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FAX COVER SHEET

To:	David Alnwick Senior Advisor, Micronutrients Nutrition Cluster	City/Country: New York Addressee's Fax : 326 7336	Date: 22 May 1995
From:	Somkhuan Shampeung Acting Nutrition Project Officer UNICEF, Thailand	Our Reference: BAO/TPO/95-0482 File: IDD	Total pages(s) (including this page)

Dear David,

Attached please find a document, given to us by Mr. Pan Varghese, about use of potassium iodide and iodate in processed foods, which you may find interesting. For your information, Mr. Varghese spent a week in Thailand, visiting salt producers and providing advice on their production and iodization techniques. A visit to Madras is now being planned as several producers are interested in seeing the iodization machine built by Machine Build Industries for possible purchase. Although we have decided not to fund the trip, we will provide some discount for any machines purchased. We will also subsidize the cost of production of machines in Thailand, as a way of providing incentives to salt producers.

ND On another subject, we sent you a fax on 20 April (Ref. No. 0386) enquiring about the possibility of Thailand taking part in the study of iodine stability in salt being carried out by PATH and the University of Toronto. Are you able to give us a response to this enquiry or perhaps a contact person at one of the implementing agencies? Please let us know if you would like us to resend the fax.

MTF Finally, we would very much appreciate if you could send us by pouch five copies of the MDIS document *"Global Prevalence of Iodine Deficiency Disorders*

Thanks for your assistance,

Best regards.

KC/kc

214

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Nutritional Iodine in Processed Foods

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ABSTRACT

This study evaluates the stability of various iodine compounds in processed foods. Samples of iodized salt (NaCl) containing potassium iodide, potassium iodate, or calcium iodate were used in experimental batches of bread, frankfurters, and potato chips prepared typically. No flavor or processing abnormalities were found. Iodine stability was generally acceptable for all iodine compounds, with at least 50–80% retention of iodine throughout processing and storage.

INTRODUCTION

Some iodine deficiencies persist in the United States despite the extremely small requirement of 140 micrograms per day for an adult male (Food and Nutrition Board, National Research Council, 1968) and despite the fact that adequate iodine has been available through the use of iodized table salt for almost 50 years. The White House Conference of Food, Nutrition, and Health (1969, p. 60) recommended that industry, government, and other agencies develop a program to encourage the public to use iodized salt.

The trend in U.S. food patterns has been toward increasing use of industrially processed and prepared foods, which are pre-salted with non-iodized salt. These foods are replacing food previously salted at home, often with iodized salt. Thus one apparent solution to possible iodine deficiency problems would be a selective iodization of processed foods.

EXPERIENCE WITH SALT ADDITIVES

Food processors, however, have been somewhat reluctant to deal with iodine fortification of foods for various reasons. Besides the normal problems of quality control involved in adding precise amounts of an iodine-containing substance, there also undoubtedly are fears of adverse effects upon food processing, appearance, flavor, and odor. Although Joslyn and Timmons (1967, p. 95) commented that iodized salt should not be used in food processing, we have been unable to document their claim of adverse effects on color and flavor of food products. Kojima and Brown (1955) found no undesirable effects from the use of iodized salt in canned tomato juice, bulk or canned sauerkraut, canned green beans, canned whole kernel yellow corn, or bottled pickled olives.

According to F. C. Lamb (1972, personal communication) of the National Canners Association, the canning industry had opposed the use of iodized salt because of an observed interaction with tinplate. However, El Wakeil (1958) established that this reaction was due to the presence of sodium thiosulfate, which is no longer used to stabilize potassium iodide in iodized salt.

This article presents an evaluation of the effects of iodine from various sources upon food processing including the determination of iodine stability during food preparation and storage.

PREPARATION AND ANALYSIS OF SALT SAMPLES

Preparation

Batches of iodized salt were prepared with potassium iodide, potassium iodate, and calcium iodate as sources of iodine. Dendritic salt (NaCl) was selected for several reasons, mainly its non-caking characteristics and its ability to adhere to potato chips. Both potassium iodide and potassium iodate were added to the salt as a water solution. Since potassium iodide in salt is subject to oxidation, it was stabilized as is normal for iodized salt, by mixing with 4 grams of dextrose and 0.55 grams of sodium bicar-

3/4

bonate per gram of potassium iodide. Because of the limited water solubility of calcium iodate, it was incorporated into the salt as a solid, with 0.1% propylene glycol added to prevent segregation.

The elemental iodine level in each iodized salt, as shown in Table I, was 0.0077%, equivalent to the normal 0.01% potassium iodide level in iodized table salt. After preparation, each salt sample was analyzed to verify the iodine content; each was reanalyzed at the time of usage in a food.

Analysis of iodine in foods

Iodine analyses were performed on finished food products by Shuman Chemical Laboratory, Battle Ground, Indiana. The analytical procedure involves combustion of the food in an oxygen stream, with absorption of the products in a sulfuric acid-chromic oxide mixture. Addition of water to the acid mixture, followed by boiling, oxidizes all iodine to iodate. Phosphorous acid, arsenious acid, and hydrogen peroxide reduce the iodate; and the iodine and the hydroidic acid are distilled into an alkaline solution. Iodine content of the distillate is measured by its catalytic effect upon reduction of ceric sulfate by arsenious acid.

FOOD PRODUCTS TESTED

Bread, potato chips, and frankfurters were prepared with the various iodine compounds, and analyzed before and after storage.

Bread

Loaves of white bread containing 2% of each of the provided salt samples were baked by the American Institute of Baking, Chicago, Illinois. They were prepared in the normal manner and observed for possible abnormalities in fermentation, appearance, aroma, and taste.

No difference was observed in fermentation time, proof time, internal appearance, taste, or aroma among control and iodized bread samples. Iodine stability was checked 2 days after preparation of the bread and then after 10 days in freezer storage. As shown in Table II, iodine retention is surprisingly good—at least 70% retention throughout baking, freezer storage, and air-drying (in preparation for iodine analysis).

TABLE I

Analysis of Iodized Salt Samples

Source of Iodine	Additive Level in Salt (%)	Iodine Level in Salt (%)
Potassium iodide[a]	0.0100	0.0077
Potassium iodate	0.0123	0.0077
Calcium iodate	0.0118	0.0077

[a]Stabilized with dextrose and sodium bicarbonate.

TABLE II

Iodine Stability in White Bread[a]

Iodine Additive	Iodine Concentration[b] (ppm)		Iodine Retention[c] (%)	
	2 days after preparation	After 10 days in freezer	2 days after preparation	After 10 days in freezer
Potassium iodide	1.14	1.09	76	73
Potassium iodate	1.24	1.07	80	70
Calcium iodate	1.10	1.11	73	74

[a]All values adjusted to 2.00% salt content for easier comparison.

[b]Corrected for iodine content of control (0.38 ppm).

[c]Based only on iodine added with salt.

Potato chips

Potato chips were produced by the Frito-Lay Research Department, Irving, Texas, using the salt samples added at the normal 2% level. The prepared chips were stored in an unheated room in multiple plastic bags protected from light.

The samples of potato chips were analyzed for iodine content after 7 weeks and 13 weeks of storage. The results are shown in Table III. Since salt content varied somewhat, all iodine values in the table have been adjusted to 2% salt for easier comparison of results. The low value for potassium iodate at 13 weeks probably represents analytical difficulties. Taste panel tests 4 weeks after preparation of the chips showed no significant flavor differences between iodized and un-iodized chips.

Frankfurters

Four lots of frankfurters, both iodized and un-iodized, were made by the Swift Research & Development Center, Oak Brook, Illinois, in a manner typical for the industry. During preparation of the emulsion, the meat batter was observed carefully for any atypical change; none was noted. The frankfurters were stuffed into cellulose casings, smoked using natural smoke, chilled overnight, then

TABLE III

Iodine Stability in Potato Chips[a]

Iodine Additive	Iodine Concentration[b] (ppm)		Iodine Retention[c] (%)	
	7 weeks	13 weeks	7 weeks	13 weeks
Potassium iodide	1.14	0.94	82	67
Potassium iodate	1.22	0.71	81	48[d]
Calcium iodate	1.19	1.12	77	73

[a]All values adjusted to 2.00% salt content for easier comparison.

[b]Corrected for iodine content of the control (0.28 ppm).

[c]Based only on iodine added with salt.

[d]Value out of line, apparently due to analytical difficulty.

TABLE IV
Iodine Stability in Frankfurters

Iodine Additive	Iodine Retention[a], (%) Frozen[b]	Refrigerated[c]	Prepared[d]
Potassium iodide	46	61	93[e]
Potassium iodate	54	53	65
Calcium iodate	41	60	52

[a]Based only upon iodine added with salt.

[b]Frozen for 18 weeks.

[c]Frozen for 20 weeks, then placed in sandwich bags and refrigerated at 42°F for 10 days.

[d]Frozen for 22 weeks, then thawed at room temperature and prepared by simmering in hot water for 5 minutes.

[e]Value out of line, apparently due to analytical difficulty.

peeled. Samples from each lot were inspected and found to be typical in texture and cure-color development. The same was true after heating in simmering water for 5 minutes. As for flavor, the frankfurters containing calcium iodate were described by one or two tasters as atypical, slightly bitter or astringent. Even this batch, however, received a good flavor rating. It may be that relatively insoluble iodine sources, such as calcium iodate, are undesirable because they are not sufficiently distributed throughout certain food products.

The remaining frankfurters were packed in polyethylene bags and frozen, then kept in freezer storage for 20 weeks. Iodine content was checked after the prolonged freezer storage, then after refrigerator storage for 10 days, and again after preparation in hot water. The results are shown in Table IV. Again, one iodine value, that for potassium iodide in prepared frankfurters, is clearly out-of-line and undoubtedly results from analytical difficulties.

CONCLUSIONS

No flavor or processing abnormalities were found in this study, and iodine stability was generally acceptable for all iodine compounds, with at least 50–80% retention of iodine throughout processing and storage. Of the compounds tested, only potassium iodide (which is used for iodizing table salt) has Food and Drug Administration approval as a source of dietary iodine. This study therefore indicates that:

1) Iodization of processed foods is feasible.

2) Salt is an acceptable carrier for the iodizing additive.

3) Potassium iodide is a practical and reasonably stable iodine source.

Although the desirability of iodine fortification of commercial foods is a separate and complex nutritional problem, this study shows that such fortification is feasible.

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The Effects of Iodized Salt in Processed Fruits and Vegetables[a]

6362

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(Manuscript received June 28, 1954)

Endemic goiter is prevalent in many parts of the world *(1)* in spite of the fact that Boussingault (1824) and Chatin (1850) concluded that a deficiency of environmental iodine was definitely associated with the occurrence of goiter *(2)* and the further fact that endemic goiter is considered to be the easiest known disease to prevent *(4, 5, 6, 7, 8)*. Even in the United States, where considerable publicity has been given to the use of iodized salt for the prevention of the disease, the incidence of simple goiter may be as high as 1.4% among children in the goiter belt *(3)*. Failure to utilize iodized salt is probably a factor in this situation; a survey by means of telephone calls and personal visits revealed, for example, that only 50% of the salt sold in Columbus, Ohio, is iodized salt. Since the general use of iodized salt in widely used processed foods would appear to be an additional safeguard against endemic goiter, a study of its effects on processed foods warrants further investigation.

This paper presents the results of tests designed to evaluate the effects of added iodine on the quality including the palatability of some processed vegetables and fruit. Iodates KIO_3 (the Department of Health, Education, and Welfare does not permit the use of KIO_3 in salt) were included to learn whether or not this supposedly more stable form of iodine could be used in place of the usual KI. Cuprous iodide was also tested in a limited way to se if this relatively insoluble form (a type desired for use with livestock) had any deleterious effect on Vitamin C.

EXPERIMENTAL PROCEDURE

Tomato juice. *Preparation of Solutions:* Eleven stock solutions, each containing 259.2 g. (amount which supplies salt at rate of 60 grains per No. 2 can of tomato juice) of NaCl and, in addition, the chemicals noted below were prepared and made up to one liter with distilled water the night prior to use. All chemicals were of c.p. quality. To secure iodine equal to that in commercial iodized salt 0.026 g. of KI and 0.034 g. of KIO_3 were used in each liter. Concentrations of 0.26 g. of KI were also used. Sodium nitrate or $NaNO_3$ at the rate of 3.866 g. per liter to give a concentration of 0.01% in the tomato juice.

Processing techniques. Tomatoes of the Rutgers variety were washed, trimmed, cored, and extracted twice in a Langsenkamp laboratory model extractor. The second extractions were combined. The mixture was then pumped through a Walker Wallace heat exchanger where it was held for 2⅔ minutes at 240° F. The flash sterilized tomato juice flowed directly into No. 2 fruit enamel cans which had previously received 15 ml. of one of the prepared chemical solutions. The uniformly filled cans were then sealed in an atmosphere of steam to insure a higher vacuum. The canned juices were kept at room temperature for about 3 months before the products were evaluated.

Cabbage. *Fermentation.* The Bugner variety was harvested early in October and wilted for a few days at room temperature. The outer leaves and core were removed by hand, and the leaves were shredded by a laboratory model kraut cutter. Fifteen pounds of the shredded cabbage were weighed and packed very tightly into glazed crocks. In packing, sufficient salt was added to give a concentration of 2.5%. At the same time, 15 ml. of distilled water were added to the controls. For the iodized and iodated salt batches, 0.0205 g. of KI and 0.0265 g. of KIO_3 were added in solution. This is an amount equivalent to that secured by using iodized salt containing 0.012% KI.

During the fermentation, the acidity was checked every 3 days. All lots were allowed to ferment for thirty-one days at room temperature. At the end of the fermentation, samples (10 ounces per sample) of each lot of kraut were packed in polyethylene bags. These samples were stored at 35° F. for 2 days before being evaluated by the panel. The rest of the kraut was canned.

Canning. After weights were removed from the kraut, the discolored upper layer of kraut was thrown away. The remaining kraut was transferred to a cheesecloth, and the juice extracted by a slight pressure.

The acidity of the juice was determined and adjusted to one percent by the addition of a calculated amount of distilled water. Salt concentration was determined on the adjusted juice chemically and by salometer readings. The salt concentrations were found to be the same, and therefore, no adjustment was made. The adjusted juice was brought to boiling.

The kraut was steamed at 214° F. for 5 minutes, weighed and packed into plain tin cans. Kraut juice at 210° F. was used to cover the kraut in the cans.

The canned lots were exhausted for 5 minutes in steam, sealed and processed at 214° F. for 15 minutes. The processed kraut was cooled immediately in running water. After being cooled down to room temperature, the lots were stored at room temperature for about 2 months before the evaluations.

Green beans. The freshly harvested Hyscore green beans were washed in a spray rotary washer, inspected on a moving belt for defects, and graded into sizes No. 5 and No. 6 (7⁄64 in. or more in thickness). They were then cut into pieces 1½ to 2 inches in length.

The cut beans were blanched at 212° F. in steam for 3 minutes, cooled immediately in running water, drained, and 0.66 lbs. weighed into No. 2 cans, with 30 grains (1.944 g.) of either plain or iodized salt[b] added. Boiling distilled water was added to the packed cans to fill but not to overflowing. They were exhausted for four minutes in steam. Upon emerging from the exhaust box, the cans were sealed and processed at 240° F. for 20 minutes. After processing, they were immediately cooled by circulating cold water and stored at room temperature for about three months.

Yellow sweet corn. The Golden Cross Bantam ears were harvested and brought into the processing laboratory immediately; they were husked by a FMC (Food Machinery Co.) husker. The defects were removed, and whole kernels were cut by a FMC No. 2 Universal corn cutter. The kernels were washed by a high pressure spray rotary washer and blanched in steam for three minutes. After being cooled in cold water 13.5 oz. of kernels were packed in No. 2 C-enamel cans with 30 grains of either plain salt or iodized salt. A boiling sugar solution which contained 3.5 pounds of sugar in 10 gals. of water, was then added.

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[a] A contribution of the Department of Horticulture and the Institute of Nutrition and Food Technology of The Ohio State University. Financed by contributions from the Chilean Iodine Educational Bureau, Inc., and Kelvin Smith.

[b] The iodized salt used (Morton) contains a maximum of 112 p.p.m. of KI.

The corn was exhausted for 3 minutes, sealed by a closing machine in a head of steam, processed at 250° F. for 30 minutes, and cooled immediately in running water; it was stored at room temperature for about 3 months.

Pickled olives. The pitted pickled olives from Spain were stuffed with pieces of red pimientos. The olives were washed and packed at the Kroger Company's plant, Cincinnati, Ohio, in a brine solution in glass jars. The following formula was used:

Salt	350 pounds
Lactic acid (50%)	67.5 pounds
Water to make	570 gals.

For the iodized salt brine 0.0335 g. of KI was dissolved in a gallon of the above brine, to give 0.02% of KI. For iodated salt brine, 0.0502 g. of KIO_3 (equivalent amount of 0.0335 g. of KI cited above) was dissolved in a gallon of the brine.

The pickled olives were packed in the above three kinds of brines in glass bottles and sealed while the head space was steam filled. The bottled olives were stored at room temperature for about 2 months.

Flavor evaluation. *Numerical Scoring.*[2] The flavors of canned tomato juices and bulk and canned kraut were scored from one to 10 (10 being the best) by the experienced panel. A control sample was known to the judges, and they were told to check the other samples against it. An identical unknown sample was also included to check the judges. The judging on a group of samples was repeated at different intervals.

Triangle Test.[2] Triangle tests were also conducted to see whether there is any detectable differences between the controls and iodized or iodated salt-treated samples.

Dilution Tests. Six samples of tomato juice containing increasing amounts of iodine were served. Judges were asked to check the first sample in the series in which they detected an off-flavor.

Color determination. Panel grading of color was used only in the case of bulk kraut, where the subjective numerical scoring by the judges was used to evaluate color differences between the treatments.

The Hunter Color Difference Meter. Differences in color of the tomato juices and the canned sauerkraut were measured by the Hunter instrument. A small aperture with a small area illumination with "L" scale was used for the tomato juice. A large aperture and large area illumination with "Rd" scale was used for evaluating the color of sauerkraut.

Subjective Texture and Color Evaluations. The flavor and odor evaluations of the canned tomato juices and sauerkraut were scored numerically from one to 10. Texture was also evaluated numerically in the same way on the same score card for sauerkraut.

Ascorbic acid determination. Ascorbic acid contents of the tomato juices and the fresh and canned green beans were determined by the indophenol titration method of the A. O. A. C. with the following modifications: One percent oxalic acid was used in place of one percent metaphosphoric acid. Homogenization was eliminated in the case of tomato juice, and instead the weighed juices were transferred into 200-ml. volumetric flasks with the oxalic acid, mixed well, made up to volume, mixed again, and filtered.

RESULTS AND DISCUSSION

Flavor evaluation. *Canned Tomato Juice.* The average scores of treated tomato juice are shown in Table 1.

Table 2 shows the results of analysis of variance.

As seen from Table 2, the judges could not find a significant difference in the flavor of the canned tomato juices due to the addition of iodized or iodated salt. Even ten times as much KI or I_2 failed to produce any distinguishable off-flavor.

[2] In both numerical scoring and triangle tests, the containers used for tomato juices were 10 ml. clean glass beakers; for other samples, shallow white china dishes of about 3 inches in diameter were used.

TABLE 1

Average scores of 16 judgings of flavor of canned tomato juices

Chemicals added	Average score
Control	8.3
KI	7.4
KI_3	8.0
KI and $NaNO_3$	7.6
KI and $NaNO_2$	7.7
KIO_3 and $NaNO_3$	7.1
KIO_3 and $NaNO_2$	7.7
KI × 10 and $NaNO_2$	7.8
KI × 10 and $NaNO_3$	7.4
I_2	7.6
I_2 × 10	7.0

TABLE 2

Analysis of variance of flavor evaluation of canned tomato juice

Source	DF	SS	MS	F	F (.05)	F (.01)
Treatments	11	20.552	1.87	1.53	1.84	2.36
Judges	15	292.365	19.49	15.97**	1.73	2.16
Error	165	201.198	1.22			

** Highly significant difference.

The effect of iodized salt in the presence of considerable amounts of nitrite or nitrate on tomato juice flavor seems to be negligible.

Color evaluation. The "a" and "b" readings on the Hunter Color Difference Meter were repeated 3 times. The resulting "a/b" ratios were combined and the average values are shown in Table 3.

TABLE 3

The "a/b ratios" of tomato juice (three replicates)

Treatment	Replicates			Average
	1	2	3	
Control	1.63	1.78	1.72	1.71
KI	1.63	1.78	1.72	1.71
KIO_3	1.63	1.74	1.76	1.71
KI and $NaNO_3$	1.71	1.87	1.81	1.79**
KI and $NaNO_2$	1.56	1.78	1.74	1.69
KIO_3 and $NaNO_3$	1.69	1.78	1.74	1.73
KIO_3 and $NaNO_2$	1.63	1.78	1.74	1.71
KI × 10 and $NaNO_3$	1.66	1.78	1.76	1.73
KI × 10 and $NaNO_2$	1.55	1.78	1.76	1.69
I_2	1.66	1.81	1.81	1.76
I_2 × 10	1.68	1.81	1.81	1.76

** Significantly different from the control at 5% level (L.S.D. 5% —0.57; 1% —0.0961.

Though there was a highly significant difference in "a/b" ratio between the treatment receiving (KI — $NaNO_3$) and the control, it is important to note that the average score of the treated lots is higher than that of the control.

Iodized salt thus did not adversely affect the color of tomato juice.

Odor. Odor of the canned tomato juices was evaluated subjectively from 1 to 10.

Table 4 shows the average scores of the seven judges. It shows that the judges could not detect any significant difference in odor between the treatments.

Ascorbic acid. Ascorbic acid determinations on the 11 treatments were also repeated 3 times.

Table 5 shows the average values of the 3 determinations of ascorbic acid for the 11 lots of canned tomato juice.

From Table 5 it can be seen that 3 nitrite treatments had but half the reduced ascorbic acid content of other treatments including the controls.

Tests with Cuprous Iodide. Relatively insoluble cuprous iodide was added to 2 samples of tomato juice at the rate of 0.01%. One lot was agitated for 5 minutes with a Waring blender and the other by pouring the juice 40 times from one tin can to another. The check and CuI treated lots agitated by pouring, both contained 21.5 mg. ascorbic acid per 100 g. and the check agitated by the Waring blender contained 18.4 and the CuI treated lot 18.0 mg. ascorbic acid per 100 g.

TABLE 4
The average scores of seven judges evaluating odor of the eleven treatments of canned tomato juices

Treatment	Average score of judges
Known control	8.50
Unknown control	8.50
KI	8.57
KIO_3	8.63
KI and $NaNO_3$	8.63
KI and $NaNO_2$	8.50
KIO_3 and $NaNO_3$	8.50
KIO_3 and $NaNO_2$	8.63
KI × 10 and $NaNO_3$	8.50
KI × 10 and $NaNO_2$	8.63
I_2	8.30
I_2 × 10	8.63

TABLE 5
The average values of three ascorbic acid determinations of the canned tomato juices

Treatment	Average amount of reduced ascorbic acid (mg./100 grams)
Control	23.50
KI	24.00
KIO_3	23.40
KI and $NaNO_3$	23.33
KI and $NaNO_2$	10.44**
KIO_3 and $NaNO_3$	23.93
KIO_3 and $NaNO_2$	9.73**
KI × 10 and $NaNO_3$	23.46
KI × 10 and $NaNO_2$	10.63**
I_2	23.46
I_2 × 10	24.00

** Highly significant differences (L. S. D. 5% —5.35; 1% —7.27).

Triangle test. Canned tomato juice containing a commercial salt and another containing a commercial iodized salt were subjected to a triangle test to see whether the judges could distinguish between iodized and non-iodized tomato juices.

On two occasions the 8 judges were given 3 samples of tomato juices, 2 of which were identical. They were asked to identify the identical two, and the number of correct answers were interpreted statistically to see if there were any significant difference between the 2 treatments. The table prepared by Rosseler *et al.* (10) was used to analyze the data.

The 2 judgings were combined, and the results in Table 6 show clearly that the judges could not detect any difference between iodized and non-iodized salt-treated tomato juices. If there were difference in any of the qualities which can be detected subjectively, i.e., flavor, odor, and color, they should have been detected by the panel.

TABLE 6
Analysis of the results of triangle taste tests on iodized and non-iodized canned tomato juices

No. of tastings	No. of correct answers	No. of correct answers necessary to establish significant difference	
		P.05	P.01
16	2	10	11

To get an idea how much iodine must be present to impart a detectable off-flavor to the tomato juices, a concentration test was conducted on the canned tomato juice to which increased amounts of iodine were added.

Eight judges participated in the test, and the results are shown in Table 7.

TABLE 7
The results of concentration tests on different concentrations of iodine in canned tomato juices

Concentration of I_2 in canned tomato juice (p.p.m.)	No. of tasters who detected an off-flavor
0.000	0
0.625	0
2.500	0
6.250	0
12.500	1[1]
25.000	2

[1] The judge stated that he tasted this as slightly different from the preceding concentrations but would not call it off-flavor.

The iodine concentration of canned tomato juice, in which iodized salt is used, is about 0.5 p.p.m. From the Table 7, therefore, it may be said that even at the level of 12.5 p.p.m. (25 times as much iodine as in ordinary iodized tomato juice), iodine failed to impart any appreciable off-flavor to tomato juice.

Bulk and Canned Sauerkraut. The results of the acid determinations made every 3 days while the cabbage was fermenting are shown in Table 8.

TABLE 8
Acidity produced by sauerkraut fermentation treated with iodized and iodated salts (acidity expressed as percent lactic acid)

Treatment	Days of fermentation								
	7	10	13	16	19	22	25	28	31
Control-1	0.88	1.20	1.40	1.52	1.44	1.48	1.52	1.60	1.68
Control-2	0.84	1.01	1.22	1.43	1.56	1.60	1.65	1.70	1.71
Iodized-1	0.77	1.05	1.19	1.30	1.38	1.30	1.60	1.65	1.70
Iodated-2	0.78	1.00	1.16	1.33	1.51	1.56	1.60	1.68	1.75
Iodated	0.88	1.31	1.45	1.56	1.64	1.68	1.71	1.73	1.75

The data indicate no appreciable effects from the use of iodized or iodated salts on the acid formation during kraut fermentation.

Flavor evaluation. *Bulk Kraut.* Since the total acidities of the 2 control samples were slightly different it was deemed essential to evaluate each by taste panels. The results are shown in Table 9.

TABLE 9
The average scores of eight judges evaluating flavor of bulk kraut using Control-1 as a check

Treatment	Average scores of eight judges
Control-1 (known)	7.60
Control-1 (unknown)	6.60
Control-2	6.90
Iodized-1	7.00
Iodized-2	6.70
Iodated	7.30

The judges failed to detect any significant differences between samples.

Canned Kraut. The differences in flavors of the canned kraut were evaluated subjectively after two months' storage at room temperature. The results obtained show that in both cases, using control-1 or control-2 as a check, no significant difference in flavor could be detected between the lots of canned kraut. In other words, the use of iodized or iodated salt in sauerkraut failed to produce any significant detectable off-flavors.

Bulk Kraut. Color differences between the lots of bulk kraut were scored subjectively. The judges could not detect any difference in color due to the presence of iodized or iodated salts.

Canned Kraut. In the case of canned kraut, "a" readings on "R_d" scale of the Hunter Color Difference Meter were taken as objective measures of color. The "a" values were exactly the same for all the lots, i.e., 58. It is safe to conclude that iodized or iodated salts can be used without producing any changes in kraut color.

Bulk Kraut. The textures of both bulk and canned kraut were scored subjectively from 1 to 10. The average scores of judges are given in Table 10.

TABLE 10

The average scores of eight judges scoring texture of bulk kraut using Control-2 as a check

Treatment	Average scores
Control-2 (known)	8.20
Control-2 (unknown)	7.60
Control-1	6.60
Iodized-1	7.60
Iodized-2	7.70
Iodated	8.00

It may be concluded that the judges could not detect any significant effects of iodized or iodated salt on the texture of bulk kraut.

Canned Kraut. The texture of the canned kraut was also evaluated subjectively. Table 11 shows the average scores of the judges using different controls as a check on texture of the canned kraut.

TABLE 11

The average scores of eight judges scoring texture of canned kraut using Control-1 as a check

Treatment	Average scores
Control-1 (known)	7.63
Control-1 (unknown)	7.38
Control-2	7.63
Iodized-1	8.00
Iodized-2	7.63
Iodated	7.88

From this and other data, we can conclude that neither iodized nor iodated salt induced any deterioration in the texture of canned kraut.

Odor evaluation. The judges scored odor subjectively.

The results in Table 12 show that the judges could not detect any different or undesirable odor due to the use of iodized or iodated salts in canned sauerkraut.

Canned Green Beans. Since only two lots of canned green beans were prepared, i.e., with iodized salt and plain salt, the triangle test was used to detect differences in flavor, texture, odor, or color. The results of the 2 triangle tests were combined and are shown in Table 13.

These results show that there was no difference in flavor, color, texture, or odor which may have been utilized in identifying the duplicates.

Ascorbic acid. The amounts of reduced ascorbic acid found in the beans in 6 different cans are shown in Table 14.

TABLE 12

The average scores of eight judges scoring odor of canned kraut using Control-1 as a check

Treatment	Average scores
Control-1 (known)	8.00
Control-2 (unknown)	8.00
Control-2	7.75
Iodized-1	7.38
Iodized-2	7.63
Iodated	7.75

TABLE 13

Results of triangle test of canned green beans stored for three months at room temperature

No. of judgings	No. of correct answers	No. of correct answers necessary to establish significant difference	
		5%	1%
14	3	9	10

TABLE 14

The amount of ascorbic acid in canned green beans after three months' storage at room temperature (expressed in mg./100 g. of juice)

Replicate	Control	Iodized salt
1	4.75	4.75
2	5.13	4.94
3	4.81	4.90
Average	4.89	4.86

Without resorting to analysis of variance, it is obvious that the results show no effect of iodized salt on the ascorbic acid content of canned green beans.

Canned Yellow Corn. Triangle tests failed to find any detectable differences in flavor or color between iodized and plain salted, canned, yellow, whole kernel corn.

TABLE 15

Result of two triangle tests using different treatments as duplicate in canned whole kernel yellow corn stored for three months at room temperature

No. of judgings	No. of correct answers	No. of correct answers necessary to establish significant difference	
		5%	1%
16	5	10	11

Pickled Olives. Since pickled olives were treated three ways, i.e., plain-salted, iodized-salted, and iodate-salted, 4 judgings were made. The results of the triangle tests are shown in Tables 16 and 17.

TABLE 16

Result of triangle test on iodized-salted and plain-salted olives

No. of judgings	No. of correct answers	No. of correct answers necessary to establish significant difference	
		5%	1%
15	4	9	10

TABLE 17

Result of triangle test on iodated-salted and plain-salted olives

No. of judgings	No. of correct answers	No. of correct answers necessary to establish significant difference	
		5%	1%
15	4	9	10

The results again show that the judges could not find any detectable differences between plain-salted and iodized-salted or iodated-salted bottled pickled olives.

CONCLUSIONS

In conclusion, the results obtained in this work all show no detectable deterioration in quality due to use of iodated or iodized salt in canned tomato juice, bulk and canned sauerkraut, canned green beans, canned whole kernel yellow corn, and bottled pickled olives.

Since the products tested were representative of processed fruits and vegetables which contained considerable amounts of salt, it may be concluded that as far as processed fruits and vegetables are concerned, there will be no fear of deterioration of the quality of products due to the use of iodized salt instead of plain salt.

Therefore, it would seem wise to use iodized salt in processing vegetables and fruits to reduce the incidence of goiter. It might even be wise to state on the label that iodized salt had been added as an additional safeguard to health.

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The Effect of Aureomycin Treatment on the Shelf Life of Fresh Poultry Meat[a]

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Several recent studies report the effect of certain antibiotics in the preservation of canned goods. A few studies have been made to determine the preservative effect of antibiotics on fresh food products.

Tarr, Southcott and Bessett *(4)* conducted trials in which the preservation effect of fifteen antibiotics on fresh fish was studied. They found that aureomycin, terramycin and chloromycetin were consistently effective in delaying spoilage. Goldberg, Weiser and Deatherage *(2)* found that these same three antibiotics were the most effective of the six used to preserve fresh beef.

Kohler, Broquist and Miller *(3)* reported increases in shelf life of eviscerated and cut-up chicken of from 7 to 14 days when the meat was dipped into aureomycin solutions containing from 3 to 30 p.p.m. and then was stored at 40° F. (4.4° C.).

Since aureomycin was considered one of the most effective antibiotics in the studies mentioned above, it was used in this study of shelf life with fresh chicken fryers.

[a] Scientific paper No. 1358, Washington Agricultural Experiment Stations, Pullman; project No. 1076.

EXPERIMENTAL METHODS

This study consisted of an experiment made up of three replicates which were not conducted simultaneously. Each replicate consisted of twelve fryers. The birds were dressed in the college poultry plant which is equipped with a Greenbriar Rotomatic Scalder and Greenbriar picker. Scalding was done in 128° F. (53.3° C.) water for forty seconds. The dressed birds were cooled for two hours in water containing melting ice, after which they were eviscerated and cut into halves. Four experimental treatments were applied on a half bird basis. The basic design was plan 11.1 of Cochran and Cox *(1)*, which is a balanced incomplete block design with the treatments in blocks of two and each treatment repeated three times. The possible replicate grouping was not utilized in the present instance. Each bird, being halved, formed a block of two treatments and thus possible bird to bird differences were removed from the treatment comparisons. Three runs of twelve fryers were utilized with the basic design being repeated within each run. Thus,