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Continental Can Company, Inc.

The Determination of the Suitability of Aluminum Containers for the Packaging of Irradiated Foods

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QUARTERMASTER FOOD AND CONTAINER INSTITUTE FOR THE ARMED FORCES
Research and Engineering Command
Quartermaster Corps, U.S. Army
Chicago, Illinois

CONTRACT RESEARCH PROJECT REPORT

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SUMMARY

Five different food products, whole kernel corn, green beans, phosphate cured ham, tuna chunks, and peaches, have been packed in aluminum and tinplate cans, irradiated to a dosage level of 5.0 megarads, and stored for one year at 77° and 100° F. Samples from the same lots of cans were

SUMMARY - (continued)

thermal processed as controls.

All enameled aluminum containers performed satisfactorily with W. K. corn, green beans, ham, tuna, and peaches when irradiated or thermal processed. The irradiation treatment appeared to have less effect on the enamels as measured by a lesser amount of darkening and staining and fewer micro-blisters as compared to the thermal process treatment.

Plain aluminum containers performed satisfactorily with W. K. corn but unsatisfactorily with green beans, tuna, ham and peaches when processed either by irradiation or thermal treatment, due to excessive corrosion and staining of the plate.

The tinplate variables performed satisfactorily for peaches, corn, tuna and green beans when irradiated or thermal processed.

In the case of ham packed in enameled tinplate cans, the irradiated samples were satisfactory while the thermal processed cans showed some loss of enamel adhesion peeling, blisters and corrosion at the drawn corners of the cans.

The product appearance varied from product to product in comparing irradiated samples with thermal processed samples. W. K. corn, green beans and peaches were darker when irradiated as compared to the thermal processed products, while the reverse was true for ham and tuna.

SUMMARY - (continued)

Irradiation caused considerable hydrogen formation in all of the products as determined by headspace gas analyses.

INTRODUCTION

There is a need for a strong, rigid container of low absorber density for the radiation preservation of subsistence items. Aluminum as a packaging material appears to provide these desirable characteristics and consequently a project was initiated to determine the effect of irradiation upon aluminum containers and inside can enamel systems during storage for one year at 77° and 100° F.

The following products were selected for this study:

1. Green beans
2. Whole kernel corn
3. Peaches
4. Tuna chunks
5. Phosphate cured ham

In order to set up proper conditions for the project, the work was divided into two phases. The first phase (Phase I) was designed to eliminate any unsatisfactory container variables and to establish any special packing requirements that might be necessary. The second phase (Phase II) included long term evaluation studies of the most promising container variables and packing conditions found in Phase I.

INTRODUCTION (continued)

Rectangular drawn (306 x 510 x 103) aluminum cans were used in the preliminary Phase I studies, enameled in the flat with several enamel systems, including a plain aluminum variable. The drawn aluminum cans were fabricated from 3003 H 14 aluminum alloy, 0.012" gauge plate. Each enamel and plain variable was packed with each product as described in an earlier report. Special sample holding racks were engineered to accommodate the rectangular drawn aluminum cans. Likewise, it was necessary to develop specially constructed containers to permit accurate dosimetry readings so that exact dosages could be attained. A dosage level of 5 megarads was used for irradiating all samples.

Based on the results of the Phase I studies, two phenolic modified vinyl enamel systems were selected for the longer term Phase II studies.

This report is a summary of the results of the Phase II studies on determining the performance of enameled and plain aluminum containers packed with five food products, irradiated with a dosage of 5 megarads at Argonne National Laboratories, Lemont, Illinois, and stored at 77° and 100° F. for one year. Examination schedules were set up for 0, 3, 6 and 12 month intervals.

EXPERIMENTAL METHODS AND MATERIALS

Rectangular drawn 306 x 510 x 103 size drawn aluminum cans were used in the Phase II studies. Two different types of phenolic modified vinyl enamel variables, in addition to one plain aluminum variable, were used.

EXPERIMENTAL METHODS AND MATERIALS - (continued)

These enamels were flat applied to the aluminum prior to the drawing operations. For control purposes, commercial specification tinplate containers were used for each product involved. A detailed outline of the container specifications is shown in Table I.

The special sample holding racks previously described were used at Argonne. All containers received exact dosages during irradiation. Details on packing data are shown in Table II.

Peaches

Frozen, sliced freestone peaches were allowed to thaw. They were heated to 170-180° F., drained and filled into the cans. The aluminum cans were filled with 7-1/2 oz. of product and then closed under mechanical vacuum (final vacuum - 6-8 inches). The tinplate cans were filled with 16 oz. of product and closed under mechanical vacuum (final vacuum - 16-20 inches). All samples were stored at -10° F. until irradiated or thermal processed. The irradiated samples received 5×10^6 rads exact dose. The thermal processed samples (controls) were allowed to thaw to 80° F. before processing. All processed samples were stored at 77° and 100° F. for one year with intervals of examination of 0, 3, 6 and 12 months.

Whole Kernel Corn

Frozen whole kernel corn was blanched for 2 minutes at 195° F., cooled in water and packed into the sample containers. The aluminum cans were packed with 7 oz. of product, 3/4 oz. of salt brine, and then closed under

mechanical vacuum (final vacuum - 11-13 inches). The tinplate cans were filled with 13 oz. of product, 1 oz. of salt brine and closed under mechanical vacuum (final vacuum - 20-21 inches). All samples were stored at -10° F. before processing. The irradiated samples were given an exact dose of 5×10^6 rads. The thermal processed samples were thawed to 70° F. before processing.

All processed samples were stored at 77° and 100° F. for one year with intervals of examination of 0, 3, 6 and 12 months.

Ham

Non-sterile phosphate cured canned hams were secured for this pack. The hams were sliced into steaks 1-25/32" thick. Both the aluminum and the tinplate cans were filled with 8 oz. of product to 6-7 sixteenth gross headspace, and closed under mechanical vacuum (final vacuum - 11-12 inches). All samples were stored at -10° F. before processing. The irradiated samples were given an exact dose of 5×10^6 rads. The thermal processed samples were thawed to 70° F. and then processed.

All samples were stored at 77° and 100° F. for one year with intervals of examination of 0, 3, 6 and 12 months.

Green Beans

Frozen cut green beans were blanched for 2 minutes at 195° F., cooled with water and packed into cans with salt brine. The aluminum cans were filled with 6 oz. of product, 3/4 oz. of salt brine and closed under mechanical

vacuum (final vacuum - 11-13 inches). The tinplate cans were filled with 14 oz. of product, 1-1/2 oz. of salt brine and closed under mechanical vacuum (final vacuum - 15-17 inches). All samples were stored at -10° F. before processing.

The aluminum cans were given an exact dose of 5×10^6 rads. The tinplate cans were thawed to 70° F. before processing. All processed samples were stored at 77° and 100° F. for one year with intervals of examination of 0, 3, 6 and 12 months.

Chunk Tuna

Frozen, precooked Japanese Albacore tuna loins were thawed and hand packed into the cans with 1/4 oz. salt and 3 oz. of Wesson oil. Both the aluminum cans and the tinplate cans were filled with 6 oz. of tuna and closed under mechanical vacuum (aluminum cans - 8-10 inches, tinplate cans - 15 inches). All samples were stored at -10° F. before processing. The aluminum cans were given an exact dose of 5×10^6 rads. The thermal processed samples were thawed to 70° F. before processing.

All processed samples were stored at 77° and 100° F. for one year with intervals of examination of 0, 3, 6 and 12 months.

RESULTS AND DISCUSSION

I. Enameled Aluminum Can Variables

(a) Whole Kernel Corn

No failures of the enamel systems occurred in the irradiated samples at any of the examination periods up to one year when stored at

77° and 100° F. Some isolated traces of blistering and corrosion occurred in the thermal processed samples. However, the performance of these cans was considered satisfactory.

(b) Green Beans

There were no failures of the enamel systems in the irradiated samples at any of the examination periods up to one year when stored at 77° and 100° F. Some slight staining and micro-blistering occurred in the thermal processed samples. In all cases, however, the performance of the cans was considered satisfactory.

(c) Phosphate Cured Ham

The performance of the enameled variables packed with ham and irradiated was satisfactory at all examination periods up to one year when stored at 77° and 100° F. Similar results were observed for the thermal processed variables, although some loss of adhesion and micro-blistering occurred at the drawn corners. The performance of these cans, however, was considered satisfactory.

(d) Tuna (Chunk Style)

The performance of the enameled variables packed with tuna and irradiated was entirely satisfactory at all examination periods up to one year when stored at 77° and 100° F. Some slight staining occurred in the enamel of the thermal processed samples. However, the performance of these cans was considered satisfactory.

(e) Peaches

The performance of both irradiated and thermal processed enameled variables was satisfactory at all examinations up to one year when stored

at 77° F. Due to excessive hydrogen production during irradiation, the samples stored at 100° F. became swells shortly after storage and consequently no data are available on the shelf life performance of these cans at that temperature. Headspace gas analyses of these cans indicated 86% hydrogen. The performance of the thermal processed cans stored at this temperature was satisfactory.

II. Plain Aluminum Can Variables

(a) Whole Kernel Corn

There were some traces of corrosion and slight staining of the plate in both irradiated and thermal processed cans. However, the performance of the cans was considered satisfactory at all examinations when stored at 77° and 100° F.

(b) Green Beans

There was surface type corrosion and staining of the plate in both irradiated and thermal processed samples when stored for one year at 77° and 100° F. The performance of the plain aluminum cans was not considered satisfactory for packing green beans, either irradiated or thermal processed.

(c) Phosphate Cured Ham

The performance of both the irradiated and thermal processed cans using plain aluminum plate was not considered satisfactory after storage up to one year at 77° and 100° F. due to excessive corrosion and staining of the plate.

(d) Tuna (Chunks)

The performance of both the irradiated and thermal processed cans packed with tuna was not considered satisfactory due to excessive corrosion

and staining of the plain aluminum plate when stored up to one year at 77° and 100° F.

(e) Peaches

The performance of both irradiated and thermal processed cans using plain aluminum plate was not considered satisfactory when stored at 77° and 100° up to one year due to excessive corrosion and staining of the plate.

III. Tinplate Controls

(a) Whole Kernel Corn

The performance of the irradiated samples was similar to that for the thermal processed samples when stored for one year at 77° and 100° F. Some slight corrosion and staining occurred in the samples; however, the cans were considered commercially acceptable.

(b) Green Beans

The performance of the irradiated samples and thermal processed samples was considered satisfactory when stored at 77° and 100° F. for one year. It was observed that at 100° F. there was less detinning of the irradiated samples than in the thermal processed samples.

(c) Phosphate Cured Ham

The performance of the irradiated samples was superior to the thermal processed samples stored for one year at 77° and 100° F. The thermal processed samples showed some loss of adhesion, peeling, blistering, and corrosion at the drawn corners which was not evident in the irradiated samples.

(d) Tuna (Chunks)

The performance of the irradiated and thermal processed samples was satisfactory when stored for one year at 77° and 100° F. There was slightly

more sulfide discoloration and staining of the enamel in the thermal processed samples as compared to the irradiated samples.

(e) Peaches

The performance of both the irradiated and thermal processed samples was similar and considered satisfactory. Some traces of corrosion sulfide staining and detinning occurred in all samples but was not considered objectionable.

In general, irradiation had little effect on the container when packed with the above five products and stored for one year at 77° and 100° F.

As was indicated in previous reports of Phase I studies and from analyses of headspace gas, the irradiation treatment caused product breakdown with the evaluation of hydrogen. This effect of irradiation has been reported by other collaborators in the field. Consequently, vacuum loss data were not included in this report since it was found to be inaccurate and misleading. The following data on the amount of hydrogen resulting from the irradiation treatment in the Phase I and Phase II studies were as follows:

Product	Phase I Studies	Phase II Studies
Peaches	56%	86%
W. K. Corn	55%	15%
Tuna	41%	23%
Ham	33%	28%
Green Beans	59%	-

Swelled cans were also examined bacteriologically and no viable organisms were found. This indicated that the containers were commercially sterile

and that the swelled cans were caused by excessive hydrogen production.

A detailed analysis of container and product performance is shown in Table III.

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TABLE I

SPECIFICATIONS FOR VARIOUS CANS

Product	Can Code	Can Size	PLATE		ENAMEL	
			Body	Ends	Body	Ends
Peaches	6823-P	306x510x103	Alum.3003H14 .0012"	Alum.3003H14 .0012"	Enameled	Enameled
	6825-P	306x510x103	Alum.3003H14 .0012"	Alum.3003H14 .0012"	Enameled	Enameled
	6827-P	306x510x103	Alum.3003H14 .0012"	Alum.3003H14 .0012"	Plain	Plain
	7080-P	303x406	Tinplate #100/25	Tinplate #25	Plain	Enameled
Whole Kernel Corn	6823-C	306x510x103	Alum.3003H14 .0012"	Alum.3003H14 .0012"	Enameled	Enameled
	6825-C	306x510x103	Alum.3003H14 .0012"	Alum.3003H14 .0012"	Enameled	Enameled
	6827-C	306x510x103	Alum.3003H14 .0012"	Alum.3003H14 .0012"	Plain	Plain
	7079-C	303x406	Tinplate #25	Tinplate #25	Enameled	Enameled
Ham	6823-H	306x510x103	Alum.3003H14 .0012"	Alum.3003H14 .0012"	Enameled	Enameled
	6825-H	3-6x510x103	Alum.3003H14 .0012"	Alum.3003H14 .0012"	Enameled	Enameled
	6827-H	306x510x103	Alum.3003H14 .0012"	Alum.3003H14 .0012"	Plain	Plain
	7081-H	306x510x103	Tinplate #50	Tinplate #50	Enameled	Enameled
Tuna	6824-T	306x510x103	Alum.3003H14 .0012"	Alum.3003H14 .0012"	Enameled	Enameled
	6826-T	306x510x103	Alum.3003H14 .0012"	Alum.3003H14 .0012"	Enameled	Enameled
	6828-T	306x510x103	Alum.3003H14 .0012"	Alum.3003H14 .0012"	Plain	Plain
	7082-T	307x113	Tinplate #25	Tinplate #25	Enameled	Enameled
Green Beans	6823-GB	306x510x103	Alum.3003H14 .0012"	Alum.3003H14 .0012"	Enameled	Enameled
	6825-GB	306x510x103	Alum.3003H14 .0012"	Alum.3003H14 .0012"	Enameled	Enameled
	6827-GB	306x510x103	Alum.3003H14 .0012"	Alum.3003H14 .0012"	Plain	Plain
	7078-GB	303x406	Tinplate #100/25	Tinplate #25	Plain	Enameled

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TABLE II

EXPERIMENTAL PACKS

Product	Container	Fill-in Weights Product	Fill-in Weights Liquid	Treatment	Vacuum (Inches Hg.)	Headspace (16ths")	Irradiation (rads)	Thermal Process	Storage
Peaches	306x510x103 Aluminum	7-1/2 oz.	-	Heated to 170°-180°	6-8	6-7	5×10^6	15' @ 212°F.	77 & 100°F.
Peaches	303x406 Tinplate	16 oz.	-	Heated to 170°-180°	16-20	6-7	5×10^6	15' @ 212°F.	77 & 100°F.
Whole Kernel Corn	303x510x103 Aluminum	7 oz.	3/4 oz.	Blanched 2'@ 195°F.	11-13	6-7	5×10^6	60' @ 240°F.	77 & 100°F.
Whole Kernel Corn	303x406 Tinplate	13 oz.	1 oz.	Blanched 2'@ 195°F.	20-21	6-7	5×10^6	60' @ 240°F.	77 & 100°F.
Ham	306x510x103 Aluminum	8 oz.	-	-	11-12	6-7	5×10^6	45' @ 240°F.	77 & 100°F.
Ham	306x510x103 Tinplate	8 oz.	-	-	11-12	6-7	5×10^6	45' @ 240°F.	77 & 100°F.
Tuna (Chunks)	306x510x103 Aluminum	6 oz.	3 oz.	No Blanch	8-10	6-7	5×10^6	75' @ 240°F.	77 & 100°F.
Tuna (Chunks)	307 x 113 Tinplate	6 oz.	3 oz.	No Blanch	15	6-7	5×10^6	75' @ 240°F.	77 & 100°F.
Green Beans	306x510x103 Aluminum	6 oz.	3/4 oz.	Blanched 2' @ 195°F.	11-13	6-7	5×10^6	21' @ 240°F.	77 & 100°F.
Green Beans	303 x 406 Tinplate	14 oz.	1-1/2oz.	Blanched 2' @ 195°F.	15-17	6-7	5×10^6	21' @ 240°F.	77 & 100°F.

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TABLE III

Can Spec.	W. K. Corn Processed By Irradiation	W. K. Corn Processed By Thermal	Green Beans Processed By Irradiation	Green Beans Processed By Thermal	Ham, PO_4 Cured Processed By Irradiation	Ham, PO_4 Cured Processed By Thermal
Enameled Aluminum (A)	No failures	1-2% enamel micro. blisters with tr-vsl corr. t/o. There was sl mottled effect on ends & tr on bodies above product level.	No failures	3% enamel micro. blisters with vsl corr. on ends at 100°F. There was vsl brown enamel staining on bodies.	No failures	Vsl enamel staining throughout
Enameled Aluminum (B)	No failures	1-2% enamel micro. blisters with tr corr. There was sl mottled effect on ends & tr on bodies above product level.	No failures	1-3% micro. blisters of enamel with tr-vsl corr. throughout.	No failures	Tr enamel staining throughout.
Plain Aluminum	Vsl surface type corr. on ends & bodies. There was tr on ends and vsl brown staining on alum. sheet throughout.	Sl corr. & dark grey staining on alum. sheet throughout.	Sl surface type of corr. & sl staining of alum. sheet.	Sl surface type & sl in depth pit type corr. There was vsl staining of alum. sheet.	Vsl-sl surface type corr. sl higher in degree of intensity at product level. There was tr brown enamel staining on ends & sl on bodies.	Sl corr. surface & pit type, sl in depth t/o. There was vsl dark grey staining on ends & sl-mod on bodies.
Control	Vsl corr. on ends & bodies above product level.	Vsl corr. on ends & trace on bodies.	Tr.corr. on ends. Bodies had sl-mod corr.(25% body area detinned below product level @ 77°F. & 50% area @ 100°F.) There was vsl staining of body sheet.	Tr. corr. on ends & bad corr. on bodies(@ 77°F. 20% body area below product level detinned, @ 100°F. 95% detinned).	1-3% microblisters in fabricated corners with tr-vsl corrosion.	Drawn corners 3/4" area lost enamel adhesion. There was tr corr. on ends & sl on bodies at fabricated corners.

TABLE III

Can Spec.	W. K. Corn Processed By Irradiation	W. K. Corn Processed By Thermal	Green Beans Processed by Irradiation	Green Beans Processed by Thermal	Ham, PO_4 Cured Processed By Irradiation	Ham, PO_4 Cured Processed By Thermal
Product Performance	Sl. brown-grey discol. of prod. at 77°F. & bad at 100°F.	Tr-sl grey-brown discol. of prod. at both temp.	In alum. & tinplate cont. sl dark-green discol. of prod. 4 weeks exam. Only at headspace was product & brine slightly dark in color.	In alum. container vsl dark prod. In tinplate sl light color of product.	In alum. container meat was light pink in color & fat white at 77°F. At 100°F. meat was brownish-pink & fat sl brownish. In tinplate meat & fat was vsl brown at 77°F. & sl brown at 100°F.	In alum.container meat was reddish in color, fat vsl-sl brown at 77°F. At 100°F. sl-mod brown meat & fat. In tinplate sl brown meat & fat at 77°F. At 100°F. sl-mod brown meat & fat.

TABLE III

Spec.	Tuna (Chunk Style) Processed By Irradiation	Tuna (Chunk Style) Processed By Thermal	Peaches Processed By Irradiation	Peaches Processed By Thermal
Enameled Aluminum (A)	No failures @ 100°F.	No failures @ 77°F. At 100° tr-vsl brown enamel staining throughout.	No failures at 77°F. At 100°F. there were no cans available due to swells from hydrogen formations shortly after irradiation.	No failures.
Enameled Aluminum (B)	No failures	Vsl-sl yellowish enamel staining throughout.	No failures, all cans low or zero vac.	No failures
Plain Aluminum	Sl surface type corr. on ends, mod on bodies There was vsl staining throughout.	Sl corrosion on ends, mod on bodies & vsl staining throughout.	No cans available at this examination due to excessive corrosion.	No cans available at this examination due to excessive corrosion.
Control	No failures	Tr-vsl black sulfide discol. of plate (expansion rings). There was 20% dealum. on ends with sl enamel softening. Sulfide staining of body plate was slight.	Tr corrosion on ends at both temp. Vsl detinning on bodies at 77°F. At 100°F. sl-mod detinning with tr-vsl base metal exposure. There was vsl-sl sulfide staining of plate.	Tr corrosion on ends at both temp.Vsl detinning on bodies at 77°F. At 100°F. sl-mod detinning with tr-vsl base metal exposure. There was vsl-sl sulfide staining of plate.
Product Performance	White-pink color of product at 77°F. Vsl brown headspace at 100°F.	Vsl-sl brown discol. of product at both temp.	Sl-mod discol. of prod. at 77°F. Bad brown discol. of prod. at 100°F. Variation in degree of brown discol. between cans examined.	In alum.container tr-vsl brown discol. of prod. at 77°F. & sl at 100°F. In tinplate sl brown discol. at 77°F. and sl-mod at 100°F. Variation in degree of brown discol. between cans examined.

corr. = corrosion
t/o = throughout
Vsl = very slight
tr = trace
sl = slight