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Studies on Commercially Canned Juices Produced Locally in Saudi Arabia: (1) Mineral Composition and Tin and Iron Contents during Storage

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Abstract. Canned orange, tomato, apple and pineapple juices were obtained from a commercial canning plant in Saudi Arabia. The mineral composition of these juices was determined, and the tin and iron contents were followed during one year of storage at different temperatures. percentage of Recommended Dietary Allowance (RDA) and estimated safe and adequate daily dietary intake per 100 g of each type of juice were calculated. Tomato juice provided the highest percent- age of RDA for potassium (3.70%), sodium (13.20%) and copper (4%) per 100 g. The sulfur dioxide content and acidity of these juices ranged from 147.67 to 202.33 ppm and 0.747 to 1.143% respectively. The tin uptake by the four types of juices during one year of storage at different temperatures was minimal and the tin content in the juices in the last month (12th.) of storage ranged from 12.8 to 45.2 ppm (less than Codex maximum of 250 ppm). Storage temperature (5°C, 24°C, 33°C) and time had no effect on iron content of tomato, orange or pineapple juices stored up to 12 months. However, storage of apple juice at temperatures above refrigeration temperature increased the iron uptake by the juice. The concentration of iron in apple juice was however below the maximum permitted by the Saudi Arabian Standard Organization.

Introduction

In recent years, the local production of canned juices in Saudi Arabia has increased steadily. It is highly recommended that any additives of commercially canned juices locally produced be declared on the labels. In addition, some of these juices have a high acidity and contain sulfur dioxide which might cause corrosion and attack both the tin and iron layers during storage.

The detinning process is affected by a number of factors. Rouseff and Ting [1] reported that the rate of tin uptake by grape-fruit juice was temperature and acid dependant. Also Saguy *et al.* [2] indicated that addition of sulfites and sulfur dioxide accelerated the detinning of canned grape-fruit juice. The effect of temperature and storage time on iron and tin contents of commercially canned single strength orange juice was studied by Nagy *et al.* [3], who found that the uptake of tin by orange juice was related to storage time and temperature. The corrosion occuring in tin cans has been reported to be dependent on chemical composition of the product [4], character of the tinplate [5], presence of nitrates [6] and oxygen [7,8]. The corrosion mechanism was studied by Vaurio [9] and Koehler and Canonico [10], who found that this process entails dissolution of tin coating, dissolution of the steel base, and evolution of hydrogen. Tin content that does not exceed the level of 250 ppm is permitted by the Codex Alimentarius Commission [11, p. 45] and Saudi Arabian Standards Organization [12–15].

Several studies have indicated that tin is not toxic because ingested tin does not accumulate in organ tissues and is not absorbed during digestion but is excreted in the feces [16–19]. However, Nagy *et al.* [3] and Benoy *et al.* [20] indicated that ingestion of food products containing high levels of tin (> 400 ppm) causes nausea, diarrhoea vomiting, fever, headache, and other gastrointestinal disturbances.

Untill the present time, no attempt was made to determine the mineral composition of commercial canned juices locally produced in Saudi Arabia. In addition, no study has been conducted to show the effect of local storage conditions (time–temperature) on tin and iron uptake by the juices.

The objectives of this study are (1) to determine the mineral composition (including tin and lead) of four types of juices (orange, tomato, apple and pineapple) obtained from the largest commercial canning plant in Saudi Arabia, and (2) to determine the effect of storage temperature and storage time on the tin and iron contents of these juices. Results will be useful in making recommendations with regard to the most suitable storage and handling conditions of canned juices.

Materials and Methods

Preparation of samples

Single-strength orange, tomato, apple and pineapple juices (reconstitutes) from concentrates, packed in tin cans, were obtained from the largest commercial plant in Saudi Arabia. The canned juices from this plant are distributed all over the Kingdom. Samples were collected in three different production periods and were coded accordingly. Three different coded lots for each type of canned juice were collected with a total of 12 carton boxes for each type of juice. Thus 48 carton boxes (each containing 48–6 oz. cans) were obtained for the four types of juices. Three boxes (from the three different coded lots) of each fruit juice were kept in one of the three temperature-controlled rooms for one year: 5°C ± 1; 24°C ± 1 and 42°C ± 1. In addition, a fourth storage treatment was undertaken where juices were kept under normal fluctuating temperature (warehousing conditions) where temperatures ranged between 20–43°C during 1 year storage (average warehouse temperature was 33°C).

For analysis, 6 cans were drawn randomly from each different coded lot at intervals for 1 year and thus for each temperature condition 18 cans were thoroughly mixed to form a composite sample for each juice. However, the initial analysis of minerals and quality factors was conducted for each different coded lot separately where eight cans from each carton box (with a total of 24 cans for each code lot) were mixed.

Chemical and physical analysis

Sugars were determined by the Lane-Eynon Volumetric method described in the A.O.A.C.[21] (secs. 31.034). The acidity was determined by titrating the samples with 0.1 N NaOH and was expressed as percent citric acid according to A.O.A.C. procedure [21] (secs. 22.060).

The A.O.A.C. procedures were used for the determination of Vit. C [21] (secs. 43.056), sulfur dioxide [21] (secs. 20.020), and benzoic acid [21] (secs. 20.020).

pH was measured using a pH digital meter (Jenwey, Model PHM 10) standardized with pH2 buffer and pH7 buffer. Total soluble solids were measured using an Abb'e refractometer as in A.O.A.C. [21] (secs. 22.024). Viscosity was measured with a Brookfield viscometer (Model LVT, Brookfield Engineering Lab., Stoughton, MA) using UL adapter, 60 rpm at ambient temperature (25°C). Vacuum measurements were made with a Flip Vacuum Gauge graduated from 0–30 inches Hg.

Mineral analysis

Minerals were extracted by the wet ashing method [22] and determined by atomic absorption spectrophotometer (Instrumentation Laboratory, Mod. 252). K and Mg were determined using a flamephotometer (Eppendorf, No. 0700). Phosphorus was determined colorimetrically according to A.O.A.C. procedure [21] (secs. 22.042) using a digital spectrophotometer (Spectronic 21, Bausch and Lamb). Tin content was determined by a colormetric procedure described by Pearson [23]. The sample is wet oxidized and the color developed by adding alcoholic solution of quercetin. The intensity of color was measured at 537 nm using a digital spectrophotometer (Spectronic 21, Bausch and Lamb).

Results and Discussion

Table 1 shows the results of mineral determination of commercially canned tomato, orange, apple and pineapple juices (expressed on a fresh weight basis). Percentages of estimated safe and adequate daily dietary intakes and recommended dietary allowance (RDA) per 100 g serving of these juices are shown in Table 2. Differences in mineral contents among various juices are evident. The potassium content of tomato juice was higher than in other juices studied. The potassium content of tomato juice was found to be 138.68 mg/100 g. The estimated safe and adequate daily dietary intake of potassium (ESADI) for adults is 3750 mg/day [24]. Consumption of a 100 g of tomato juice will provide about 3.70% of ESADI for potassium. Commercially canned tomato juices were found to contain the highest level of sodium (270.13 mg/100 g) compared to other juices. Current estimated safe and adequate daily dietary intake of sodium for adults is 2200 mg/day [24]. A 100 g serving of tomato juice will supply 12.28% of ESADI for sodium. The RDA of magnesium for adult males is 300 mg/day [24]. All the four types of juices were poor

Table 1. Mineral concentration of commercially canned tomato, orange, apple and pineapple juices[a]

	Tomato juice	Orange juice	Apple juice	Pineapple juice
	mg/100g (± S.D.)	mg/100g (± S.D.)	mg/100g (± S.D.)	mg/100g (± S.D.)
Potassium	138.68 (15.89)[b]	120 (10.15)	84.03 (6.776)	81.57 7.150)
Sodium	290.79 (3.315)	5.20 (0.40)	5.23 (0.374)	5.45 (0.658)
Magnesium	7.20 (0.265)	8.17 (0.907)	5.41 (0.843)	8.87 (1.058)
Calcium	4.79 (0.607)	4.73 (0.462)	5.61 (0.373)	5.76 (0.745)
Manganese	0.05 (0.023)	0.05 (0.026)	0.07 (0.031)	0.37 (0.029)
Lead	C	C	C	C
Zinc	0.13 (0.025)	0.11 (0.031)	0.10 (0.032)	0.17 (0.08)
Copper	0.10 (0.08)	0.073 (0.028)	0.05 (0.020)	0.03 (0.011)
Iron	0.193 (0.003)	0.023 (0.058)	0.19 (0.006)	0.20 (0.001)
Phosphorus	31.86 (0.563)	22.38 (0.495)	8.99 (2.287)	18.19 (1.899)

[a] Each value is the mean of duplicate determinations of three different coded lots.

[b] Values in parenthesis represent standard deviation.

[c] Not detected.

sources of magnesium (5.41 – 8.87 mg/100 g), and a 100 g serving will provide 1.55 – 2.53% of RDA for magnesium. The pineapple juice had the highest level of manganese (0.37 mg/100g) compared to other juices, a 100g serving will supply 9.87% of the estimated safe and adequate daily dietary intake. The iron content of all four types of juices was found to be almost the same (0.20mg/100g). The current RDA of iron for adults is 10 mg/day [24], and 100g of these juices supply about 2% of RDA for iron. Tomato juice is a fairly good source of phosphorus (31.86 mg/100g), and a 100 g serving supplies 4% of the RDA.

Table 2. Percentage of estimated safe and adequate daily dietary intakes and recommended dietary allowances (RDA) per 100g of commercially canned tomato, orange, apple and pipeapple juices.

Element	Tomato juice (%)	Orange juice (%)	Apple juice (%)	Pineapple juice (%)
Potassium	3.70[a]	3.20	2.24	2.18
Sodium	13.20[a]	0.24	0.24	0.25
Magnesium	2.06[b]	2.33	1.55	2.53
Calcium	0.60[b]	0.60	0.70	0.72
Manganese	1.33[a]	1.33	1.87	9.87
Lead	0.00	0.00	0.00	0.00
Zinc	0.87[b]	0.73	0.67	1.13
Copper	4.00[a]	2.92	2.00	1.20
Iron	1.93[b]	2.30	1.90	2.00
Phosphorus	4.00[b]	2.80	1.12	2.27

[a] Calculated as % estimated safe and adequate daily dietary intakes in 100 g serving for adults according to the Food and Nutrition Board, National Research Council [24]; % are calculated on the mid-point values of ranges of recommended intakes.

[b] RDA as set by the Food and Nutrition Board, National Research Council [24]; calculated as % RDA in 100 g serving for adult male.

Table 3 reveals the physico-chemical and quality characteristics of commercially canned tomato, orange, apple and pineapple juices. The results show the following quality factor ranges: percent titratable acidity (0.747–1.143), pH (3.46–3.774), and Brix to percent acid ratios (9.10–14.82). The acidity was higher in orange juice than in the other juices. The vitamin C content of orange and pineapple juices were higher than that of the tomato and apple juices and the vitamin C content in the juices varied from 50.917–61.35 mg/100g. Pineapple, orange, tomato and apple canned juices contained 202.33, 197.67, 189 and 147.33 ppm sulfur dioxide respectively. The vacuum values inside the cans were approximately the same in all the four types of juices (17–18 inches Hg). The reducing sugars varied from as low as 1.29% in tomato juice to a concentration of 7.14% in apple juice and sucrose percentages ranged from 0.93% (tomato juice) to 4.46% (orange juice).

Table 3. Quality factors of commercially canned single-strength tomato, orange, apple and pineapple juices[a]

	Tomato juice	Orange juice	Apple juice	Pineapple juice
Quality factor	Mean (± S.D.)	Mean (± S.D.)	Mean (± S.D.)	Mean (± S.D.)
% Acid	0.747 (0.015)[b]	1.143 (0.021)	0.810 (0.010)	0.977 0.006)
pH	3.774 (0.100)	3.667 (0.021)	3.46 (0.20)	3.498 (0.011)
Brix	6.80 (0.60)	12.00 (0.50)	12.00 (0.20)	13.00 (1.00)
Brix/% acid	9.10 (0.626)	10.65 (0.871)	14.82 (0.430)	13.31 (1.091)
Viscosity (centipoise)	190 (6.245)	2.867 (0.058)	1.40 (0.100)	2.497 (0.095)
Vit. C (mg/100g)	53.817 (0.580)	61.32 (0.638)	50.917 (0.031)	61.016 (0.333)
Benzoic acid	nil	nil	nil	nil
SO_2 (ppm)	189.00 (6.00)	197.67 (7.095)	147.33 (7.024)	202.33 (4.041)
Vacuum (inches Hg)	18.173 (0.893)	17.75 (0.125)	17.715 (0.655)	18.042 (0.072)
% Reducing sugars	1.29 (0.195)	4.01 (0.105)	7.14 (0.135)	7.10 (0.170)
% Sucrose	0.93 (0.153)	4.46 (0.140)	1.59 (0.195)	2.25 (0.087)

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

The Brix, acidity and Brix/acid ratio for canned tomato, orange, apple and pineapple juices meet the Saudi Arabian Standards [12–15]. However, the level of sulfur dioxide in apple juice was higher than that set by the Saudi Arabian Standards Organization (10mg/kg) [15].

Results of tin contents of orange juice as a function of storage temperature (5, 24, 33 and 42°C) and storage time (up to 12 months) are illustrated in Fig.1. The 33°C temperature represents the average temperature during warehouse storage for 1 year, where temperatures ranged from 20 to 43°C. Initial tin content of pre-stored canned orange juice was 0.3 ppm. Canned orange juices stored at 5, 24, 33 and 42°C were monitored for a period of 12 month to determine the tin content. Results indicated a continual uptake of tin by orange juice during the 12 month storage time for all the four temperatures used. The detinning rate increased with increase in storage temperature. For example, tin contents of juices stored at 5, 24, 33 and 42°C

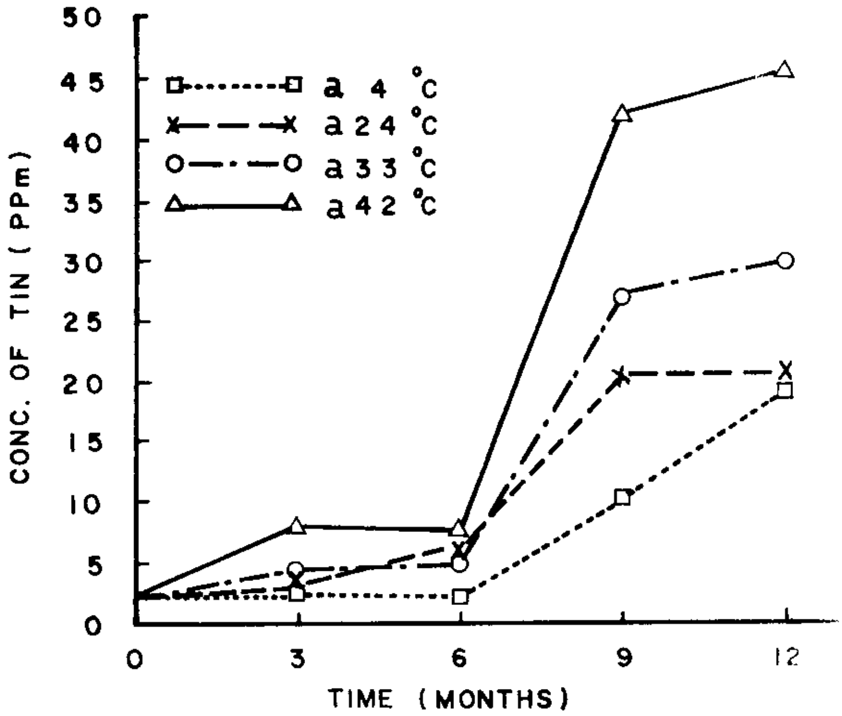

Fig. 1. Tin concentration of orange juice during storage at 5, 24, 33 and 42°C.
a– Each point represents an average of duplicate determination.

increased up to 13.2, 18.1, 24.8 and 29.8 ppm respectively after 12 months of storage. None of the canned orange juices reached the 250 ppm maximum of the Codex Alimentarius Commission [11].

Fig.2 illustrates the tin content of canned pineapple juice during storage at 5, 24, 33 and 42°C. Initial tin content of canned pineapple juice was 10.8 ppm. Data showed a continual increase in the tin contents of juice during storage period and the rate of detinning was dependent on storage temperature and storage time. At the last month of storage (12th.) the tin contents of juice stored at 5, 24, 33 and 42°C increased to 25.4, 25.5, 25.7 and 30.1 ppm respectively.

Fig.3 illustrates the uptake of tin by apple juice during 12 month storage at 5, 24, 33 and 42°C.

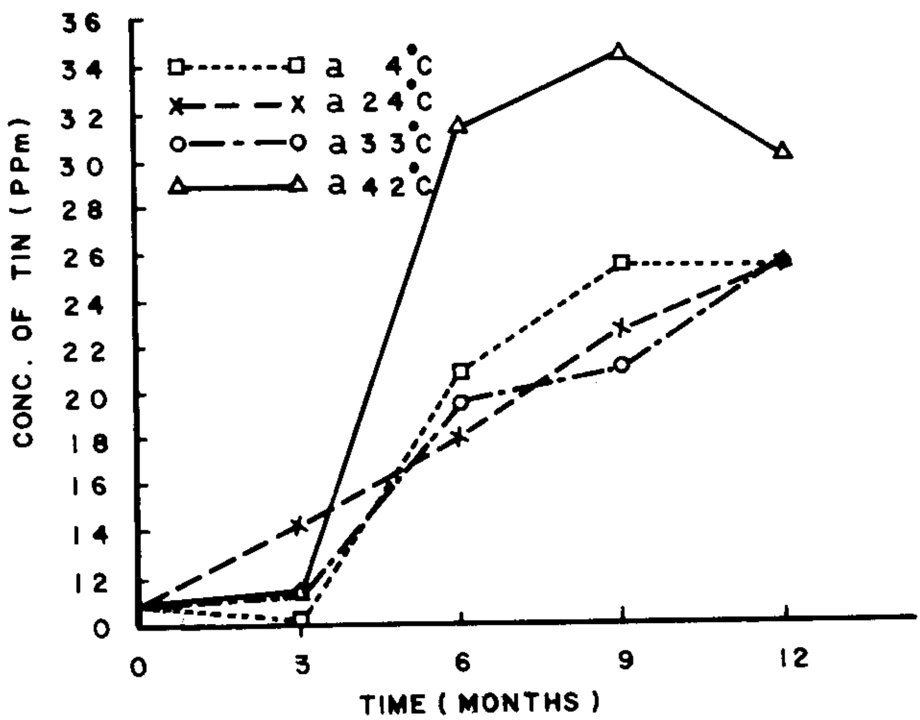

Fig. 2. Tin concentration of canned pineapple juice during storage at 5, 24, 33 and 42°C.
a– Each point represents an average of duplicate determination.

At the four storage temperatures, the tin contents of juice increased continually during the 12 months of storage time: 0.5 to 11.7 ppm for the juice stored at 4°C; 0.5 to 12.8 for the juice stored at 24°C; 0.5 to 16.4 ppm for the juice stored at 33°C; and 0.5 to 24 ppm for the juice stored at 42°C.

Fig.4 shows the tin content of tomato juice during storage at 5, 24, 33 and 42°C. A continual detinning during the 12 months of storage occured in all the juices stored at the four mentioned temperatures. Tin contents of juice stored at 5°C increased from 1.9 to 19 ppm whereas those stored at 24 and 33°C increased to 20.4 and 29.4 ppm respectively. Extensive detinning was observed in tomato juices stored at 42°C where tin content over the 12 months storage period increased from 1.9 to 45.2 ppm. However, the levels of tin detected in tomato juice were much lower than the Codex Alimentarius Commision maximum of 250 ppm. The obtained results illustrated in

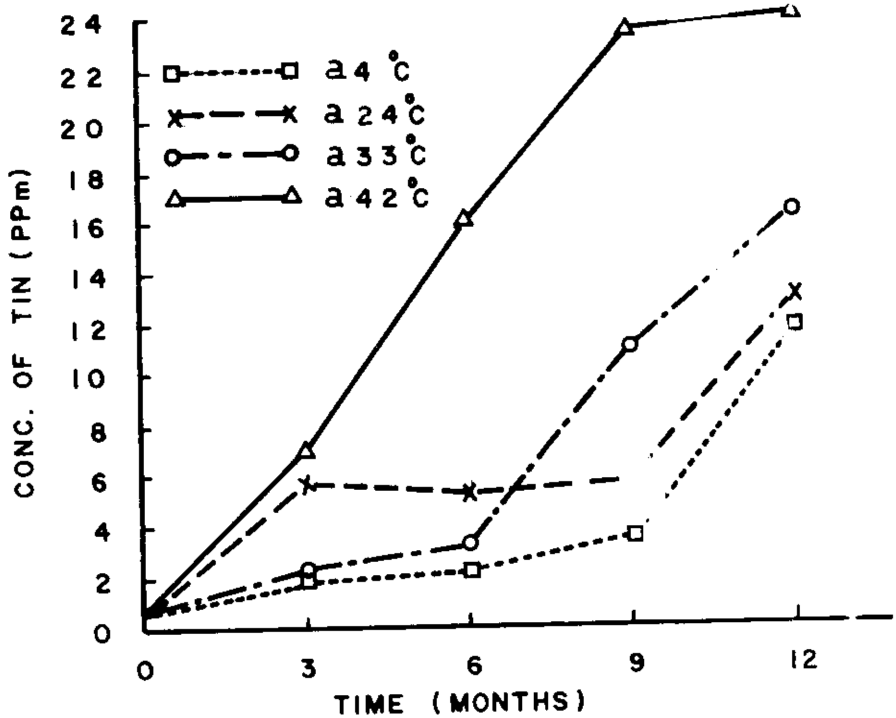

Fig. 3. Tin concentration of canned apple juice during storage at 5, 24, 33 and 42°C.
a– Each point represents an average of duplicate determination.

Figs. 1, 2, 3 and 4 are in agreement with the results reported by Nagy *et al.* [3], Mahadeviah *et al.* [25], Somel and Saguy [6] where they found a marked increase in tin content of canned orange juice packed in metal cans during the storage period. A similar result was reported by Frankenthal *et al.* [26], where they found a marked tin uptake by tomato and grapefruit juices packed in tin cans and stored at 37.8°C for 150–300 days.

Table 4 reveals the iron content of the four various canned juices during storage at 5°C, 24°C, 33°C and 42°C. The iron content of tomato, orange and pineapple juices stored at 5, 24 and 33°C (warehouse temp.) remained constant during storage period. However, at 42°C all the four types of juices showed an extensive increase in iron contents at the last month of storage, varing from 1.0 to 5.74 mg/100g. For apple juice, a gradual increase was shown clearly in iron content during the 12 months of storage at 24, 33 and 42°C and the rate of iron uptake increased with increasing tem-

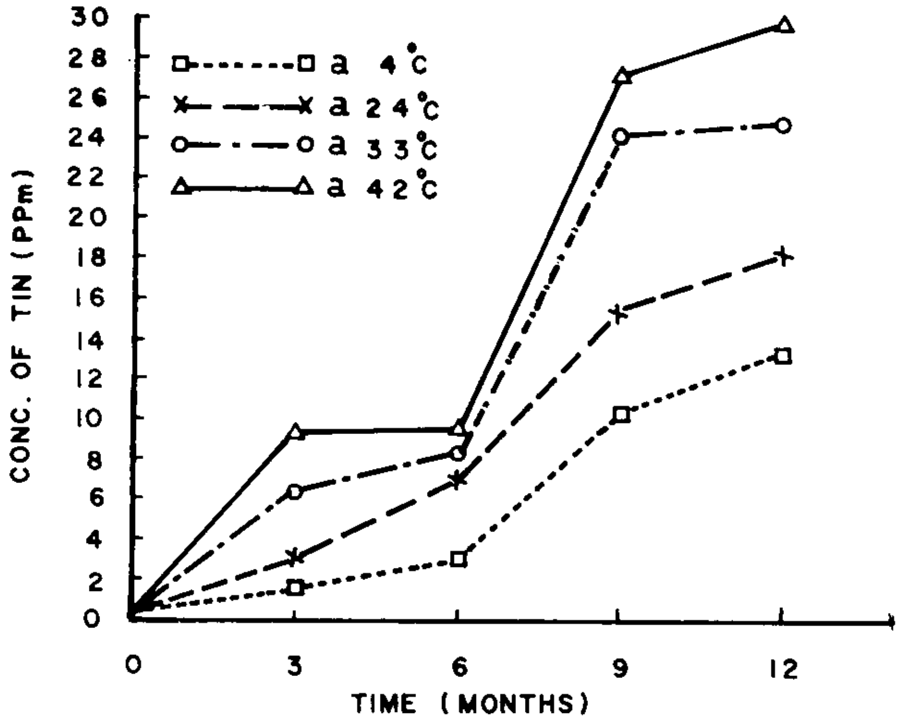

Fig. 4. Tin concentration of canned tomato juice during storage at 4, 24, 33 and 42°C.
a– Each point represents an average of duplicate determination.

perature. This result could be due to the presence of high concentration of sulfur dioxide (147.33 ppm) in the apple juice where its level was higher than that required by Saudi Arabian Standards Organization (10 ppm) [15]. Frankenthal *et al.* [26] and Nagy *et al.* [3] reported that temperature and storage time had little effect on the uptake of iron by canned grape-fruit, tomato and orange juices. However, the storage temperature of 42°C and the storage time of 12 months had a marked effect on the uptake of iron by these canned juices. Apple juice showed the highest uptake of iron as compared with the other juices.

In conclusion, a 100 g serving of locally produced canned tomato, orange, apple or pineapple juices will provide less than 4% (except soidum), 3.2%, 2.24% or 2.53% (except calcium) respectively of the RDA or estimated safe and adequate daily dietary intakes of the elements studied.

Table 4. Iron concentration of canned tomato orange, apple and pineapple juices during storage at 5°C, 24°C, 33°C and 42°C.

Storage temperature	Storage period (months)	Tomato juice mg/100g	Orange juice mg/100g	Apple juice mg/100g	Pineapple juice mg/100g
5°C	Initial	0.191	0.194	0.190	0.189
	6	0.194	0.198	0.294	0.199
	12	0.194	0.295	0.200	0.198
24°C	Initial	0.191	0.194	0.190	0.189
	6	0.186	0.199	0.917	0.199
	12	0.198	0.198	1.000	0.191
33°C	Initial	0.191	0.194	0.190	0.189
	6	0.197	0.199	2.312	0.198
	12	0.191	0.199	4.307	0.193
42°C	Initial	0.191	0.194	0.190	0.189
	6	1.489	0.198	5.740	0.192
	12	2.393	1.251	8.391	1.000

[a] Each value represents the mean of triplicate determinations of 3 mixed different code lots.
[b] Average warehouse temperature during 1 year storage period (ranged from 20–43°C).

Although there was no label declaration of added preservatives, sulfur dioxide was detected in all juices. The increase in the tin content during storage of juices was minimal and below the Codex Alimentarius Standard (250 ppm) and Saudi Arabian Standards (150–250 ppm). In addition, storage of various types of juices up to 12 months at 5, 24 and 33°C had no effect on iron content, but long storage of apple juice at warehouse temperature should be avoided. Further studies of physiochemical, microbial and organoleptic charactristics of these juices during storage are in progress.

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دراسات على العصائر المعلبة المنتجة تجاريًا في المملكة العربية السعودية
١ ـ العناصر المعدنية ـ نسبة الحديد والقصدير أثناء التخزين.

عصام حسن عويضة

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ملخص البحث. تمت دراسة العناصر المعدنية في أربعة أصناف من العصائر (برتقال، طماطم، تفاح، أناناس) وقد درس تأثير التخزين تحت درجات حرارة مختلفة (٥°م، ٢٤°م، ٣٣°م، ٤٢°م) على حدوث التآكل في العلب الصفيح وذلك بتتبع عنصري الحديد والقصدير لمدة سنة من التخزين.

أشارت النتائج بأن عصير الطماطم يحتوى على أعلى كمية من عناصر Cu, Na, K حيث إن ١٠٠ جرام من هذا العصير تعطي (تزود) ٧ر٣٪ من البوتاسيوم و ٢ر١٣٪ من الصوديوم و ٤٪ من النحاس من المقررات اليومية الموصى بها (RDA) ووجد أن محتوى العصائر تحت الدراسة من ثاني أكسيد الكبريت والحموضة كانت تتراوح بين ٦٧ر١٤٧ـ٣٣ر٢٠٢ ملليجرام/ كجم و٧٥ر‌ـ١٤ر١ جرام/ ١٠٠ جرام (كحمض ستريك) على التوالي.

أشارت النتائج بأن محتوى العصائر الأربعة من القصدير أثناء فترة التخزين تحت درجات حرارة مختلفة لمدة سنة كانت قليلة جدًا حيث إن نسبة القصدير في نهاية فترة التخزين تراوحت بين ٧ر١١ـ٢ر٤٥ ملليجرام/ كجم. وتعتبر هذه النسبة أقل من أعلى مستوى (٢٥٠ ملليجرام/ كجم) مسموح به من الوكالة العالمية للأغذية (C.A.C.).

ووجد أن التخزين على درجات حرارة ٥°م، ٢٤°م، ٣٣°م لايؤثر على محتوى الحديد بالنسبة لعصائر البرتقال، الطماطم والأناناس بينما وجد أن عصير التفاح المخزن على ٢٤°م، ٣٣°م أظهر ارتفاعًا بسيطًا في محتواه من الحديد.