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Lead Contents of Commercially Canned Single-Strength Orange Juice Stored at Various Temperatures

The lead contents of commercially canned single-strength orange juice varied within a narrow region (0.02–0.32 mg/kg of juice). Analysis of 168 samples showed that only four samples exceeded by 0.01–0.02 ppm the stringent tolerance level of 0.3 ppm established by FAO/WHO for canned baby juices. No statistical relationship was observed between storage temperature and lead content with commercial samples. Our data suggest that the variability in the lead contents of commercially canned orange juice was primarily due to the amount of solder (splashings and seepage through the side seam) exposed to the juice.

Lead is nutritionally a nonessential mineral that shows moderate toxicity. The toxic nature of lead is due to its binding to active sites of important enzyme systems in cells and to some ligands in the cell membrane (Stoewsand, 1980). Lead in food essentially originates from three sources, namely, (1) the natural lead content of food, (2) environmental pollution (lead dust from automobile exhausts or lead in runoff water enters food crops in certain areas), and (3) food processing activities involving the use of lead (Department of Health and Human Services, 1979). The most important source of added lead in a canned food product is not from the container (cans are constructed from plain carbon steel plates with a thin coating of tin) but from the solder (98% lead; 2% tin; American Can Company, 1973) used to seal the side seam. The Department of Health and Human Serivces (1979) estimates that ~14% of the total lead ingested by humans comes from the solder of canned foods. In this communication we report the results of temperature effects on the lead contents of commercially canned single-strength orange juice (SSOJ) that was stored for 12 weeks.

MATERIALS AND METHODS

Sample and Storage Treatment. Commercially cannned SSOJ was obtained from four processors located in Florida. SSOJ in 46-oz cans was taken directly from production lines and stored for 12 weeks at 21, 27, 32, 38, 43, and 49 °C.

Methods. Fifty grams of SSOJ was removed from a 46-oz can and placed in a tared platinum crucible. Charring of the sample, followed by ashing at 510–525 °C, was accomplished by a procedure previously described (Nagy et al., 1980). After ashing, the sample was dissolved in 2 mL of 1:1 concentrated HNO_3 and made up to a 100-mL volume with distilled water, and a portion transferred to a 60-mL polyethylene bottle. Replicate samples were run at each storage temperature. Nitric acid was distilled from glass at atmospheric pressure. Lead was determined by flameless atomic absorption spectroscopy by the method of Rouseff and Ting (1980).

RESULTS AND DISCUSSION

The concentration of lead in canned single-strength orange juice is due to (a) the natural lead content of orange juice and (b) lead derived from the solder. Because of the diversity of samples, we did not determine the natural lead levels for these juices prior to commercial canning. There is limited information on the natural lead content of Florida orange juice; Roberts and Gaddum (1937) reported 0.03–0.14 ppm of lead in blood orange juice, whereas McHard et al. (1980) reported values less than 0.1 ppm of lead (based on single strength) for Florida concentrated orange juices that were reconstituted. Recently, Rouseff and Ting (1980) reported an average value of 0.06 ppm of lead for noncanned single-strength grapefruit juice.

Storage of juices for a 12-week period (Table I) at temperatures ranging from 21 to 49 °C showed no statistical relationship (analysis of variance, 1% level of significance) between storage temperature and lead content. This lack of correlation was apparently due to the nonuniformity of the cans. In a study on canned fruit, Thomas et al. (1975) found the intercan variations of lead (solder) to have a coefficient of variation range from 18.2 to 97.8%. Rouseff and Ting (1980) found during a carefully controlled temperature experiment with canned grapefruit juice that considerable variation existed in the lead contents. This variation was primarily due to differences in solder splashings and solder seepage through the side seam. On the basis of these observations, Rouseff and Ting con-

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Table I. Effect of Temperature on the Lead Contents of Canned Single-Strength Orange Juice Stored for 12 Weeks

	lead contents, ppm (mg/kg of juice)											
	21 °C		27 °C		32 °C		38 °C		43 °C		49 °C	
processor	R^a	$\overline{X}^{a,d}$	R	$\overline{X}$	R	$\overline{X}$	R	$\overline{X}$	R	$\overline{X}$	R	$\overline{X}$
A[b]	0.05–0.30	0.17	0.08–0.15	0.11	0.04–0.17	0.10	0.05–0.14	0.08	0.02–0.28	0.10	0.03–0.26	0.11
B[b]	0.09–0.32	0.14	0.05–0.08	0.07	0.04–0.17	0.11	0.04–0.29	0.13	0.04–0.19	0.13	0.05–0.14	0.09
C[b]	0.07–0.29	0.16	0.04–0.23	0.11	0.04–0.29	0.14	0.04–0.25	0.08	0.06–0.32	0.16	0.03–0.19	0.08
D[c]	0.07–0.20	0.11	0.07–0.13	0.09	0.10–0.14	0.12	0.12–0.31	0.21	0.06–0.10	0.08	0.04–0.13	0.07

[a] R = range; $\overline{X}$ = mean. [b] Eight samples were analyzed at each storage temperature; 48 samples per processor; total of 144 samples. [c] Four samples were analyzed at each storage temperature; 24 samples for processor D. [d] Analysis of variance (1% level of significance) of lead means at various temperatures (treatments) showed no statistical relationship by the F test.

cluded that the large can to can lead variations were primarily due to the different amounts of the solder surface exposed to the juice.

Our experiment was intended to show the effects of temperature on the lead contents of canned SSOJ. If a relationship did exist, we did not find this because of the lead variation of the commercially canned product. A careful screening of cans, prior to canning, to group those that showed minimal solder splashings and seepage would have yielded a theoretical analytical conclusion; however, a practical conclusion from analysis of randomly selected commercial samples would not have been ascertained.

The FAO/WHO (Codex Alimentarius Commission, 1971) has established a lead tolerance limit of 0.3 ppm for canned juice consumed by infants, whereas the United Kingdom (Ockerman, 1978) has established a limit of 0.5 ppm for canned orange, grapefruit, and mandarin juices and 2.0 ppm for lemon and lime juices. The United States does not have an official tolerance limit for lead in canned foodstuffs (Department of Health and Human Services, 1979). However, FDA (Food and Drug Administration, 1968) has established a tolerance of 1 ppm for combined lead in or on fresh citrus fruits. Our results (Table I) show that of the 168 samples analyzed, only 4 samples exceeded the stringent tolerance level of 0.3 ppm established by the FAO/WHO for canned citrus baby juices. Storage temperature of a canned citrus product is not as important as the can used in packaging. Reduction of lead could result from a better can-manufacturing practice, whereby the interior solder surface area of the can is reduced.

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Variation of Myristicin Content in Cultivated Parsnip Roots (*Pastinaca sativa* ssp. *sativa* var. *hortensis*)

The roots of 24 varieties of cultivated parsnip were investigated to determine the myristicin content of the essential oil. The results show that the high myristicin content is not an effect of cultivation. Different chemical types of plants were not found. The aspects of the selection of the variety in regard to the insecticidal, psychotropic, and possibly toxic effect of myristicin are discussed.

Myristicin as a substituted allylbenzene must be classified as a hazardous environmental agent. Nevertheless myristicin is present in many foodstuffs encountered in everyday life. Lichtenstein and Casida (1963) isolated myristicin from the edible parts (roots) of *Pastinaca sativa* parsnip and reported on its insecticidal and synergistic properties.

In our previous work we confirmed myristicin as a main component of the essential oil content of the above and underground parts of *P. sativa* (Kubeczka and Stahl, 1975, 1977). Further investigations (Stahl and Kubeczka, 1979) proved that the myristicin content of the above-ground parts could be used to define two different groups of plants, a high-content type (17.4–44%) and a low-content type

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