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EFFECT OF FROZEN STORAGE ON THE QUALITY ATTRIBUTES OF FRESH AND CONCENTRATE CUT-BACK STRAWBERRY JUICES

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ABSTRACT: The present study was aimed to evaluate the effect of frozen storage at -18°C for 6 months on the quality attributes of the fresh and the concentrate Cut-back strawberry juices. The obtained results showed that the concentrate Cut-back strawberry juice was more acceptable by panelists. A significant decline in titratable acidity after freezing was observed in both types of strawberry juices; it decreased from 0.85 to 0.41 and from 0.98 to 0.49% for fresh strawberry juice and concentrate Cut-back juice, respectively. After 6 months of frozen storage similar tendency was observed for their vitamin C content having 9.45 and 29.23 mg/100ml for fresh and concentrate Cut-back strawberry juice, respectively. The pH increased from 3.805 to 4.340 and from 3.604 to 4.252 for fresh strawberry juice and concentrate Cut-back juice, respectively. The concentrated Cut-back strawberry juice prior to freezing was found to be rich in ferulic acid, resorcinol and quercetin being 10.09, 0.24 and 731.98 ppm which were by respectively compared to fresh strawberry juice. Quercetin was the dominant compound, it was the only one that found in the two juices after 6 months of frozen storage. While, kaempherol was appeared after freezing for the two types of juices and showed gradual increase by increasing the duration of frozen storage. The Cut-back strawberry juice showed higher antioxidant activity and viscosity than fresh juice. A slight decrease in viscosity was observed for the two types of juice after storage at -18°C for 6 months. The colour was not stable during the frozen storage at -18°C , The colour values increased in fresh strawberry juice for L^* , a^* and b^* from 12.73, 21.00 and 7.77 to 16.89, 25.94 and 9.91, respectively, but in Cut-back strawberry juice the value of L^* was only increased from 13.23 to 13.55 while, a^* and b^* values decreased from 25.75 and 8.11 to 22.68 and 7.00, respectively. From results, it could be concluded that the Cut-back strawberry juice had the best quality after 6 months of frozen storage.

Key words: Strawberry juice, Cut-back, freezing, Vitamin C, antioxidant activity, colour, viscosity

INTRODUCTION

Strawberry (*Fragaria ananassa*) is an important fruit. It is an attractive fruit and widely appreciated by the consumers because of its appealing fruity flavour particularly sweetness and aroma, bright red colour and juicy texture. Nutritionally, strawberry contains low calorie and a potential source of vitamin C, fibers and provides more vitamin C than oranges (Wisal *et al.*, 2014). The main constituents in 100 g of the fruit are vitamin C (64.0 mg), water (91.75 g), protein (0.61 g), fat (0.37 g), carbohydrate (7.02 g), fibre (2.3 g), calcium

(14.0 mg), potassium (103.75 mg) and vitamin-A (27 IU). The pH value ranges from 3.27 to 3.86, which help in stabilizing colour (Wisal *et al.*, 2014). Acidity range is between 0.58 and 1.35% calculated as citric acid. Citric and malic acids are primary organic acids contributing excellent flavour. Soluble solids are in the range of 8.0-11.5% and are ideal for juice concentrate needed in the market. Soluble solids: acid ratio is 8.52: 13.79 given good balance of sweet-tart flavour (Ayub *et al.*, 2010). The red colour of the fruit is due to presence of an anthocyanin, pelargonidin 3-monoglucosides, and traces of cyaniding. Strawberries have high level of

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antioxidant compounds that provide the protection against harmful free radicals (Zheng *et al.*, 2007) and can be considered as a functional food because they contain biologically active compounds that provide clinically proven health benefits for the prevention, management or treatment of diseases (Singh *et al.*, 2011; Skrovankova *et al.*, 2015).

Strawberry can be consumed in fresh or processed form such as preserved fruit juice. But, due to the seasonality of the strawberry, the fresh fruits are only available for few months per year. In order to overcome this seasonality, the fresh fruits are preserved by freezing and it is one of the best options to preserve such fruits. So, the frozen strawberry can be used in the production of attractive products through the year (Chandra and Kumari, 2015) such as pies, tart, strawberry juice, concentrate, puree, milkshake, jam and in the production of red wine alone or in combination with other fruits (El Samh *et al.*, 2013). Strawberries are well known for their extensive flavour and are widely used to prepare juices (Bood and Zabetakis, 2002). Fruit juice concentrates are produced by a freeze concentration, low temperature vacuum evaporation, high speed high temperature evaporation and reverse osmosis. In the last decade there has been considerable increase in demand for a strawberry juice because it possesses an excellent flavour with attractive colour. However, being a soft Textured fruit, a little fluctuation in a temperature results in spoilage and wastage of fruit.

Due to lack of other preservation facilities to preserve the product in raw form, this study has been conducted to utilize the very perishable fruit in the form of juice concentrates and to study the effect of cut back process and freezing at -18°C for 6 months on quality attributes of the end product. To achieve these goals, a concentrate of strawberry juice was prepared using rotary evaporator, the Cut-back technique was used in the preparation of strawberry juice from the concentrate and the obtained juice was compared with fresh one in terms of sensory quality attributes, chemical and physical characteristics during freezing at -18°C for 6 months.

MATERIALS AND METHODS

Materials

Fully ripe red strawberry fruits (*Fragaria ananassa* Duch, cultivar Fortuna) were purchased in March from a local Farm in Mashtool El-Souk, Sharkia Government, Egypt. 50 Kg strawberry fruits were washed by tap water and the calyx, sand and non-edible parts were removed, then the fruits were packed in airtight polyethylene bags and stored at -18°C until their use.

Methods

Preparation of fresh and concentrated strawberry juices

Strawberry juice (6.2° Brix) was obtained using domestic juice extractor (Kenwood, KHH326WH MultiOne, 1000 W). To obtain the concentrated juice (30° Brix), the water was evaporated using rotary evaporator (BuchiRotavapor R-124 Rotary Evaporator, Switzerland). Preliminary trial was carried out at different temperatures: 30, 40 and 50°C, in order to optimize the operating conditions and to obtain a strawberry concentrate with acceptable sensory quality in terms of colour and flavour. The temperature of 40°C was the optimum one according to the preliminary sensory evaluation results (Nistor *et al.*, 2010).

Preparation of cut-back strawberry juice

The Cut-back strawberry juice (22.3° Brix) was prepared from concentrated strawberry juice (30° Brix), by adding fresh strawberry to concentrated one with a ratio of 1:2 (V/V), respectively.

Frozen storage of fresh and cut-back strawberry juices

The fresh and Cut-back strawberry juices were packed in plastic jars (330ml) and stored in a freezer at -18°C for six months.

Various assessments and characterizations were carried out monthly during the six months of frozen storage for the two types of strawberry juices; fresh and Cut-back, as previously described; except the sensory evaluation, flavonoids and phenolic acids determinations were carried out only 3 times; directly after preparation, after 3 months and at the end of frozen storage after 6 months.

Sensory evaluation

The frozen fresh and Cut-back strawberry juices were submitted to their sensory evaluation. In order to evaluate the sensorial characteristics of Cut-back strawberry juice, 260 ml of distilled water was added to 100 ml Cut-back strawberry juice to get 6.2° as Brix of fresh strawberry juice. Sensory evaluation was conducted by using the score sheet according to (Vranac *et al.*, 2017). The panelists (n= 10) were asked to score flavour, odour, texture, colour and appearance of strawberry juices; each was judged on a scale from 1 (extremely dislike) to 5 (extremely like) grade as a score for each of strawberry juice

Titrateable acidity and pH determination

Titrateable acidity of fresh and Cut-back strawberry juices were determined using the titration with 0.1M sodium hydroxide solution to pH=8.2 as an end point using pH meter (model 646 Digital, USA) at room temperature. The acidity was expressed as citric acid (SI Analytics, 2012). The pH values of the two strawberry juices were measured using the aforementioned pH meter at the same room temperature.

Vitamin C determination

Vitamin C of fresh and Cut-back strawberry juices was determined according to Rangana (1977) which is based on the reduction of 2,6 dichlorophenol indophenol dye by ascorbic acid.

Antioxidant activity, flavonoids and phenolic acids determination

Antioxidant activity of strawberry juices was evaluated as free radical scavenging activity by DPPH as described by Su and Silva (2006) and expressed as per cent of antiradical activity against DPPH. Flavonoids and phenolic acids contents in fresh and Cut-back strawberry juices were determined using HPLC (The system Thermo (Ultimate 3000) consisted of: pump, automatic sample injector, and associated DELL-compatible computer supported with Cromelion7 interpretation program) according to Biswas *et al.* (2013).

Colour

The colour of fresh and Cut-back strawberry juices was determined using a Hunter Lab

(Colour Flex EZ Spectrophotometer, USA) according to Granato and Masson (2010). The apparatus was calibrated with a white and black standard tile using the CIE scale L* a* b* before running the measurement. Samples were placed in the standard cup and the colour values were recorded and expressed as L* (0: black, 100: white), a* (-a*: greenness, +a*: redness), and b* (-b*: blueness, +b*: yellowness).

Viscosity

The viscosity of fresh and Cut-back strawberry juices were carried out using the Brookfield rotational viscometer (model DV-I+ Viscometer, LV version 4.1, USA) using spindle No.4 for fresh juices and spindle No.1 for Cut-back strawberry juices at 60 rpm at 25°C (Bukurov *et al.*, 2012).

Statistical Analysis

An ANOVA was performed by the General Linear Models using SPSS 22.0 package program (SPSS Inc., Chicago, IL), and LSD test was used to find significant differences (P <0.05) (McClave and Benson, 1991).

RESULTS AND DISCUSSION

Sensory Evaluation

Table 1 shows the mean score values of sensory evaluation of both fresh and Cut-back strawberry juices. The evaluation was performed at zero time (directly after preparation), after 3 months and after 6 months of frozen storage.

As general tendency, it could be noticed that the freezing process had a negative effect on the sensory characteristics of both fresh and concentrate Cut-back strawberry juices; whereas, all the quality attributes decreased during the frozen storage especially odour, colour and texture of concentrate Cut-back strawberry juice after 6 months. These decreased may be attributed to enzymatic activity such as peroxidase, lipoxygenase, catalase, polyphenol oxidase, and pectin methylesterase. However, peroxidase activity does not diminish strawberry juices quality under freezing conditions, by reason of the freezing process is thought to increase the solubility of some peroxidase fractions that are attached to cell membranes (Cano *et al.*, 1998).

Table 1. Sensory evaluation of fresh and reconstituted Cut-back strawberry juices during frozen storage at -18°C

Sensory properties	Zero-time		After 3 months		After 6 months		
	Sample	Fresh	Cut-back	Fresh	Cut-back	Fresh	Cut-back
Flavour (5)		4.20 ^a	4.10 ^{ab}	4.00 ^{bc}	4.00 ^{bc}	3.80 ^d	3.90 ^{cd}
Odour (5)		3.80 ^a	3.81 ^a	3.60 ^b	3.72 ^{ab}	3.40 ^c	3.70 ^{ab}
Colour (5)		4.20 ^a	4.20 ^a	4.00 ^a	4.00 ^a	3.50 ^b	4.00 ^a
Texture (5)		4.00 ^a	4.18 ^a	3.90 ^{ab}	4.00 ^a	3.81 ^b	4.00 ^a
Appearance (5)		3.90 ^a	4.00 ^a	3.90 ^a	4.00 ^a	3.60 ^b	3.90 ^a
Overall acceptability (%)		80.4%	81.2%	77.6%	78.8%	72.4%	78.0%

Others factors such as changes in pH, water activity, temperature and length of frozen storage could have contributed to the degradation of pigments (Bonat Celli *et al.*, 2016). Whatever, the case may be, at the duration of frozen storage, the concentrate Cut-back strawberry juice was the most preferable than fresh strawberry juice having an overall acceptability score of 78% versus 72.4% for fresh juice (Table 1).

Titrateable Acidity and pH

The titrateable acidity and pH value of fresh and concentrate Cut-back strawberry juices during frozen storage are shown in Fig. 1. The obtained results showed significant decline in the titrateable acidity during the frozen storage of the two types of strawberry juice. It was decreased from 0.85 to 0.41 and from 0.98 to 0.49 for fresh strawberry juice and concentrate Cut-back juice, respectively, while the pH values increased from 3.805 to 4.340 and from 3.604 to 4.252 for fresh strawberry juice and concentrate Cut-back juice, respectively. The decreasing in titrateable acidity and increasing the pH value could be explained by increasing the content of alcoholic compounds during the storage. These findings agree with those of Forney *et al.* (2000) and Ayub *et al.* (2010).

Vitamin C

Fig. 2 shows vitamin C content of fresh and concentrate Cut-back strawberry juices. The juices varied in their values of vitamin C

retention during the frozen storage at -18°C. The obtained results revealed a loss in vitamin C for the two types of juice; it decreased by about 53 and 36% for fresh and concentrate Cut-back strawberry juices after freezing for 6 months, respectively. So, vitamin C loss was more remarkable in fresh strawberry than the concentrate Cut-back one. Sahari *et al.* (2004) reported that ascorbic acid level decreases with time and with loss of 33-55% at the end of one year frozen storage. In general, losses of ascorbic acid resulted thorough freezing process may differ within the range from 10 to 80%, with an average rate of 50% (Rickman *et al.*, 2007). The loss in vitamin C may be related to oxidation of ascorbic acid during storage. The oxidation of ascorbic acid may be enzymic or nonenzymic. The enzyme that mainly cause the loss of vitamin C is ascorbate oxidase. If this enzyme is not inactivated by pretreatments, it keeps its activity during the frozen storage of the product (Hui *et al.*, 2011). The obtained results are in agreement with those obtained by Sapei and Hwa (2014); Sheraz *et al.* (2015).

Phenolic Acids and Flavonoids Content and Antioxidant Activity

Table 2 illustrates the phenolic acids and flavonoids contents in fresh and concentrate Cut-back strawberry juice during frozen storage. The obtained results showed that the concentrate Cut-back strawberry juice (prior to freezing) was rich in ferulic acid, resorcinol and quercetin reflecting higher values than those of fresh

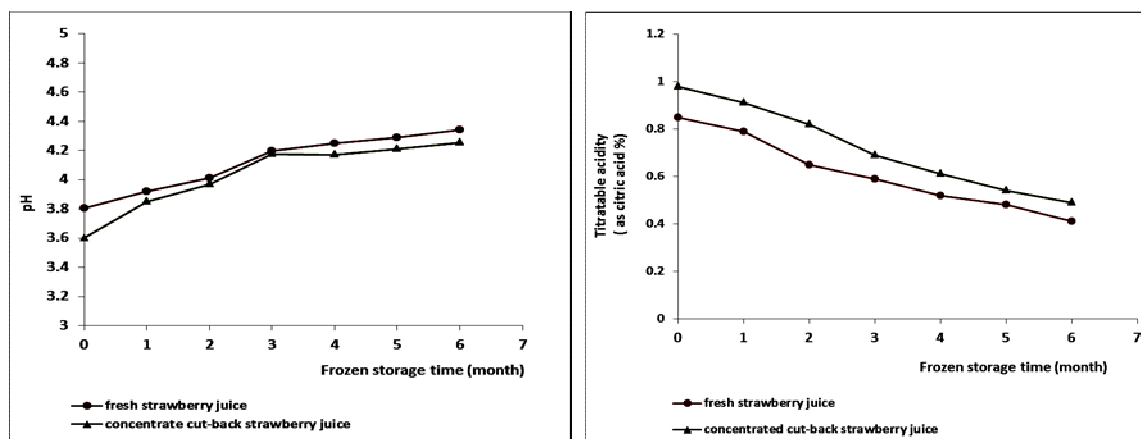


Fig. 1. Titratable acidity as citric acid (%) and pH of fresh and concentrate Cut-back strawberry juices during frozen storage at -18°C

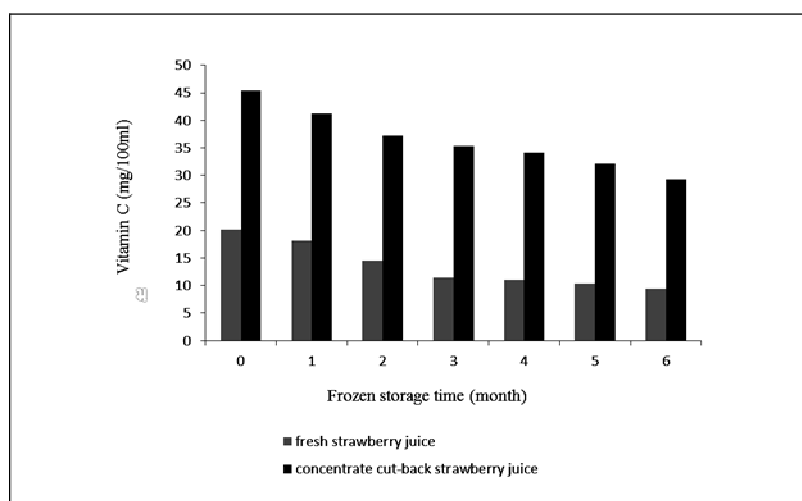


Fig. 2. Vitamin C content of fresh and concentrate Cut-back strawberry juices during frozen storage at -18°C .

Table 2. Phenolic acids and flavonoids contents (ppm) extracted from fresh and concentrate Cut-back strawberry juices during frozen storage at -18°C

Compound	Zero time		3 months		6 months	
	Fresh	Cut-back	Fresh	Cut-back	Fresh	Cut-back
Ferulic acid	4.1668	10.0884	ND	ND	ND	ND
Resorcinol	0.0652	0.2404	ND	ND	ND	ND
Quercetin	615.7831	731.9814	354.1582	338.9551	450.7553	305.9836
Kaempherol	ND	ND	540.2301	668.4359	519.0599	632.8034

ND: Non detected

strawberry juice. Quercetin was decreased by 42.5 and 53.7% after freezing for 3 months and by 26.8 and 58.2% after freezing for 6 months for fresh and concentrate Cut-back strawberry juices, respectively. It is worth to mention here that kaempferol compound was appeared after freezing the two types of juices, its content was higher in concentrate Cut-back strawberry juice by about 23.7 and 21.9% than those of fresh strawberry juice after 3 and 6 months, respectively. (Table 2). The decrease of ferulic acid, resorcinol and quercetin may due to enzymatic activity of polyphenol oxidase (Chaovanalikit and Wrolstad, 2004) while, the increase in kaempferol content in the two types of strawberry juices may be related to a hydrolysis and transformation processes of some flavonoid compounds.

Fig. 3 shows the antioxidant activity of fresh and concentrate Cut-back strawberry juices. The obtained results showed that the concentrate Cut-back strawberry juice had higher antioxidant activity than fresh juice even after freezing. The initial antioxidant activity before freezing was higher by about 166% and 328% for the final antioxidant activity after 6 months of freezing at -18°C when compared to fresh strawberry juice. The high antioxidant activity of concentrate Cut-back strawberry juice could be attributed to its higher content of vitamin C and phenolic compounds such as flavonoids and phenolic acids than fresh juice. A gradual reduction in antioxidant activity was also observed during frozen storage for the two types of strawberry juices, it decreased by about 45.4 and 12.0%, respectively for fresh and concentrate Cut-back strawberry juice after 6 months of freezing at -18°C . This reduction in antioxidant activity after freezing may be due to the oxidation of some phenolic compounds by polyphenol oxidase and transformation to other compounds. These observation are in line with those of Lee *et al.* (2003), Muller *et al.* (2010) and Gurel *et al.* (2018).

Colour

Fig. 4 a, b and c illustrate the colour parameters L^* , a^* and b^* of fresh and concentrate Cut-back strawberry juices during frozen storage at -18°C . The obtained results showed a gradual

increase in L^* of fresh strawberry juice during frozen storage by about 32.6% at the end of frozen storage after 6 months. While, the L^* value of concentrate Cut-back strawberry juice was almost constant during frozen storage at -18°C . Slightly increase in a^* and b^* values for concentrate Cut-back strawberry juice compared with fresh strawberry juice. The colour was highly unstable during long-term frozen storage because the serious colour changes that occurred. These changes in the two types of strawberry juice can be explained by the conversion of monomeric form of anthocyanins to polymeric form reducing the colour intensity; also the developing of brown colour which not hastened destruction of red colour concerning the b^* value in the case of fresh strawberry juice. These obtained results are in harmony with those of Poiana *et al.* (2010) and Sriwattana *et al.* (2015).

Viscosity

Fig. 5 shows the viscosity of fresh and concentrate Cut-back strawberry juices. The concentrate cut back strawberry juice was more viscous than the fresh juice. This was due to the concentration process where the Brix degree of concentrate Cut-back strawberry juice was higher than fresh juice reflecting the high soluble solids content; 22.3° versus 6.2° . The freezing time caused a slight effect on the juice consistency. The obtained results showed non-pronounced decrease in the viscosity of the two types of strawberry juices and this could be explained by the decrease of pectin fraction through the chemical and enzymatic modifications which can interfere with juice quality as reported by Lisiewska and Kmiecik (2000).

Conclusion

The freezing time had significant impact on chemical and physical properties for both types of strawberry juices, however the concentrate Cut-back strawberry was the best for all chemical and physical properties during freezing storage for 6 months, it was more acceptable compared to fresh juice by panelists. So, concentration process maintain the quality attributes of the juice during freezing storage not more than 3 months.

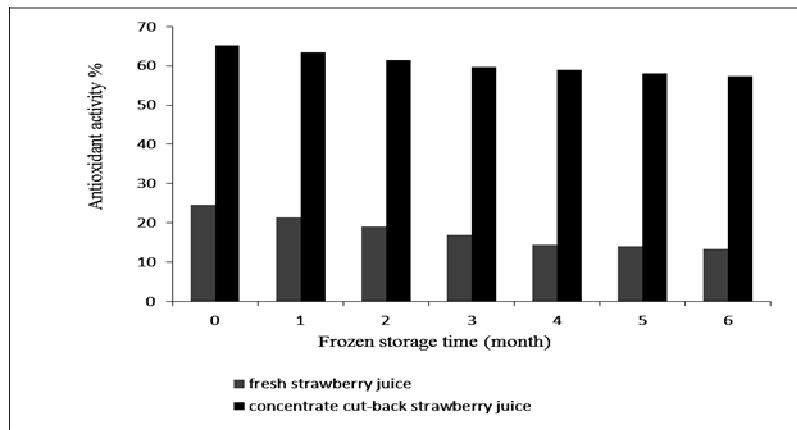


Fig. 3. Antioxidant activity of fresh and concentrate Cut-back strawberry juices during frozen storage at -18°C

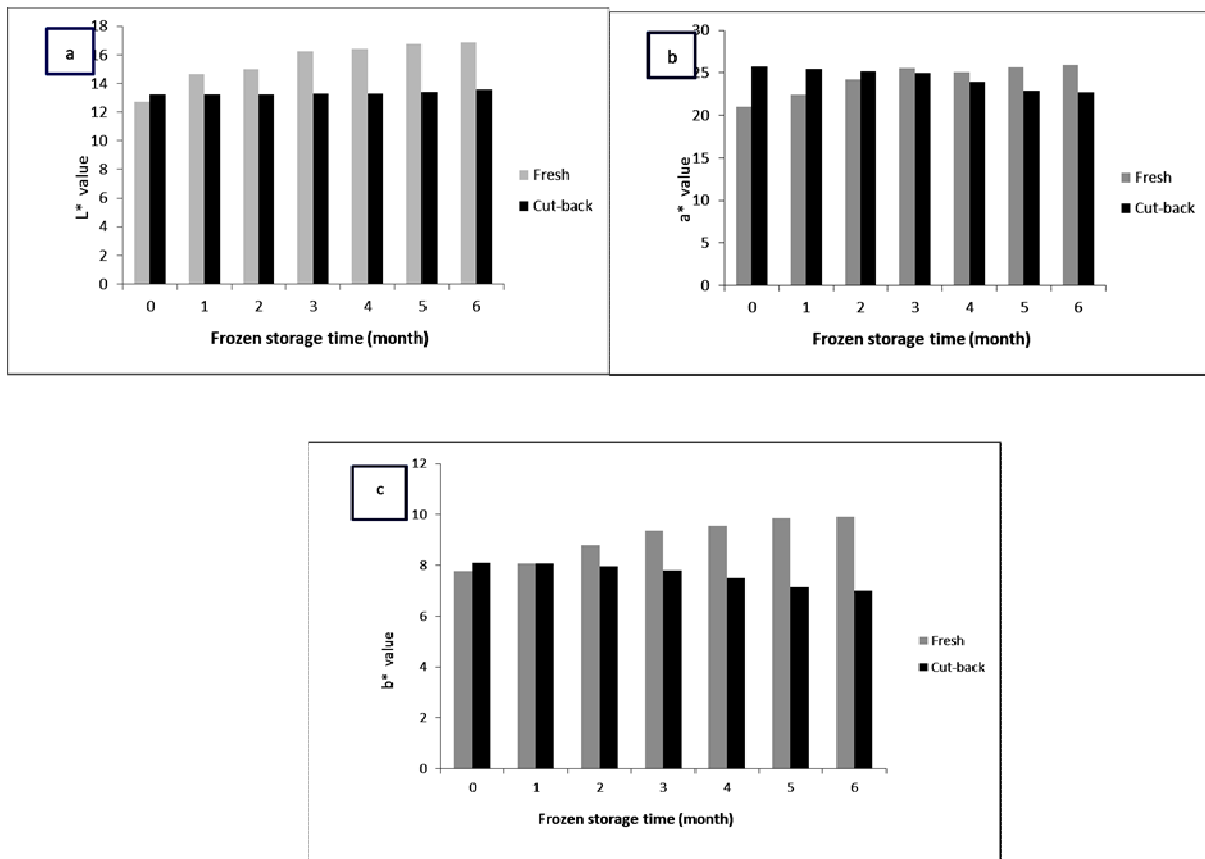


Fig. 4. Colour parameters; L*, a* and b* of fresh and concentrate Cut-back strawberry juices during frozen Storage at -18°C

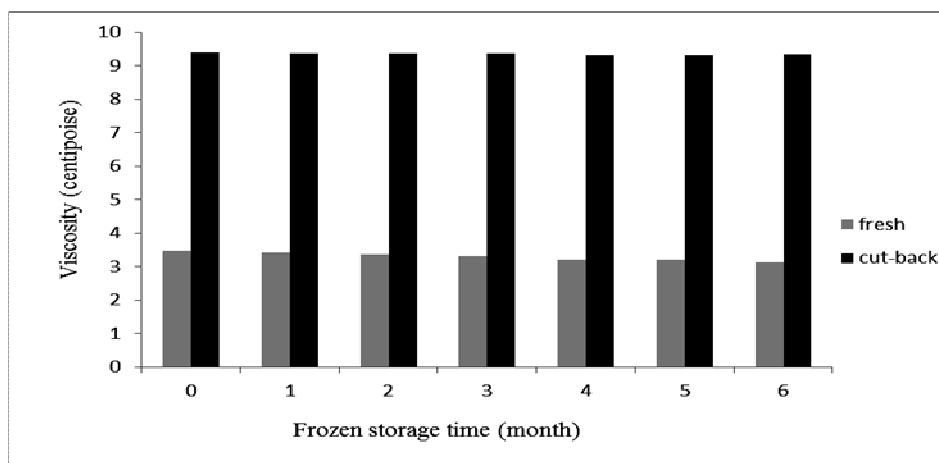


Fig. 5. Viscosity of fresh and concentrate Cut-back strawberry juices during frozen Storage at -18°C

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تأثير التخزين بالتجميد على جودة عصير الفراولة الطازج والمركز بطريقة Cut-back

فتحي محمد محمد فتحي - محمد رجب عبد المجيد- حسن علي إبراهيم صليحة- عبدالرحمن محمد سليمان

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تهدف هذه الدراسة الي تقييم تأثير التخزين بالتجميد علي درجة حرارة -18م لمدة 6 شهور علي خواص الجودة لعصير الفراولة الطازج و Cut-back المركز، أظهرت النتائج المتحصل عليها أن عصير الفراولة Cut-back المركز أكثر قبولا من قبل المحكمين، كما وجد انخفاض معنوي في الحموضة بعد التجميد لكلا النوعين من عصير الفراولة حيث انخفضت بنسبة 51,8 و 55% لكل من عصير الفراولة الطازج و Cut-back المسترجع، على التوالي، ولقد وجد نفس الإتجاه مع محتواها من فيتامين C حيث انخفضت بعد 6 أشهر من التخزين المجمد بحوالي 36,53% لكل من عصير الفراولة الطازج و Cut-back المركز على التوالي، وازداد رقم الحموضة بنسبة 14,9 و 17,9% لكل من عصير الفراولة الطازج وال Cut-back المركز على التوالي، وكان لعصير الفراولة Cut-back المركز قبل التجميد محتوى عالي من حمض الفيربولىك والريزورسينول والكيورسيتين وكانت مرتفعة بنسبة 142,7 و 268,7 و 18,9% على التوالي عنها في عصير الفراولة الطازج. علاوة علي ذلك كان مركب الكيورسيتين هو المركب السائد كما لوحظ زيادة تدريجية في محتوى كايفيرول لكلا النوعين من العصير بزيادة فترة التخزين المجمد، وأظهر عصير الفراولة Cut-back نشاطا مضادا للأكسدة ولزوجة مرتفعة عن العصير الطازج ولكن كان هناك إنخفاض بسيط في اللزوجة لكلا نوعين العصير بعد التخزين علي -18م لمدة 6 أشهر، وأظهر اللون عدم الثابت خلال التخزين المجمد علي -18م حيث أزدادت قيم اللون لعصير الفراولة الطازج *a، *b، *L من 12,73، 21,00 و 7,77 إلى 16,89، 25,94 و 9,91 على التوالي ولكن في حاله عصير الفراولة Cut-back أزدادت قيمة *L من 13,23 إلى 13,55 ولكن وجد انخفاض في قيم *b، *a من 25,75، 11,25 و 8,11 إلى 22,68، 7,00 و 7,00 على التوالي، ولوحظ من نتائج البحث أن عصير الفراولة المركز بطريقة Cut-back كان الافضل بعد التخزين المجمد لمدة 6 أشهر.

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