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Studies on commercially canned juices produced locally in Saudi Arabia: Part 3—Physicochemical, organoleptic and microbiological assessment

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Single-strength canned apple and pineapple juices (SSAJ and SSPJ) were obtained from a commercial canning plant in Saudi Arabia and were stored at controlled temperatures of 5, 24 and 42°C and under ambient warehouse conditions (average 33°C) for a 12-month period. Changes during storage in physicochemical (ascorbic acid, sucrose, reducing sugars, acidity, pH and vacuum), microbial, and sensory characteristics were studied to determine the effect of storage time and storage temperatures on the quality. Losses in vitamin C content of apple juice (AJ) and pineapple juice (PJ) stored for 12 months in the warehouse under Saudi Arabian conditions were 45·8% and 49·8%, respectively. The decrease in ascorbic acid, sucrose and vacuum and increase in reducing sugars were linearly related to the storage time. The increase in the reducing sugars was due to the hydrolysis of the sucrose under these conditions. Based on the results of sensory evaluation on month 12 of storage, panellists were able to detect significant changes in quality attributes among samples stored at different temperatures. The overall acceptability of the AJ stored at the warehouse temperature was rated as neither like nor dislike and PJ stored under the same conditions was also rated as 'neither like nor dislike', on a 9-point hedonic scale. Microbial analysis of the two types of juices revealed the absence of aerobic plate counts, coliforms, sporeformers and yeasts and moulds either on the initial analysis (month 1) or on month 12 of storage at the four different temperatures.

INTRODUCTION

This work complements previous studies on commercially canned juices produced locally in the largest commercial plant in Saudi Arabia (Ewaidah, 1988; Ewaidah, 1990).

In recent years the local manufacturing of canned juices in Saudi Arabia has increased steadily. Juices are stored in warehouses and groceries for extended periods of several months, and yet no study has been conducted regarding the effect of the storage conditions (temperature–time) on the quality characteristics of canned juices under Saudi Arabian climate conditions. The quality of the canned juices is a function of the physicochemical properties (acidity, pH, total soluble solids (TSS), sugars, colour, viscosity, vacuum, vitamin C), microbiological and organoleptic characteristics. Many studies have shown that quality characteristics of canned fruit juices can be affected during the storage period; for example, browning of apple juice during storage (Toribo & Lozana, 1984; Toribo *et al.*, 1984; Smith & Cline, 1984), developing an off-flavour in orange juice (Tatum *et al.*, 1975; Aharoni & Houck, 1982), browning and loss in vitamin C of single-strength orange juice (Trammell *et al.*, 1986), decrease in vitamin C, Hunter colour values and taste panel scores of orange juice (Marcy *et al.*, 1984), loss in total free amino acids of apple juice (Babsky *et al.*, 1986) and degradation in the colour of grape juice (Montgomery *et al.*, 1982).

The aim of this study was to evaluate the effect of storage temperature and storage time on the chemical, physical, microbial and sensory characteristics of canned apple juice (AJ) and pineapple juice (PJ) produced in the largest commercial plant in Saudi Arabia in order to make recommendations with regard to the most suitable conditions for canned juices.

MATERIALS AND METHODS

Sampling

This study was conducted during September 1985 and September 1986. Canned single-strength apple juice (SSAJ) and pineapple juice (SSPJ) from concentrates packed in tin cans, were obtained from the largest commercial plant in Saudi Arabia. Samples were collected in three different production periods and were coded accordingly. Three different code lots for each type of canned juice were collected with a total of 12 cartons for each type of juice. Thus 24 cartons (each containing forty-eight 6 oz cans) were obtained from two types of juice. Samples were kept in one of the three temperature-controlled rooms for 1 year: 5 ± 1°C; 24 ± 1°C and 42 ± 1°C. In addition, a fourth storage temperature — warehousing conditions, where temperatures ranged between 20 and 43°C during 1 year's storage (average warehouse temperature was 33°C) was used.

For analysis, six cans were drawn randomly from each of the three different code lots at monthly intervals for 1 year; the 18 cans for each temperature condition were thoroughly mixed to form a composite sample for each juice.

Chemical and physical analyses

Sugars were determined by the Lane and Eynon Volumetric method described in the AOAC (1980). The acidity was determined by titrating the samples with 0·1 N NaOH and was expressed as per cent citric acid according to AOAC (1980) procedures. Also, AOAC (1980) procedures were used for the determination of vitamin C.

pH was measured using a pH digital meter (Jenwey, Model PHM 10) standardised with pH 2 buffer and pH 7 buffer. Vacuum measurements were made with a Flip Vacuum Gauge graduated from 0 to 30 in of Hg.

Sensory evaluation

Sensory evaluation was carried out on the AJ and PJ after 12 months of storage at 5, 24, 33 and 42°C. The colour, flavour and overall acceptability of the samples were rated on a 9 point hedonic scale in which 9 = like extremely and 1 = dislike extremely (Larmond, 1970). Assessment was carried out by 19 experienced panellists selected from the Food Science Department Staff (King Saud University, Saudi Arabia). Juice samples were placed in individual white plastic containers, coded with a three-digit randomised number and served in a randomised order for evaluation. The panellists were provided with water (20°C) for mouth rinsing between samples and judged the samples in a room under diffusion of light at room temperature. Judges were asked to evaluate four samples in each session.

Microbial analyses

The initial microbial analysis was conducted on the first month of the manufacturing date and a second analysis on the last month of the expiry date. All four types of juice were subjected to the following microbial analysis according to the procedures described in the Compendium of Methods for the Microbiological Examination of Foods (APHA, 1987).

(1) Total plate count	(TGEA, 32°C/48h)
(2) Total coliforms	(VRB, 37°C/24h)
(3) Yeasts and Molds	(APDA, 25°C/5 days)
(4) Sporeformers	(TGEA, 32°C/48h)

Statistical analysis

Statistical analysis was performed for the two-factor experiment as outlined by Steel and Torrie (1980). Both factors (temperature, time) were considered fixed and the interaction between the two factors was used as the error term.

As the objective of the present investigation was to study the response of the different quality characteristics (Y) to storage periods under different temperatures, the following quadratic regression model was used.

$$Y = a + b_1X_1 + b_{11}X_1^2$$

where Y = quality characteristics; a = intercept; b_1 = linear regression coefficient; b_{11} = quadratic regression coefficient and X_1 = storage period in months (time).

The significance of the regression coefficient was tested using the remainder mean square. As the quadratic coefficient was not significant for all the characteristics under test, only the linear regression model was considered (Steel & Torrie, 1980).

Sensory data were subjected to analysis of variance (Steel & Torrie, 1980) and significant differences among the means were determined using Duncan's New Multiple Range Test (DMRT). The analysis was carried out using SAS computer programs.

RESULTS & DISCUSSION

Physical and chemical characteristics

Table 1 shows the initial physico-chemical composition of commercially canned AJ and PJ. The results show the following quality factors values for AJ and PJ respectively: Per cent titratable acidity (0·810 and 0·977), pH (3·460 and 3·498), and Brix to per cent acid ratios (14·8 and 13·3). The acidity of PJ was slightly higher than that of AJ. The vitamin C content of PJ was higher than that of AJ (61·1 and 50·9 mg/100 g) respectively. The vacuum values inside the cans were approximately the same in the two types of juice. Also, the reducing sugar percentages were the same in the

Table 1. Quality factors of commercially canned SSAJ and SSAP

Quality factor	Apple juice	Pineapple juice
	Mean (± SD)	Mean (± SD)
Acid (%)	0·810[a] (0·010)[b]	0·977 (0·006)
pH	3·46 (0·20)	3·498 (0·011)
Brix	12·0 (0·20)	13·0 (1·00)
Brix/% acid	14·8 (0·43)	13·3 (1·09)
Viscosity (Centipoise)	1·40 (0·100)	2·50 (0·095)
Vitamin C (mg/100g)	50·9 (0·03)	61·0 (0·33)
Benzoic acid	nil	nil
SO_2 (ppm)	147 (7·02)	202 (4·04)
Vacuum (in Hg)[c]	17·7 (0·66)	18·0 (0·07)
Reducing sugars (%)	7·14 (0·14)	7·10 (0·17)
Sucrose (%)	1·59 (0·20)	2·25 (0·09)

[a] Each value represents a mean of a duplicate determination of three different case lots.
[b] Values in parenthesis represent standard deviation.
[c] Each value represents a mean of 24 measurements of three different code lots.

two types of juices (7·1%) while the sucrose percentages varied from 1·59% in AJ to 2·25% in PJ.

The Brix, acidity and Brix/acid ratio for canned AJ and PJ meet the Saudi Arabian Standards (SASO, 1981, 1982). However, the level of sulfur dioxide in AJ was higher than that set by the Saudi Arabian Standards Organization (10 mg/kg) (SASO, 1982).

Figures 1 and 2 show the level of vitamin C in canned AJ and PJ, respectively, as a function of storage temperature and storage time.

Results show that, as the storage time proceeded, the vitamin C contents of juices stored at 5, 24, 33 and 42°C gradually decreased. Also, the loss in vitamin C content increased with increasing storage temperature. For example, after 12 months of storage at 5, 24, 33 and 42°C, the losses in vitamin C were 15·7, 27·6, 45·8 and 73·2% respectively for AJ while those for PJ were 20·7, 32·8, 49·8 and 80·6% respectively. Results obtained in this study are in agreement with those reported by Ewaidah (1988) who found that the vitamin C losses of orange juices after 12 months storage at 5, 24, 33 and 42°C were 10·4, 15·8, 37·7 and 71·6% respectively. A significant difference ($p < 0.05$) in vitamin C levels of AJ and PJ stored at 42°C and those stored at 5, 24, and 33°C was found. However, no significant difference in the vitamin C level of juices stored at 33 and 24°C was found (Table 2). Marcry *et al.* (1984)

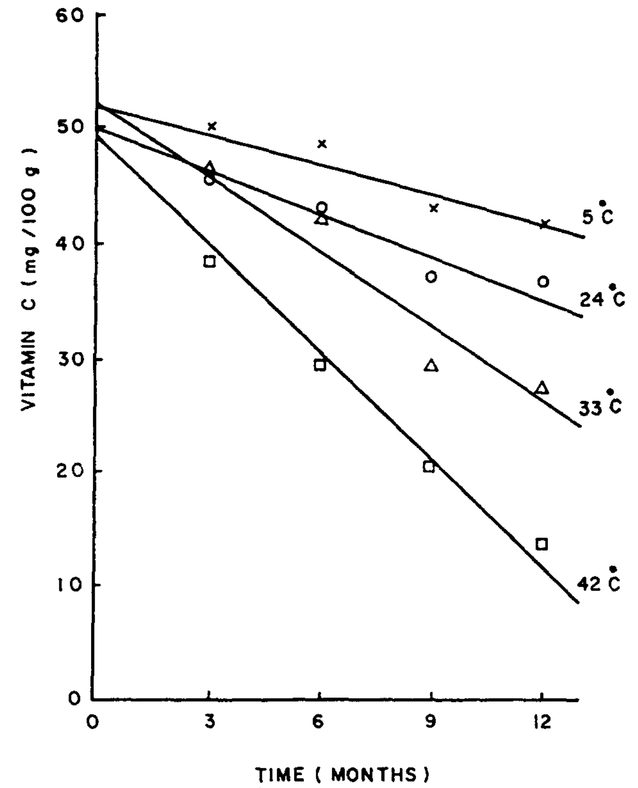

Fig. 1. Effect of storage temperature and time on vitamin C concentration of apple juice.

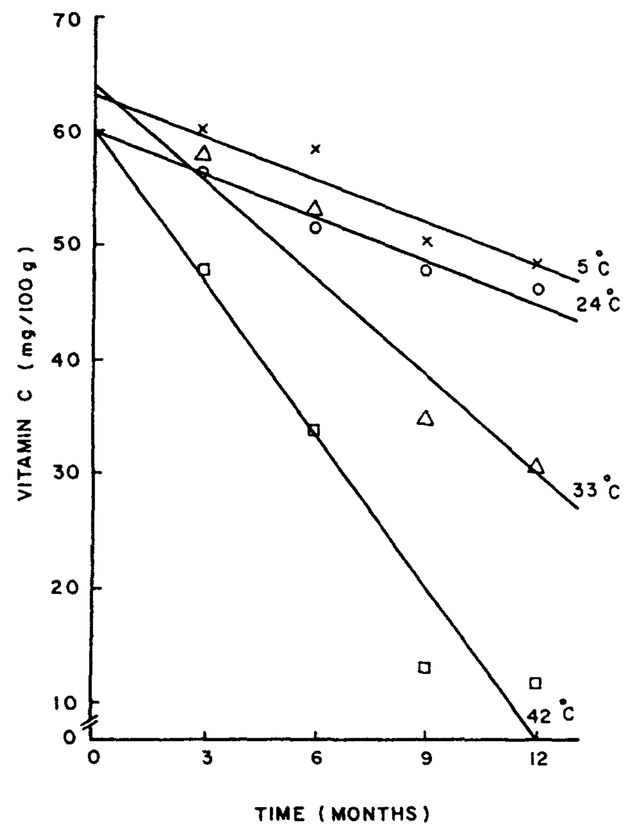

Fig. 2. Effect of storage temperature and time on vitamin C concentration of pineapple juice.

Table 2. Linear regression coefficient per month and mean of vitamin C of AJ and PJ during 1 year of storage at different temperatures

Product	Statistics	Storage temperature			
		5°C	24°C	33°C	42°C
Apple	L	−0·837*	−1·214**	−2·131**	−3·087*
	M	47·044[a]	42·750[ab]	39·502[b]	30·592[c]
Pineapple	L	−0·150*	−1·263**	−2·810*	−4·443**
	M	55·900[a]	52·652[a]	47·460[a]	33·396[b]

L = Linear regression, M = mean.
* and ** = Significant effect at 0·05 and 0·01 levels of probability, respectively.
Means followed by the same letter are not significantly different at the 0·05 level of probability.

reported that a significant ($p < 0{\cdot}01$) decrease was found in ascorbic acid (7 mg/100 ml) of orange concentrate after 12 months of storage at 4·4°C.

Statistical analysis, using regression, indicated that the rates of vitamin C decrease per month were 0·84, 1·21, 2·13 and 3·09 mg/100 g for AJ and 0·15, 1·26, 2·81, and 4·44 mg/100 g for PJ stored at 5, 24, 33 and 42°C respectively (Table 2). Kanner *et al.* (1982) reported that the rates of degradation of vitamin C for the first 100 days were 0·24 and 0·70 mg/week/kg in orange juice of 11 Brix stored at 17 and 25°C respectively.

Figures 3 and 4 show the sucrose content of canned AJ and PJ respectively during storage up to 12 months at various temperatures.

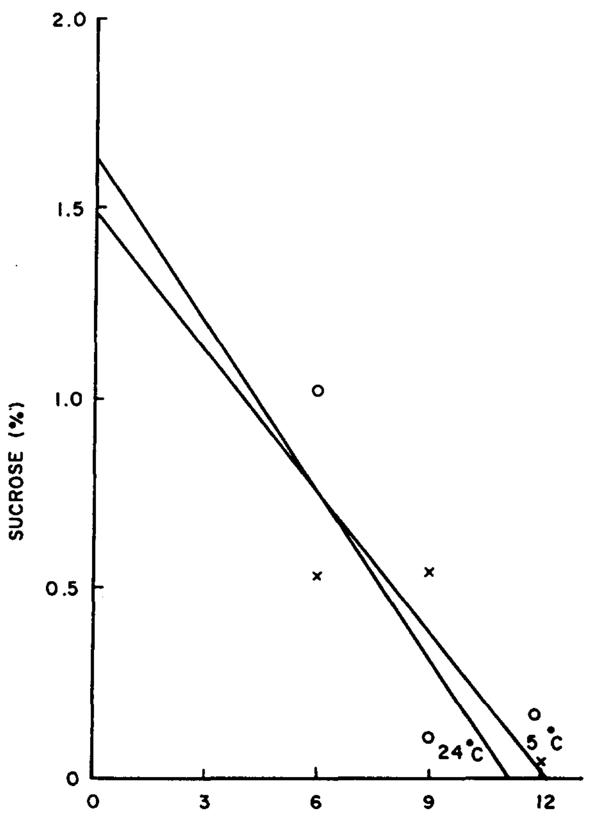

Fig. 3. Effect of storage temperature and time on sucrose concentration of apple juice (at 33°C and 42°C linear regression is not adequate to describe the relationship).

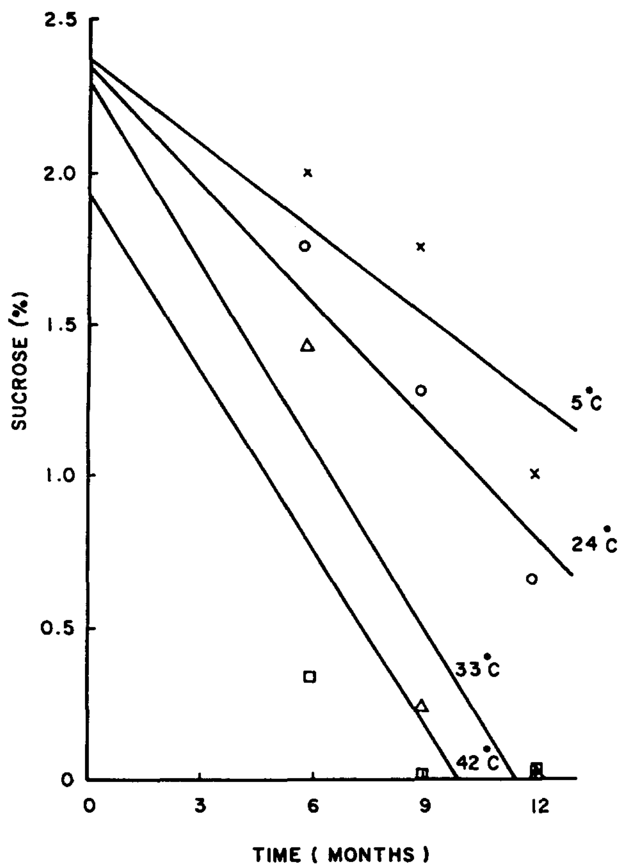

Fig. 4. Effect of storage temperature and time on sucrose concentration of pineapple juice.

Results indicate that, as the storage period of canned AJ and PJ proceeds, sucrose content decreases. This decrease in the sucrose content was due to conversion of sucrose to reducing sugars. No sucrose was detected in any of the juice samples on months 9 and 12 of storage at 33°C. However, juices stored at 5 and 24°C still contained a marked quantity of sucrose up to month 12 of storage. That means the high storage temperatures (33 and 42°C) facilitated the conversion rate of sucrose to reducing sugars. Glasstone (1946) reported that the rate of sucrose hydrolysis is a function of reactants, temperature and acid-catalyst concentration. Results obtained in this study are in agreement with those obtained by Babsky *et al.* (1986) who reported hydrolysis of sucrose in apple concentrate during 111 days of storage at 37°C. Statistical analysis, using regression, revealed that, during one year of storage at 5, 24, 33 and 42°C, the rates of sucrose decrease for AJ were 0·12, 0·15, 0·14 and 0·14% per month while the rates of decrease for PJ were 0·09, 0·13, 0·20 and 0·20% per month respectively (Table 3). Ewaidah (1988) reported that the rates of sucrose decrease per month were 0·055, 0·061, 0·084 and 0·089% for tomato juice stored at 5, 25, 33 and 42°C respectively.

Figure 5 and 6 show the reducing sugars of canned

Table 3. Linear regression coefficient per month and mean of sucrose and reducing sugars of AJ and PJ during 1 year of storage at different temperature

Quality factor	Statistics	Storage temperature			
		5°C	24°C	33°C	42°C
Apple juice					
Sucrose	L	−0·124*	−0·146^NS	−0·136^NS	−0·136^NS
	M	0·670^a	0·655^a	0·397^a	0·397^a
Reducing sugars	L	0·131**	0·212*	0·230**	0·238**
	M	8·232^a	8·730^ab	8·700^ab	9·015^b
Pineapple juice					
Sucrose	L	−0·094^NS	−0·129*	−0·202*	−0·196^NS
	M	1·775^a	1·493^ab	0·958^bc	0·645^c
Reducing sugars	L	0·127^NS	0·226*	0·356*	0·359*
	M	7·725^a	8·456^ab	9·190^b	9·655^b

See Table 2 footnotes.
NS = No significant effect.

AJ and PJ over 12 months of storage at various temperatures.

Per cent reducing sugars of AJ and PJ increased by increasing the storage time and temperature. However, the reducing sugar levels of the apple juice stored at 5 and 24°C were lower than those of the juices stored at 33 and 42°C on month 12 of storage. For example, the reducing sugar levels of AJ on month 12 of treatment were 9·10% and 9·52% for juices stored at 5°C and 24°C, respectively, whereas the reducing sugar contents of juices stored at 33°C and 42°C were 9·9 and 10·0,

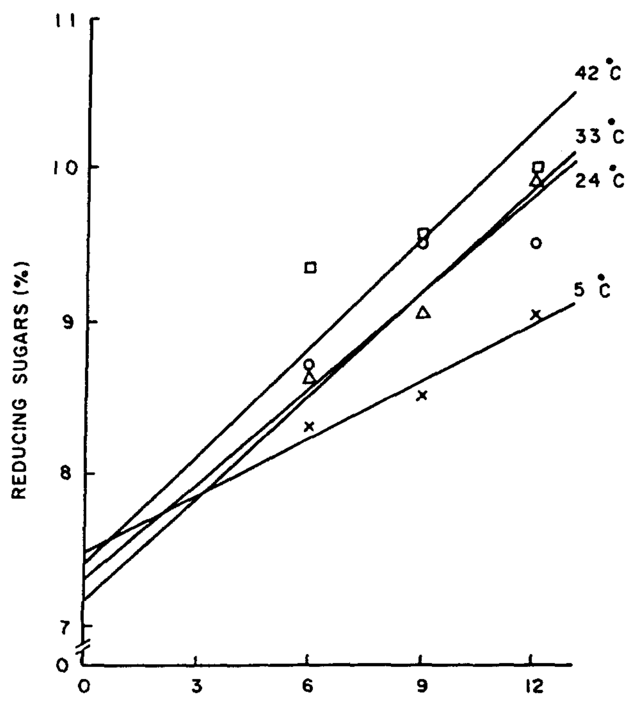

Fig. 5. Effect of storage temperature and time on reducing sugar concentration of apple juice.

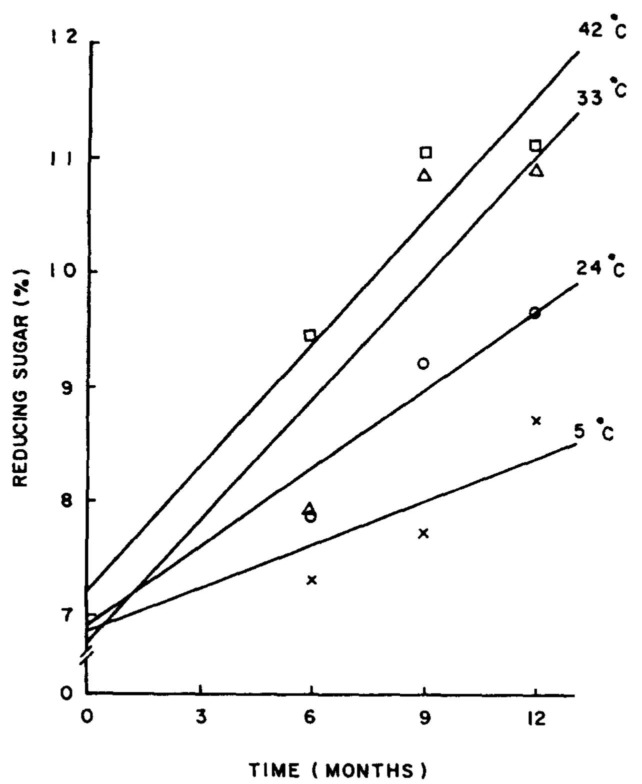

Fig. 6. Effect of storage temperature and time on reducing sugar concentration of pineapple juice.

respectively. This increase in reducing sugar content was due to the conversion of sucrose to reducing sugars. As with AJ, the reducing sugars level of PJ followed the same trend. These results showed that the rate of conversion of sucrose to reducing sugars was affected by both storage temperature and storage time. Similar results were reported by Babsky *et al.* (1986) who found a gradual increase in reducing sugars of AJ concentrate over 120 days of storage. Also, Ewaidah (1988) found a marked increase in the reducing sugar levels of orange and tomato juices stored at 5°C, 24°C, 33°C and 42°C for 12 months. Statistical analyses (regression) showed that the increases in reducing sugars during 12 months of storage at 5, 24, 33 and 42°C were significant ($p < 0{\cdot}05$ or $p < 0{\cdot}01$) and the rates of these increments were 0·13, 0·21, 0·23 and 0·24% per month for AJ and 0·13, 0·23, 0·36 and 0·36% per month for PJ respectively (Table 3).

Figures 7 and 8 show the effect of storage time and temperature and the vacuum inside the AJ and PJ cans, respectively.

When AJ and PJ were stored at 5°C the vacuum value remained approximately constant during the storage period up to 12 months. However, a significant ($p < 0{\cdot}01$) gradual decrease in the vacuum was observed during the 12 months' storage at 24, 33 and 42°C. The rates of decrease in vacuum are 0·20, 0·42 and 0·70 inches Hg/month for AJ and 0·12, 0·29 and 0·56 inches Hg/month for PJ, as shown from the

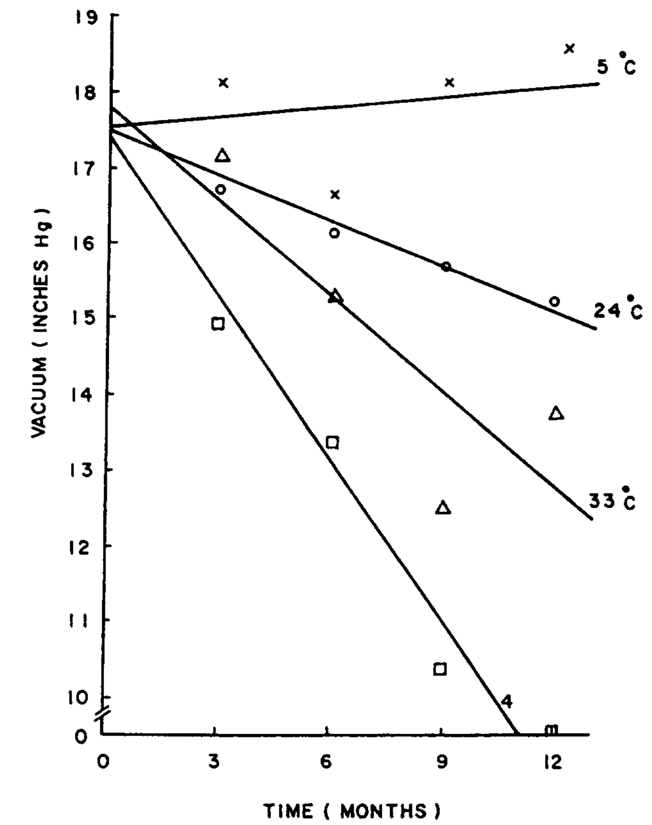

Fig. 7. Effect of storage temperature and time on can vacuum in apple juice.

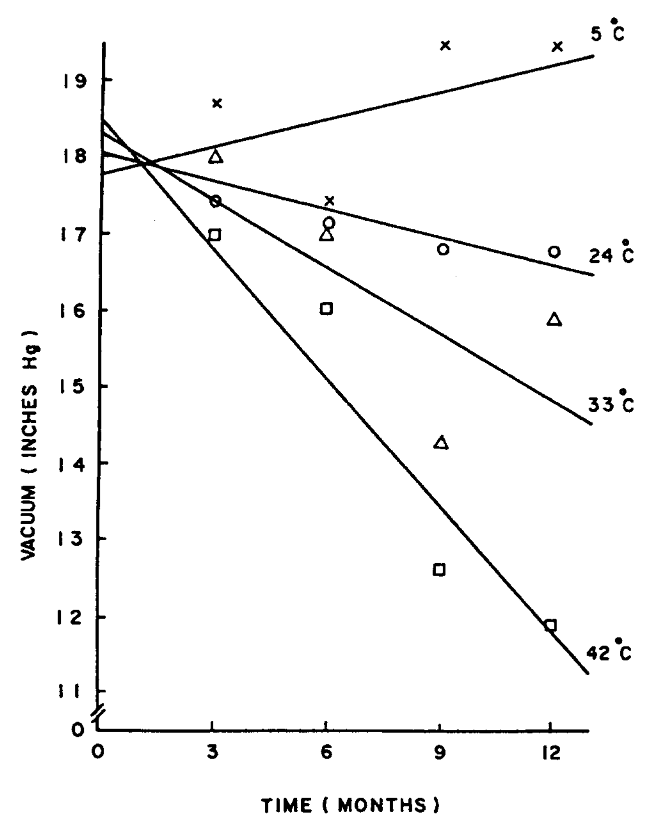

Fig. 8. Effect of storage temperature and time on can vacuum in pineapple juice.

Table 4. Linear regression coefficient per month and mean of vacuum of AJ and PJ during 1 year of storage at different temperatures

Product	Statistics	Storage temperature			
		5°C	24°C	33°C	42°C
Apple	L	$0·057^{NS}$	$-0·198^{**}$	$-0·415^{**}$	$-0·702^{**}$
	M	$17·824^{a}$	$16·280^{ab}$	$15·266^{bc}$	$13·164^{c}$
Pineapple	L	$0·125^{NS}$	$-0·117^{*}$	$-0·286^{NS}$	$-0·555^{**}$
	M	$18·516^{a}$	$17·358^{ab}$	$16·592^{ab}$	$15·124^{b}$

See Tables 2 and 3 footnotes.

regression statistical analysis (Table 4). These results are in agreement with those reported by Ewaidah (1988), who found a significant ($p < 0·05$) gradual decrease in the vacuum during 12 months' storage of the orange juice at 33°C and 42°C and the rates of decrease in the vacuum were 0·34 and 0·70 inches Hg/month respectively. Similar results were reported by Mahadeviah *et al.* (1976) who found a gradual decrease in vacuum of canned orange juice during storage at 37°C for 12 months.

The acidity of AJ and PJ as a function of storage time and temperature is shown in Table 5. In spite of the absence of significant changes ($p < 0·05$) in acidity during the 12 months storage period for all juices stored at the various temperatures, slight decreases were observed. These decreases in acidity could be partly due to the copolymerization of organic acids with products of the browning reactions (Babsky *et al.*, 1986). In addition, the organic acid can react with reducing sugars to form brown pigments (Lewis *et al.*, 1949). Montgomery *et al.* (1982) reported that there was a slight decrease in titratable acidity of grape juice stored at −1°C for 261 days. Also, Ewaidah (1988) found that the acidity of orange juices remained steady (without any significant change) during a 1 year storage period at 5°C, 24°C, 33°C and 42°C.

pH values of the juices followed the same pattern as acidity during storage periods at the different tem-

Table 5. Linear regression coefficient per month and mean of acidity and pH of AJ and PJ during 1 year of storage at different temperatures

Quality factor	Statistics	Storage temperature			
		5°C	24°C	33°C	42°C
Apple juice					
Acidity	L	$-0·032^{NS}$	$0·032^{NS}$	$-0·034^{NS}$	$-0·032^{NS}$
	M	$0·550^{a}$	$0·550^{a}$	$0·548^{a}$	$0·555^{a}$
pH	L	$-0·002^{NS}$	$-0·002^{NS}$	$0·001^{NS}$	$0·001^{NS}$
	M	$3·380^{a}$	$3·380^{a}$	$3·390^{a}$	$3·392^{a}$
Pineapple juice					
Acidity	L	$-0·04^{*}$	$-0·034^{NS}$	$-0·034^{NS}$	$-0·035^{NS}$
	M	$0·688^{a}$	$0·708^{a}$	$0·718^{a}$	$0·715^{a}$
pH	L	$-0·015^{NS}$	$-0·007^{NS}$	$-0·003^{NS}$	$-0·003^{NS}$
	M	$3·375^{a}$	$3·400^{a}$	$3·423^{a}$	$3·420^{a}$

See Tables 2 and 3 footnotes.

Table 6. Linear regression coefficient per month and mean of viscosity of AJ and PJ during 1 year of storage at different temperatures

Product	Statistics	Storage temperature			
		5°C	24°C	33°C	42°C
Apple	L	-0.009^{NS}	-0.006^{NS}	-0.008^{NS}	-0.009^{NS}
	M	1.393^{a}	1.400^{a}	1.376^{a}	1.377^{a}
Pineapple	L	0.024^{NS}	-0.008^{NS}	0.003^{NS}	-0.008^{NS}
	M	2.693^{a}	2.557^{a}	2.670^{a}	2.630^{a}

See Tables 2 and 3 footnotes.

Table 7. Sensory evaluation ratings for quality attributes of commercially canned AJ and PJ at month 12 of storage at various temperatures

Juice name	Storage temperature (°C)	Sensory attributes		
		Colour	Flavour	Acceptability
Pineapple	5	8.32^{a*}	7.89^{a*}	7.95^{a*}
	24	8.21^{a}	7.68^{a}	7.89^{a}
	33	5.32^{b}	5.00^{b}	5.00^{b}
	42	1.79^{c}	2.26^{c}	2.00^{c}
Apple	5	7.95^{a}	7.89^{a}	7.89^{a}
	24	7.47^{a}	7.32^{a}	7.21^{a}
	33	6.05^{b}	5.53^{b}	5.59^{b}
	42	3.84^{c}	3.63^{c}	3.42^{c}

* Mean rating for nineteen panellists.
Mean ratings in the same column with the same letters are not significantly different at the 5% level.
Rating scale: 1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely.
Analysis accomplished by DMRT.
See Tables 2 and 3 footnotes.

peratures (Table 5). The same results were found by Toribio and Lozano (1984) who reported that the pH value of AJ concentrate did not change during storage at 5, 25 and 37°C for 120 days.

Statistical analysis, using regression, showed that there was no significant change in the viscosity of AJ and PJ during the 12 month period of storage at various temperatures (Table 6).

Sensory evaluation

Table 7 shows the mean hedonic rating for the colour, flavour and overall acceptability of the canned PJ and AJ stored at 5, 24, 33 and 42°C up to 12 months.

Colour

The mean rating for colour on month 12 of storage at various temperatures ranged from 1 (dislike extremely) to 8 (like very much) for PJ and from 3 (dislike moderately) to 7 (like very much) for AJ. At month 12, there was no significant difference ($p < 0.05$) in colour between the PJ stored at 5°C and 24°C. However, a significant difference ($p < 0.05$) in colour was observed between the PJ stored at 4 and 24°C and those stored at 33 or 42°C. Also data revealed that the samples stored at refrigerated temperature (5°C) rated the highest in colour, while those stored at 42°C rated the lowest.

With respect to AJ, there was no significant ($p < 0.05$) difference in colour between the juices stored at 5°C and those stored at 24°C after 12 months. However, a significant ($p < 0.05$) difference existed between the juices stored at 5 and 24°C and those stored at 33 or 42°C.

Flavour

The ratings by judges for PJ and AJ ranged from 2 (dislike very much) to 7 (like moderately), respectively. There was a significant difference ($p < 0.05$) in flavour between the PJ samples stored at 5 and 24°C and those stored at 33 or 42°C at month 12 of storage. However there was no significant difference ($p < 0.05$) in flavour between the juice stored at 33 and that stored at 42°C.

With respect to AJ, there was no significant difference ($p < 0.05$) in flavour between the juices stored at 5 and 24°C and those stored at 33 or 42°C.

Acceptability

The mean ratings by panellists of the overall acceptability on month 12 of storage at various temperatures were between 2 (dislike very much) and 8 (like very much) for PJ and 3 (dislike moderately) and 7 (like moderately) for AJ.

These ratings revealed that the PJ or AJ samples stored at 5 and 24°C were not significantly different ($p > 0.05$) after 12 months of storage. However, a significant difference ($p < 0.05$) in overall acceptability existed between the PJ or AJ stored at 5 and 24°C and those stored at 33 and 42°C at month 12.

Visual observation of the juices after 12 months of storage at 5, 24, 33 and 42°C showed that, the lower the storage temperature, the less is the browning.

Microbial analysis

The microbial quality analyses were conducted on the commercially canned PJ and AJ stored at various temperatures up to 12 months (Table 8). No microbial growth (aerobic plate counts, yeasts and molds, coliforms, sporeformers) were detected initially (month 1) or in month 12 of storage at 5, 24, 33 and 42°C. This result is due mainly to the presence of sulphur dioxide (202 ppm for pineapple and 147 ppm for apple, Ewaidah, 1988), high acidity, and the effect of heat treatment during processing of cans. All the three previous factors are known to be inhibitors of microbial growth.

Table 8. Microbial results of commercially canned apple and pineapple juices stored at various temperatures[a]

Storage Temperature (°C)	Aerobic plate counts		Yeasts & molds		Total coliforms		Sporeformers	
	Initial (CFU/ml)	12 month (CFU/ml)	Initial (CFU/ml)	12 month (CFU/ml)	Initial (cell/ml)	12 month (cell/ml)	Initial (spores/ml)	12 month (spores/ml)
Apple juice								
5	ND	ND	ND	ND	ND	ND	ND	ND
24	,,	,,	,,	,,	,,	,,	,,	,,
33	,,	,,	,,	,,	,,	,,	,,	,,
42	,,	,,	,,	,,	,,	,,	,,	,,
Pineapple juice								
5	ND	ND	ND	ND	ND	ND	ND	ND
24	,,	,,	,,	,,	,,	,,	,,	,,
33	,,	,,	,,	,,	,,	,,	,,	,,
42	,,	,,	,,	,,	,,	,,	,,	,,

[a] Each value is the average of three samples in duplicate; each sample represents a different code lot.
ND = Not detected.

Conclusions

In conclusion, the results showed that storage of SSPJ or SSAJ (from concentrates) produced in Saudi Arabia at refrigerated temperature (5°C) or ambient temperature (24°C) could be recommended. However, storage of these juices for the prolonged period of 12 months in the warehouses under Saudi Arabia climate conditions developed undesirable off-flavour and darkening of the colour. Therefore, to avoid these undesirable changes another study should be conducted to determine the proper shelf life under fluctuating ambient temperature-warehousing conditions. This is essential since temperature ranges between a minimum of 20°C in winter and a maximum of 43°C in summer during one year of storage. SSPJ and SSAJ produced locally are of excellent microbial quality and this finding revealed that the canning process was proper.

ACKNOWLEDGEMENT

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