان. أدت عملية البسترة سواء للعصير الطازج أو العصير المسترجع من المركز إلى انخفاض تركيز الفينولات، بينما أدت عملية التركيز بمفردها إلى ارتفاع في تركيز الفينولات، وتميز العصير الناتج من عملية إعادة القطع بأعلى محتوى فينولات. وخلصت الدراسة إلى أن طريقة إعادة القطع cut-back process قد تكون طريقة واعدة لإنتاج عصير رمان ذو جودة أفضل.

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