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Studies of food value and contaminants in canned foods

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Analyses were performed on some shop shelf and immediate factory products of canned tomato purees and orange juices. The analyses show that the processed tomato purees contained higher concentrations of heavy metals than the orange juice products except iron, which was found in highest concentration in some of the orange juice samples. Shop shelf samples of all products analyzed contained much larger concentrations of tin, iron and lead compared to immediate factory samples. However, contaminant levels were lower than those recommended by legislation. These studies show that the proximate food compositions for both the purees and juices are comparable to those reported in several other works but products had lower values than their equivalent natural products. Single tins of these products were observed to be representative of the whole foodstuff when compared to those obtained by bulking.

INTRODUCTION

The period during which processed foods will retain acceptable quality is important to all who manufacture, transport, store or use them.

Canned, dried, frozen or processed foods are normally held from a few weeks to a year or more before being consumed. Factors which determine the storage life of processed foods include the type of product, method of processing, manner of packaging and the temperature and humidity of storage. Each item has a certain storage potential which may be used up quickly by inadequate packaging, high temperature or adverse levels of humidity or it may be extended over long periods by selection of conditions which will protect the quality of both product and container (Luh & Woodroof, 1975).

Corrosion is responsible for a number of defects in canned foods; its action takes several different forms such as etching of the surface of the plate, internal rusting of the cans, dissolution of tin, discoloration of the contents and the production of hydrogen gas. Thus, in addition to the quantity of trace elements such as lead, iron and tin added inadvertently during processing, internal rusting and etching of the cans could be possible sources of these heavy metals (Ranken, 1988). Harris and von Loesecke (1971) have investigated the effect of storage on the mineral content of processed foods and concluded that the increased lead content of canned foods in comparison to fresh foods was the result of contamination during processing or due to the release of lead from the soldered seams of the can. It has also been shown that radish plants growing in 12 000 ppm lead soil contained 550 ppm on a dry weight basis in the roots and 130 ppm in the tops. This type of uptake could partly account for lead concentration and of course for any other element observed in some canned foods.

This present work is aimed at determining food value of some processed/canned foods and also to evaluate the extent of contamination of these foods by heavy metals after a period of storage. The studies are also intended to provide information on their durability once they have left the factory.

MATERIALS AND METHODS

Three tomato purees from two different processing companies were used. They are coded P1, P2 and P3. P1 (shop shelf sample) and P2 (immediate factory sample) were from the Vegetable and Fruit Processing Company (Vegfru) Gombe in Northern Nigeria; P3 (shop shelf sample) is an Italian product. The orange juices are coded O1 (French canned orange juice) and O2 (Nigerian canned orange juice). The juices were

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shop shelf samples. All shop shelf samples were purchased in Zaria town in Northern Nigeria.

The samples were stored in a refrigerator as soon as they were purchased except for the immediate factory products which were processed immediately.

Determination of minerals and heavy metals by atomic absorption spectrophotometry

Sample preparation

About 0·25 g of air-dried sample was weighed out in a 100 ml Kjeldahl flask and 1 ml perchloric acid (60%), 5 ml nitric acid (69%) and 0·5 ml sulfuric acid (98%) were added (Allen *et al.*, 1989). The flask was swirled gently while digestion of sample was carried out at about 120°C. At the end of digestion which is shown by the appearance of whitish fumes, the digest was poured into a 50 ml volumetric flask and diluted to the mark.

The prepared sample was used for the determination of lead, tin, iron, calcium, copper, magnesium, potassium and sodium.

Instrumentation

A Perkin-Elmer model 303 atomic absorption spectrometer equipped with a three-slot burner and Perkin-Elmer hollow cathode source lamps was used.

Reagent and working standards

BDH Analytical reagent grade chemicals were used in the preparation of the sample and standard solutions. Standards were prepared as specified in analytical methods for flame spectroscopy (Varian Techtron).

Lead standard. A 1000 ppm lead solution was prepared by dissolving 1·000 g of lead in 1:1 nitric acid and diluting to 1 liter.

Tin standard. A 1000 ppm tin solution was prepared by dissolving 1·000 g tin metal in 100 ml HCl (warmed to 60°C), cooled and diluted to 1 liter. All further dilutions were made with 1:9 HCl.

Iron standard. A 1000 ppm iron solution was prepared by dissolving 1·000 g of metal in 20 ml of 1:1 HCl and diluted to 1 liter.

Calcium standard. A standard solution of calcium was prepared by dissolving 2·497 g of dried $CaCO_3$ in 1:4 nitric acid, and diluted to 1 liter to give 1000 ppm of calcium.

Copper standard. Copper metal (1·000 g) was dissolved in 1:1 nitric acid and diluted to 1 liter to give 1000 ppm of copper.

Magnesium standard. Magnesium (1·0 g) was dissolved in 1:4 nitric acid and diluted to 1 liter to give 1000 ppm of magnesium.

Potassium standard. Dried potassium chloride (1·907 g) was dissolved in distilled water and diluted to 1 liter to give 1000 ppm of potassium.

Sodium standard. Dried NaCl (2·54 g) was dissolved in water and diluted to 1 liter to give 1000 ppm sodium.

Using the appropriate wavelengths (Table 1) and hollow cathode lamps, the standard and sample solutions were aspirated into the flame, and from the calibration curves the concentrations of the elements in the various samples were determined:

$$\text{Element (\%)} = \frac{C\ \text{(ppm)} \times \text{Solution volume (ml)}}{10^4 \times \text{Sample weight (g)}}$$

where C (ppm) is the concentration from absorbance measurements (Allen *et al.*, 1989).

Proximate composition

All determinations were performed using known methods. The moisture content was determined by standard techniques (Egan *et al.*, 1981) while total solids content was done by following the procedures of Morris (1938). The sugar content was determined by the non-stoichiometric volumetric method of Lane and Eynon (Egan *et al.*, 1981) while crude fiber content was estimated by the acid and alkaline digestion methods described by Joslyn (1970) and AOAC (1980). The modified Lowenthals permanganate oxidation process was adopted for the determination of tannin (Egan *et al.*, 1981) and the protein content was determined by the macro-Kjeldahl method as shown in Egan *et al.* (1981). Ash determination was also carried out according to Egan *et al.* (1981), while starch content was estimated colorimetrically according to Allen (1989).

Table 1. Instrumental settings for the AAS

	Element	Lamp current (mA)	Fuel	Support	Wavelength (nm)
1.	Lead	6	Acetylene	Air	217·0
2.	Tin	8	Acetylene	Nitrous oxide	286·3
3.	Iron	5	Acetylene	Air	248·3
4.	Calcium	3	Acetylene	Nitrous oxide	422·7
5.	Copper	3	Acetylene	Air	324·7
6.	Magnesium	3	Acetylene	Air	285·2
7.	Potassium	5	Propane	Air	766·5
8.	Sodium	5	Propane	Air	589·0

RESULTS

Table 2 shows the mineral composition including contaminants present in samples analyzed.

The values obtained show that lead was present in trace amounts and that in all cases examined tomato purees contained larger quantities than the orange juice products. Sample P3 had the highest concentration of tin amongst all the samples.

The proximate compositions of the products are shown in Table 3. Sample O2 had the highest moisture content, while samples P1, P2 and P3 contained higher values of tannin, crude fiber, protein and starch compared to samples O1 and O2.

Moisture content, total solids, ash content and two minerals analyzed from bulking the samples (several tins of same sample mixed) compared very well with the values obtained from single tins. This result is shown in Tables 3 and 4.

As shown in Table 3 and 4, the immediate factory products contained higher values of the proximate composition than the shop shelf samples. However, the shop shelf samples had larger values of contaminants and heavy metals when compared to immediate factory products.

Three determinations per sample were made in all cases, and the mean and standard deviation values are shown in the various tables.

DISCUSSION

All shop shelf samples analyzed in this work showed higher concentrations of heavy metals compared to immediate factory products. The concentration of heavy metals in these canned foods could be attributed to quality of the can, duration of storage before consumption, the pH of the products and the concentration of oxygen in the headspace which could lead to the release of metal components in the soldered seams of cans (Luh & Woodroof 1975; Warwick, 1983; Ranken, 1988). Warwick (1983) has recorded the effect of oxygen concentration in the headspace as a function of lead deposition in canned products. Low pH values of canned foods are also known to enhance the dissolution of tin.

Warwick (1983) has also investigated the dissolution of tin and iron during a pack test of tomato pulp in tin plate containers.

The concentration of iron in any of the products could result from two factors, the concentration of iron naturally present in the food and the extent of contamination from the can which stored the food. The natural iron contents of these food items are $4·3 \times 10^{-4}$% for raw tomatoes and $3·0 \times 10^{-4}$% for orange juices. These values are far lower than those observed for the various samples and the differences noted were statistically significant. The excess iron concentration observed therefore could be attributed to the can quality and to the

Table 2. Mineral and heavy metal content (ppm × 10^{-3})

Sample	Pb	Sn	Fe	Ca	Cu	Mg	Na	K
P1	3·0 ± 0	335·0 ± 0·20	72·0 ± 0·01	27·2 ± 0	4·7 ± 0	87·2 ± 0	166·0 ± 0·07	206·0 ± 0·10
P2	2·3 ± 0	217·0 ± 0·10	60·0 ± 0·01	24·3 ± 0·01	2·52 ± 0	26·0 ± 0	79·6 ± 0·1	119·0 ± 0
P3	2·1 ± 0	495·0 ± 0·20	125·0 ± 0	105·0 ± 0·02	3·54 ± 0	89·7 ± 0	135·0 ± 0·05	240·0 ± 0·1
O1	1·8 ± 0	248·0 ± 0·01	9·1 ± 0	6·50 ± 0	0·45 ± 0	8·73 ± 0	0·70 ± 0	2·45 ± 0
O2	1·7 ± 0	418·0 ± 0	14·1 ± 0	6·2 ± 0	0·40 ± 0	13·7 ± 0	0·40 ± 0	8·8 ± 0

Concentrations of Na and K are 10^{-2} ppm.
Pb, lead; Sn, tin; Fe, iron; Ca, calcium; Cu, copper; Mg, magnesium; Na, sodium; K, potassium.

Table 3. Proximate composition (bulked samples) (%)

Sample	Moisture	Total solids	Sugar	Crude fiber	Tannin	Protein	Ash	Starch
P1	73·9 ± 0·5	26·0 ± 0·5	0·1 ± 0	1·2 ± 0·4	0·1 ± 0	3·1 ± 0·09	2·7 ± 0·4	1·0 ± 0·4
P2	71·6 ± 0·3	28·4 ± 0·3	0·1 ± 0	1·4 ± 0·2	0·3 ± 0	5·6 ± 0·1	4·2 ± 0·1	0·6 ± 0·3
P3	74·2 ± 0·2	25·8 ± 0·2	0·1 ± 0	1·4 ± 0·1	0·4 ± 0	2·9 ± 0·2	3·0 ± 0·4	0·3 ± 0·1
O1	27·4 ± 1·0	72·6 ± 1·0	0·7 ± 0	0·32 ± 0	0·1 ± 0	2·6 ± 0·2	0·1 ± 0·01	0·2 ± 0·5
O2	86·5 ± 2·4	13·5 ± 2·4	0·1 ± 0	0·2 ± 0	0·1 ± 0	1·2 ± 0	0·4 ± 0·03	0·17 ± 0

Table 4. Proximate composition (single tins) (%)

Sample	Moisture	Total solids	Ash	Lipid	Sodium	Potassium
P1	70·95 ± 1·2	29·1 ± 1·2	2·8 ± 0·1	1·6 ± 0	156 ± 0·6	198 ± 0·1
P2	70·4 ± 1·0	29·6 ± 1·0	5·0 ± 0·1	1·9 ± 0	89·6 ± 0·1	126·8 ± 0
O1	27·5 ± 0·6	72·5 ± 0·7	0·11 ± 0	1·6 ± 0·3	0·9 ± 0	2·7 ± 0
O2	86·8 ± 3·4	13·17 ± 3·4	0·42 ± 0·1	1·8 ± 0·4	0·4 ± 0	9·2 ± 0

Concentrations of Na and K are 10^{-2} ppm.

oxygen concentration in the headspace as shown in accelerated simulation can corrosion tests (Warwick, 1983). Comparing the literature and observed values for iron, therefore, the probable level of contamination is more than 10 times in the tomato purees and about one thousand times in one of the orange juice samples.

Existing legislation suggests an upper limit of 2 ppm for lead in canned foods (Statutory Instruments No. 1254, 1979). The levels of lead obtained in this research were not above this specified limit but there is a high probability that such toxicant levels could gradually accumulate above recommended limits in canned foods and consequently in the tissue of consumers.

Efforts should therefore be made towards decreasing the storage duration of canned foods after they have left the factories. It is also advisable to make adequate provisions for storage at suitable temperatures when consumable products are displayed on shop shelves. It was not certain how long the samples had been on the shelf; hence it would be useful to study the effect on shop shelf samples for varying but known periods of time. This will enable an investigation of their degradation and disintegration with time. The author intends to explore this area in due course.

The Food and Standards Committee recommends a limit for tin of 250 ppm in canned foods (Egan *et al.*, 1981). Tin will only dissolve rapidly in the food if oxygen is present so, provided the can is airtight, the major attack takes place during the early period after canning, but tends to slow down when the residual oxygen is used up. Tin plate is most likely to be attacked by acid foods, especially fruits such as rhubarb, prunes and tomato. This could be why the tomato samples contained more tin than the orange juices except sample O2.

Though iron is an essentially nutritive element, excess concentration in food can be detected by taste.

The proximate composition showed that most samples analyzed were of similar qualities as those analyzed and reported elsewhere (Braverman, 1949; Dickinson & Raven, 1962; Luh & Woodroof, 1975; Egan *et al.*, 1981). However, the ratio of total solids to moisture content in sample O1 (Table 3) compared to other samples showed the relatively high concentration of this sample. This could be due to the presence of other additives.

From the slightly varying mineral content values observed from the tomato purees, it would be pertinent to conclude that mineral content of fruit and vegetable products would depend on the soil where cultivation had taken place.

Analysis of individual tins carried out several times (including a *t*-test) showed that in most cases values obtained were representative of the whole foodstuff when compared to those obtained by bulking the samples.

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