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Effects of Brix, processing techniques and storage temperature on the quality of carambola fruit cordial

Salmah Yusof & Lee Kok Chiong

Faculty of Food Science and Biotechnology, University Pertanian Malaysia, 43400, UPM Serdang, Selangor, Malaysia

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Two methods of processing carambola fruit cordial were compared using a cold method (CM) and a hot method (HM). Characteristics of the freshly prepared product were compared. Samples were later prepared at 35°, 45° and 55° Brix concentrations and stored at 25°C and 5°C. The responses measured during storage were changes in pH, titratable acidity, ascorbic acid content, Brix, viscosity, colour, pulp sedimentation and sensory attributes of colour and taste. The pH remained stable during storage but did not show any correlation with titratable acidity, which fluctuated. The ascorbic acid content decreased. Temperature seemed to have an effect on Brix and viscosity values, colour and pulp sedimentation. The 35° and 45° Brix CM cordials stored at 5°C were more acceptable in terms of colour and taste. CM did not seem to be a feasible technique for producing cordial from fresh fruit. © 1997 Elsevier Science Ltd. All rights reserved

INTRODUCTION

Ready-to-drink fruit juices, squashes, cordials and concentrates are the forms of fruit drink preparations that are now popular in the Malaysian market. Technically, the main difference between the four types are their soluble solids (Brix) contents, which actually dictate the way each product is to be consumed. Each has inherent traits which contribute to its selling point. For example, the ready-to-drink juices are immediately consumable from handy attractive packages. Squashes and cordials need to be diluted about 1–4 times the initial volume before being used. Both products contain sugar, and drinks are prepared just by adding water to the required sweetness. A squash is not the same as a cordial even though this terminology is often used interchangeably. The main difference between a squash and a cordial is that squashes contain fruit pulp whereas cordials are clear products with fruit or non-fruit flavouring (Girdhari *et al.*, 1959). However, in this report the term cordial is still used to refer to a squash in order to avoid confusion by many readers.

To date, many types of fruits are processed into ready-to-drink juices. Other than orange, mango and litchi (the pulps of which are imported) and guava, no other locally available fruits have been prepared into a fruit cordial. Most of the fruit cordials that are available have been produced using the cold method, i.e. no heat is employed to preserve the flavour of the product. Since, at the time these experiments were conducted, no aseptically processed carambola puree was available commercially, the use of the cold technique alone might not have resulted in a stable product; therefore the normal method of using heat was also employed for comparison.

The objectives of this study were thus to compare the effects of processing carambola fruit (starfruit) cordial using two different techniques (i.e. the hot and the cold methods), as well as to determine the effects of sugar (Brix) concentration and storage temperature on the characteristics of the stored product.

MATERIALS AND METHODS

The commercial starfruit variety (B10), which has a slightly acidic taste compared to B17, was used for the study. The fruits were purchased from a supplier in Serdang at their prime ripe stage with a bright orange–yellow colour. The fruits were washed, and the ridges removed before slices were cut longitudinally along the ridges. For the cold processing technique (CM), the cut slices were first steam-blanched for 4 min before extracting the juice, while for the hot processing technique (HM) the cut slices were macerated immediately with 25% water added (percentage based on weight of fruit) to facilitate the extraction of juice. The juice from blanched slices was extracted in a similar manner. (The water used in this experiment was pure water which had undergone a series of filtration stages to remove various organic and inorganic impurities, as well as treatment with a UV lamp to kill any microbes present.) The juice obtained was filtered. For CM, the other ingredients (70% sugar, 0.1% of 20% sodium carboxymethylcellulose solution, 0.2% of 50% citric acid solution, and 0.3% of 20% sodium benzoate solution) were added and homogenized together. For HM, the filtered juice was pasteurized and, while cooling, the other ingredients were stirred in. The prepared cordials were evaluated for their physical and chemical characteristics of pH, titratable acidity, Brix, colour, flavour and taste, after dilution, as well as determination of whether there was a difference in the final product obtained from the two processing techniques using a triangle sensory test.

The second part of the experiment involved processing of cordial for a storage study. The products were processed again following the data obtained from the initial trial. The CM and HM cordials were processed at three different Brix concentration (35°, 45° and 55°B). Based on results of the test done in the first part of the experiment, the pH of samples was adjusted to 3.2. The products were then stored at 5°C and 25°C and observations were made weekly for pH, titratable acidity and ascorbic acid content (Ranganna, 1977). Viscosity was determined with a viscometer (Brookfield Model LVF) equipped with a UL adaptor for single strength juice and spindle No. 3 for more viscous solutions. Brix was determined using an Abbe hand refractometer and colour was measured using the Hunter calorimeter. Pulp sedimentation was determined after 72 h by measuring the sediment height of the product in a 100 ml graduated cylinder. Sensory testing was conducted every 2 weeks. Fifteen semi-trained panellists were asked to indicate their liking for colour using an unstructured hedonic scale of 1–10 (1, dislike most; 10, like most) and to rank their taste preferences for the samples in the order of preference (1, most preferred; 10, least preferred).

RESULTS AND DISCUSSION

Quality of freshly prepared product

The properties of products obtained from the initial run are shown in Table 1. The Brix values of samples prepared in the first and second trials varied slightly due to variation in fruit quality obtained in the different batches. The pH of the product as prepared from a standard formulation in trial 1 was around 3.8; upon dilution (cordial:water 1:4), the juice tasted merely plain sweet, indicating an imbalance of the acid:sugar ratio in the product. Trials were then conducted to determine the right acidity range for the product by adding a known amount of acid to the cordial, diluting it and then tasting it. From this test it was found that a pH reading of 3.2 gave a balanced acid:sugar ratio which was able to enhance the flavour of the final drink prepared. Thus, in the second trial, the pH of the products was adjusted to 3.2.

Table 1. Physicochemical properties of starfruit squash prepared by the cold and hot methods

	Cold method		Hot method	
	1st trial	2nd trial	1st trial	2nd trial
Brix	45.2	44.2	45.8	44.8
pH	3.87	3.2	4.04	3.2
Titratable acidity	—	0.37	—	0.35
Taste	Plain sweet	Good	Plain sweet	Good
Colour	Yellow	Yellowish	Brownish	Brownish
Flavour	Strong	Strong	Slightly burnt	Slightly burnt

The cordial prepared by CM had a more natural fruit flavour than that prepared by HM, which produced a slightly burnt taste. In terms of colour, CM produced a product with a more attractive yellow colour whereas HM produced a slightly darker colour. Results of a triangle test to determine whether there was a difference in product appearance showed that there was a significant difference in the colour of the product prepared by the two techniques. However, panellists did not object to the colour of the sample prepared by HM; some preferred the slightly burnt taste. The most important attribute that needed to be improved at this point was the taste after dilution, as mentioned above.

Quality of product during storage

pH and titratable acidity

There were no significant changes in pH values of products stored at both temperatures; therefore data are not shown. The titratable acidity readings fluctuated during storage (Fig. 1a and b). CM samples with lower Brix values of 35°B and 45°B stored at both temperatures seemed to fluctuate in acidity more than the other samples.

Ascorbic acid

The ascorbic acid (or vitamin C retention) values during storage of products at ambient temperature and 5°C are shown in Fig. 2a and b. It was apparent that, even before storage, CM samples had higher amounts of ascorbic acid compared to HM samples. This could be because the heat employed during processing of HM samples could have destroyed the ascorbic acid present in the product. Similar to previous reports (Berk & Mannheim, 1986; Garcesto & Alabastro, 1983), the ascorbic acid values decreased during storage and the rates of decrease were much faster for the HM samples both at room temperature and at 5°C than for CM

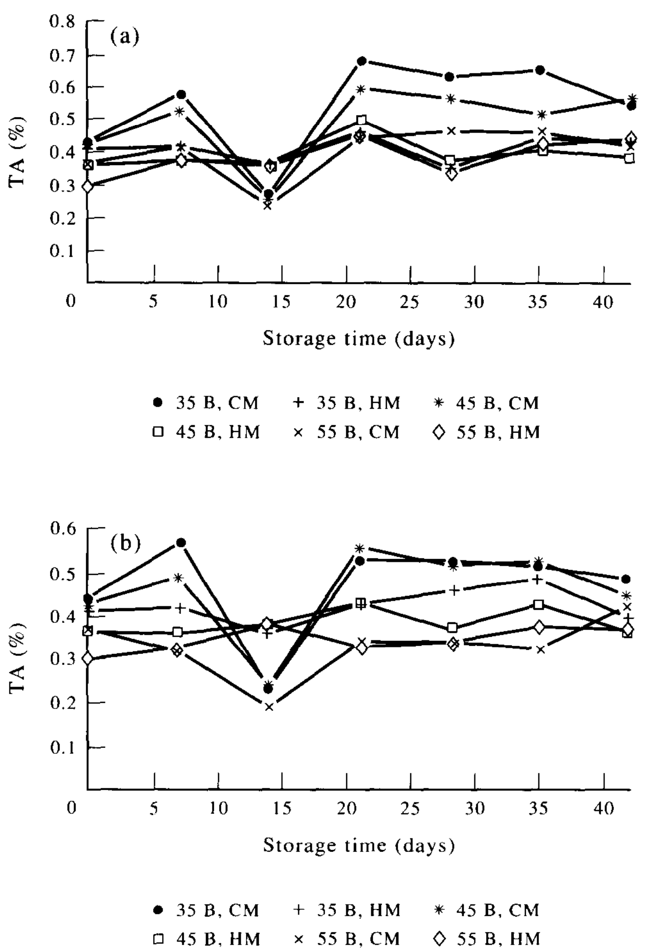

Fig. 1. (a) Effect of Brix content and processing technique on TA of starfruit cordial during storage at 25 °C. (b) Effect of Brix content and processing technique on TA of starfruit cordial during storage at 5 °C.

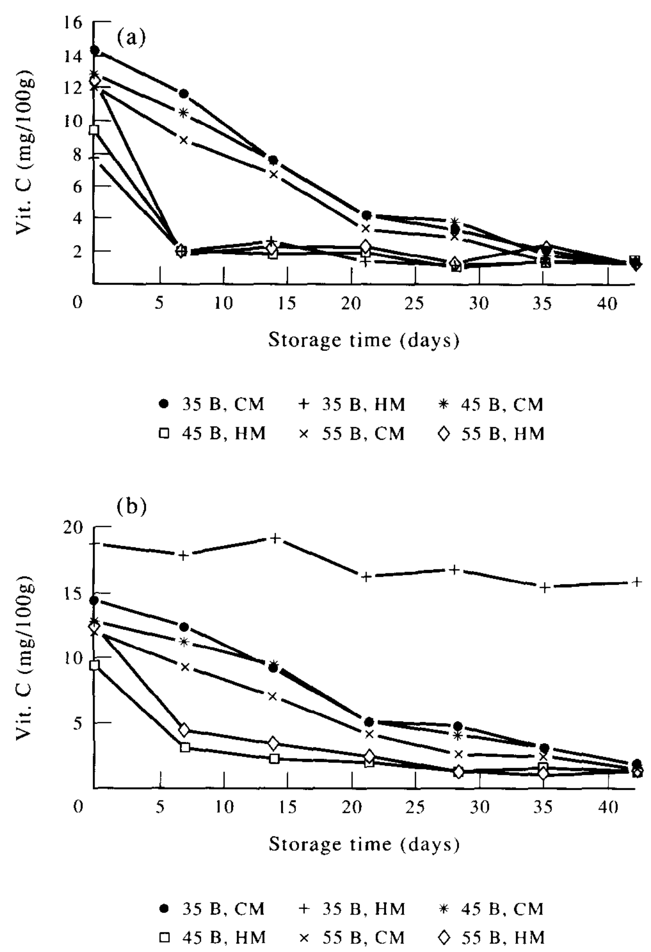

Fig. 2. (a) Effect of Brix content and processing technique on Vit. C content of starfruit cordial during storage at 25 °C. (b) Effect of Brix content and processing technique on Vit. C content of starfruit cordial during storage at 5 °C.

samples. After 1 week of storage, HM samples stored at 25 °C had already lost 75–86% of their ascorbic acid content while CM samples lost only 18–26% within the same period. A similar trend occurred in samples stored at 5 °C. HM samples lost higher amounts of ascorbic acid than CM samples, but the amount was not as high as those stored at 25 °C. Ascorbic acid loss also seemed to be affected by the Brix value of the samples. Those with higher Brix were found to lose more ascorbic acid than those with lower Brix. The rates of loss in CM samples were more gradual. However, at the end of the storage period, all the samples seemed to have lost most of their vitamin C content and retained only about 2 mg per 100 g sample.

Brix

The Brix of samples decreased during storage. The amount of decrease was higher in samples stored at ambient temperature (25 °C) (Fig. 3a) than at 5 °C (Fig. 3b). At both storage temperatures, CM samples showed a higher decrease than HM samples and this was especially significant at room temperature. Slight decreases in Brix readings may be expected to occur during storage; however, relatively large decreases, as occurred in the 35 °B and 45 °B samples stored at 25 °C, indicated that the product had spoiled. This was found to be true after the sensory evaluation test. The decrease in Brix might be due to fermentation of sugars by microbes which ultimately results in the product being unacceptable.

Viscosity

Sugar contributed to the viscous flow characteristics of product (Lakshminarayana Rao *et al.*, 1985). The higher the amount of sugar present, the more viscous was the product. It was observed that the initial increase in viscosity of product upon addition of sugar was not the same for the different Brix concentrations (Fig. 4a Fig. 4b). Even though there were equal 10° Brix differences in the readings between 35 °B to 45 °B and 45 °B to 55 °B, the increase in viscosity for the 55 °B sample was not proportional to the increase between 35 °B and 45 °B. The differences in viscosity for samples between 35° to 45 °B and 45° to 55 °B were, respectively, 4.2 cm s^{-1} and 12.1 cm s^{-1} for CM, and 0.8 cm s^{-1} and 36.7 cm s^{-1} for HM. The sample that was prepared by

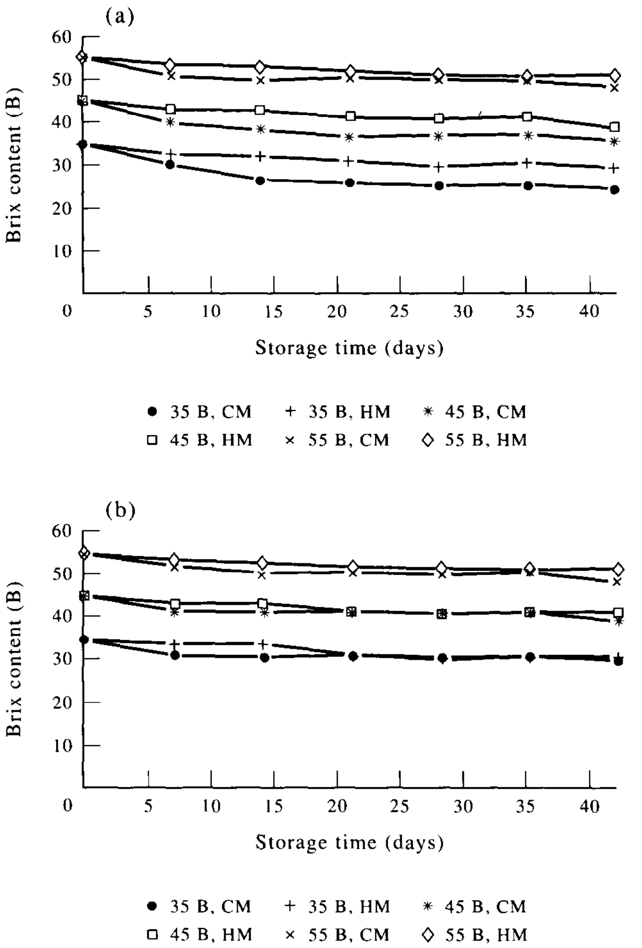

Fig. 3. (a) Effect of Brix content and processing technique on Brix content of starfruit cordial during storage at 25 °C. (b) Effect of Brix content and processing technique on Brix content of starfruit cordial during storage at 5 °C.

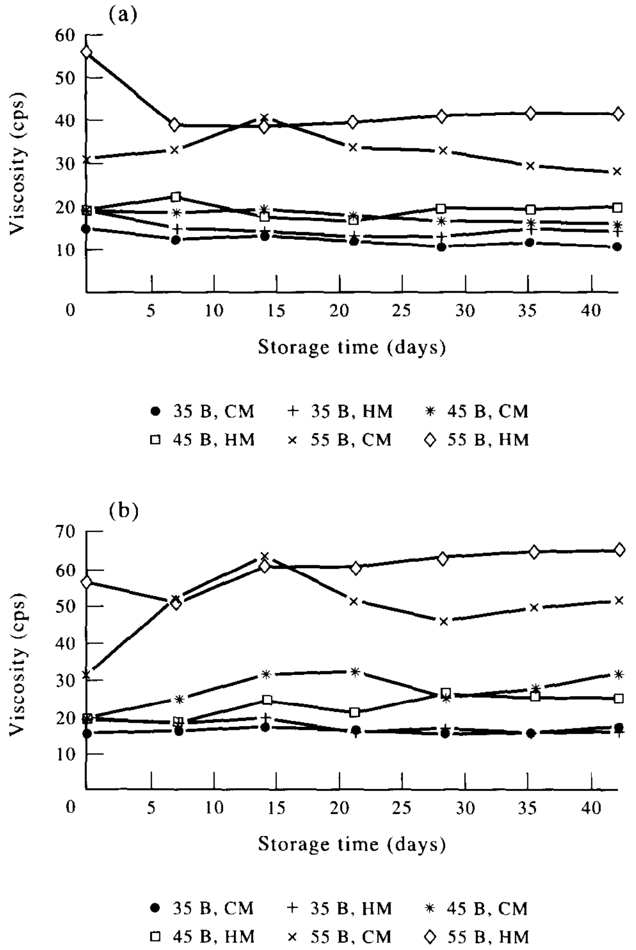

Fig. 4. (a) Effect of Brix content and processing technique on viscosity of starfruit cordial during storage at 25 °C. (b) Effect of Brix content and processing technique on viscosity of starfruit cordial during storage at 5 °C.

HM underwent an increase in viscosity (56.3 cm s^{-1}) almost three times that at 45 °B (19.9 cm s^{-1}), while the sample prepared by CM was only about one and a half times more (31.7 cm s^{-1}).

Concomitantly with the reduction in Brix (or sugar breakdown) for CM samples stored at 25 °C (Fig. 4a), the viscosity values of these samples also decreased, indicating that there were some positive correlations in the changes. However, in cold storage (5 °C) (Fig. 4b) the CM samples showed higher readings. It is presumed that, apart from microbial activity, the change in viscosity in these samples could also be due to enzyme activity. Blanching the fruit slices, as done in the sample preparation stage for CM, was perhaps not sufficient to inactivate the enzyme pectin esterase. Meanwhile HM samples showed a slight increase in viscosity values after 28 days of storage.

Pulp sedimentation

Processing technique, Brix and storage temperature seemed to affect pulp sedimentation (Table 2). HM samples stored at 25 °C exhibited pulp sedimentation as early as 1 week after storage at 25 °C and 2 weeks at 5 °C. Lowering the storage temperature seemed to prolong pulp stability. Brix concentration seemed to influence the amount of sedimentation in samples that were stored in the cold (5 °C). The higher the Brix of the sample (i.e. the more viscous the product), the less was the sediment. However, this pattern was not seen in samples stored at 25 °C. Especially for HM samples, there seemed to be no difference in sedimentation between those at 35 °B and those at 45 °B. On the other hand, CM samples began to sediment only after 2 weeks of storage; even then only those at the low Brix concentration (35 °B) showed sedimentation. The 45 °B concentration stored at 25 °C sedimented after 35 days, while the one stored at 5 °C, and those at 55 °B stored at both 25 °C and 5 °C, showed no sedimentation at all. From these observations, it is apparent that carboxymethylcellulose was able to function more effectively as a stabilizer in the CM system where no heat was employed during processing. Heating, as undergone by the HM samples, might have depolymerized the compound (Glicksman, 1969), resulting in loss of viscosity (Rao *et al.*, 1981) and ability to suspend colloidal matter.

Table 2. Percentage pulp sedimentation during storage of squash

	Days of storage					
	7	14	21	28	35	42
Storage temperature: 25 °C						
Cold method						
35 °B	0^{d}	7.1^{e}	8.3^{d}	9.3^{d}	8.1^{d}	9.1^{d}
45 °B	0^{d}	0^{i}	0^{h}	0^{g}	8.2^{d}	5.1^{u}
55 °B	0^{d}	0^{i}	0^{h}	0^{g}	0^{f}	0^{g}
Hot method						
35 °B	13.1^{b}	14.1^{b}	16.1^{b}	15.1^{b}	20.1^{b}	17.1^{b}
45 °B	20.1^{b}	21.2^{a}	6.1^{e}	20.1^{a}	14.1^{c}	20.1^{a}
55 °B	7.2^{c}	9.1^{d}	5.1^{f}	11.2^{c}	0^{f}	0^{h}
Storage temperature: 5 °C						
Cold method						
35C	0^{d}	2.1^{h}	8.2^{d}	9.3^{d}	8.1^{d}	9.1^{d}
45 °B	0^{d}	0^{i}	0^{h}	0^{g}	0^{f}	0^{u}
55 °B	0^{d}	0^{i}	0^{h}	0^{g}	0^{f}	0^{u}
Hot method						
35 °B	0^{d}	13.1^{c}	13.1^{b}	11.1^{c}	14.3^{c}	14.1^{c}
45 °B	0^{d}	4.1^{f}	10.1^{c}	8.1^{e}	17.2^{b}	8.2^{e}
55 °B	0^{d}	3.1^{g}	3.1^{g}	3.1^{f}	3.1^{e}	3.1^{g}

Data are averages of duplicate observations.
Numbers within a column with similar superscripts are not significant at $P < 0.05$.

Colour and taste

Colour and taste are the two major factor determining the acceptability of squashes. Mean L values for the stored product are shown in Fig. 5a and b. There were no significant changes in the brightness of samples stored at 5 °C, except for the 35CM samples. For those stored at room temperature, the L values of 35CM, 35HM and 45CM samples were quite stable until 35 days of storage, after which the L value of the 45CM sample decreased. The L value of the 55HM sample increased, indicating that the sample had become brighter, perhaps through decolorization of carotenoids, and 1 month later decreased, indicating that browning had occurred. Significant changes also occurred in 45HM samples. The b values of HM samples stored at room temperature (Fig. 6a) generally decreased, whereas those of CM samples remained fairly stable. At cold storage (5 °C) (Fig. 6b), the b values of all samples generally did not change except for the initial rise in the 35 °B sample and a slight increase for the 45 °B sample after 35 days of storage. These changes are unexplainable. Meanwhile HM samples showed slight increases in b values after 28 days of storage.

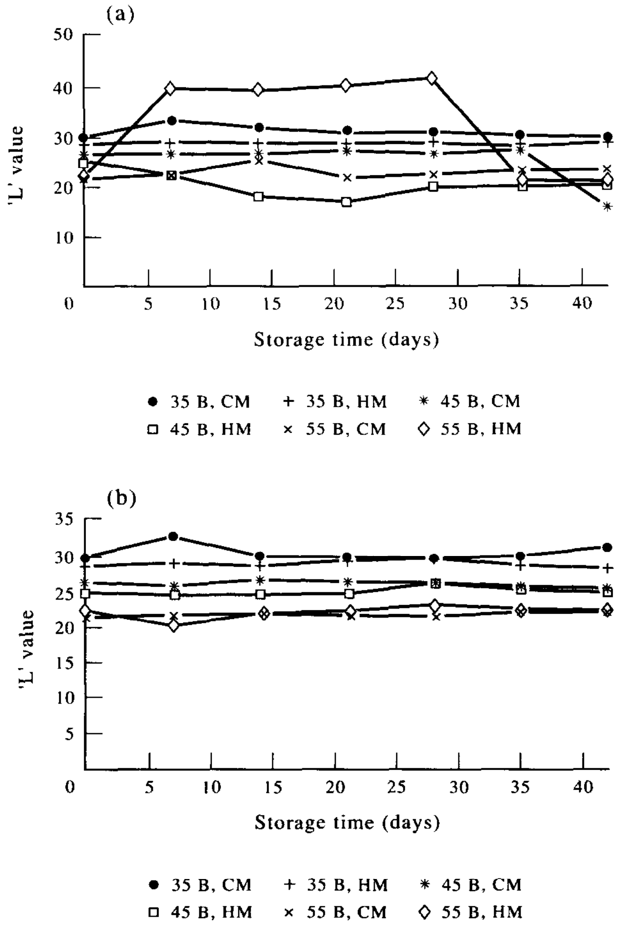

Fig. 5. (a) Effect of Brix content and processing technique on L value of starfruit cordial during storage at 25 °C. (b) Effect of Brix content and processing technique on L value of starfruit cordial during storage at 5 °C.

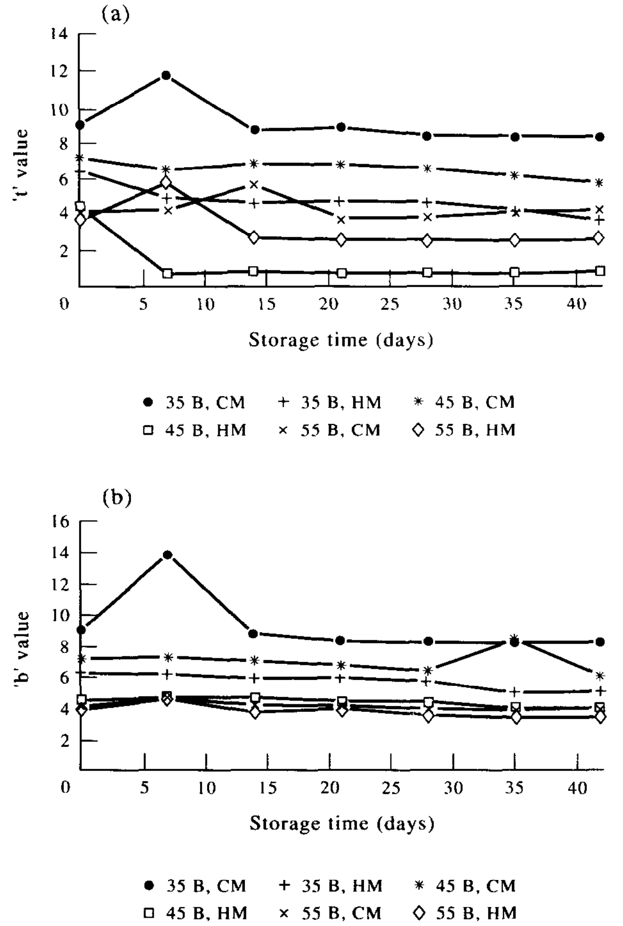

Fig. 6. (a) Effect of Brix content and processing technique on b value of starfruit cordial during storage at 25 °C. (b) Effect of Brix content and processing technique on b value of starfruit cordial during storage at 5 °C.

Table 3. Sensory results on colour and taste of squash

Sample		Days of storage					
		Average colour scores			Average rank total for taste		
		0	14	28	0	14	28
HM35	R	3.77	3.92	3.09	2.53	3.95	5.06
	C	3.77	5.29	5.53	—	4.6	4.53
HM45	R	3.7	—	—	2.87	—	4.2
	C	3.7	5.49	4.88	—	4.87	5.2
HM55	R	4.52	2.94	3.07	4.27	5.93	4.93
	C	4.52	3.71	5.3	—	5.06	7.53
CM35	R	—	—	—	3.07	—	—
	C	7.25	8.14	7.21	—	2.73	3.87
CM45	R	—	—	—	3.47	—	—
	C	7.42	8.5	8.17	—	2.87	4.87
CM55	R	—	—	—	4.8	—	—
	C	4.98	7.8	7.22	—	6	4.47

Data are average responses of 15 panellists.
R = samples stored at 25 °C. C = samples stored at 5 °C.

Sensory results on colour of undiluted squash showed that CM samples obtained higher scores than HM samples (Table 3). The most preferred sample was CM 45 °B stored at 5 °C. The sample obtained the highest average score: 7.42 at 0 days and 8.17 after 28 days of storage. Taste evaluation was done on the diluted juice (1:4, cordial:water). In this case, the lower value indicates better preference. At 0 days (i.e. when the sample was fresh), the panellists showed most preference for the 35HM sample. The sample they disliked most was 55CM, because of insufficient acidity and lack of fruit flavour. After storage, the most preferred sample was 35CM stored at 5 °C.

CONCLUSIONS

Results of this experiment showed that carambola fruit can be accepted as a cordial. Samples prepared by the hot technique (HM) were more stable than by the cold technique (CM) even though CM yielded products with good initial colour and flavour. In the industry, CM has been the common method used for cordial processing and has proved to be feasible. Products are normally stored at ambient temperature. A follow-up study is now being planned using aseptically processed carambola puree which is now available. This should remedy or at least minimize spoilage caused by microbes and enzymes.

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