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TECHNICAL REPORT
FD-15

DEVELOPMENT OF RADIATION STERILIZED FISH ITEMS FOR ARMED FORCES FEEDING

by

R. O. Sinnhuber

OREGON STATE UNIVERSITY
Corvallis, Oregon

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R. O. Sinnhuber
Oregon State University
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Project Reference:
1-K-0-12501-A-033

August 1965

U. S. Army Materiel Command
U. S. ARMY NATICK LABORATORIES
Natick, Massachusetts 01762

FOREWOPD

The availability of shelf-stable, highly acceptable seafood items for use in military feeding systems is considered a necessity. Radiation processing, or "cold" sterilization as it is frequently called, has the potentiality of yielding products that have good military utility, good storage stability, and good acceptability. Therefore, research to develop process criteria that can be used to produce irradiation sterilized seafoods is under way.

The work covered in this report was performed by Oregon State University under Contract DA19-129-AMC-155(N) during the period from 9 July 1963 to 9 November 1964. It represents an investigation of the effects of a variety of pre-irradiation process variables on the acceptability and storage stability of radiation sterilized seafood. These variables include such factors as type and quality of the raw material, enzyme inactivation techniques, and the use of selected additives such as spices and seasonings.

Professor R. O. Sinnhuber was the Project Officer and official investigator and Mrs. M. Landers the collaborator in the research work for Oregon State University. The U. S. Army Natick Laboratories' Project Officer was Dr. F. Heiligman and the Alternate Project Officer was Dr. E. Wierbicki, both of the Food Division.

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ABSTRACT

Five radiation-sterilized (4.5 Mrad) seafood products ((1) breaded prefried cod patties, (2) breaded prefried halibut patties, (3) enzyme-inactivated cod patties, (4) enzyme-inactivated halibut patties, and (5) halibut steaks) processed with and without antioxidants were evaluated periodically during 12-month storage at 72°F by subjective and objective methods. Preference panels of 132 to 210 tasters indicated all five products had acceptable flavor after 9-month storage. After 12-month storage, the panels preferred the non-irradiated frozen control samples to the irradiated samples; however, the irradiated samples received flavor scores in the acceptable range with the exception of the prefried halibut patties without antioxidant and halibut steaks with and without antioxidants. The antioxidants had little or no effect on flavor scores. Color reflectance values seemed to be the most reliable method of all the methods studied for measuring length of storage and degree of browning. Sauces, served with enzyme-inactivated halibut patties, proved to be an acceptable alternate method for serving.

DEVELOPMENT OF RADIATION STERILIZED FISH ITEMS FOR ARMED FORCES FEEDING

SUMMARY

1. Five radiation-sterilized seafood products, developed in this laboratory, were evaluated periodically, during twelve months of storage at 72°F, by subjective and objective methods. All products were packed in "C" enamel cans containing charcoal packets and vacuum-sealed. Two antioxidant preparations, Tenox VI and THBP with citric acid, were evaluated. The products are as follows:

a. Breaded, prefried cod patties
b. Breaded, prefried halibut patties
c. Enzyme-inactivated cod patties
d. Enzyme-inactivated halibut patties
e. Halibut steaks

2. Preference panels of 132 to 210 tasters indicated that the five radiation-sterilized seafood products received acceptable flavor scores after 9 months storage at 72°F. After 12 months storage, the panels preferred the non-irradiated control samples to the irradiated samples for all products. However, the irradiated samples received scores in the range of acceptability, with the exception of prefried halibut patties, without antioxidant and halibut steaks, with or without antioxidant. The addition of antioxidants had little or no effect on the flavor of the stored, irradiated products.

3. Objective evaluations of the five radiation-sterilized seafood products included total volatile bases, thiobarbituric acid number, pH and color reflectance measurements. The color reflectance values seemed to be a reliable measure of the length of storage and the degree of browning of the radiation-sterilized seafood products.

4. Sauces to improve the acceptability of radiation-sterilized seafood products were investigated. Four sauces, served on enzyme-inactivated halibut patties, proved to be acceptable, alternate methods of serving this product. The usual method is breading and deep-frying at time of serving. Flavor scores of prefried halibut patties, served with tartar sauce, showed the greater acceptability of radiation-sterilized seafood products that may be attained by the use of a suitable sauce.

I. General Objectives.

The objectives of this contract were to determine storage stability and the effect of antioxidants on five radiation-sterilized seafood products, developed in our laboratory under a previous Quartermaster Contract (DA19-129-QM-1356). The products included prefried cod patties, prefried halibut patties, enzyme-inactivated cod patties, enzyme-inactivated halibut patties and halibut steaks. Treatments were utilized that are known to improve flavor; such as, vacuum-packing and the use of charcoal packets to lessen radiation odors and flavors. The products were irradiated at 4.5 Mrad and stored for twelve months at 72°F with periodic evaluations during this time. Consumer-type preference panels were used to determine quality of the products and the effect of various treatments. Storage changes were evaluated by objective tests, including thiobarbituric acid number, total volatile bases, pH and color measurements.

II. Experimental Methods and Procedures.

A. Methods of preparation.

1. Preparation of prefried patties.

Fresh Pacific cod (Gadus macrocephalus)or halibut (Hippoglossus stenolepsis) was ground separately in a meat grinder, using a ¼-inch plate. Antioxidants were incorporated in the fish at this point by hand mixing for timed intervals, with the untreated samples receiving the same mixing. Tenox VI[1] or 2,4,5-trihydroxybutrophenone (THBP)[2] was added at the rate of 50 ppm. Citric acid (100 ppm) was added prior to addition of the THBP. In the preparation of prefried halibut patties, two lots of fish were used. Lot A was an evaluation of Tenox VI, packed in 307x409 (#2) cans and irradiated at Natick, Massachusetts.

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[1]Product of Eastman Chemical Products, Inc., containing 10% BHA, 10% BHT, 6% PG, 6% citric acid, 12% propylene glycol and 56% vegetable oil.

[2]Eastman Chemical Products, Inc., Kingsport, Tennessee

Lot B was an evaluation of THBP, packed in 307x200.25 (½ lb flats) cans and irradiated at MTR in Idaho. The ground fish was stuffed in meat casings (2½ x 32 E.P. Fibrous Visking Co.) by means of a hand stuffer. The "sausages" were quick-frozen at -18°F and sliced into 3/8-inch cakes on a band saw. The frozen cakes were dipped in DCA #4005 batter mix[1] and Modern Maid Redi-breader, medium brown[2], and deep-fried in Spry[3] at 360°F for three minutes (minimum internal temperature 160°F, 15 sec.). The fried patties were spread on wire racks, quick-frozen and packed in ½ lb flats or #2 "C" enamel cans. One 1-gram charcoal packet was attached to the underside of each can lid on the ½ lb flats and four 1-gram charcoal packets in the #2 cans.

2. Preparation of enzyme-inactivated patties.

Enzyme-inactivated fish patties were prepared as follows: To each 100 pounds of ground Pacific cod or halibut were added 4 pounds of white corn meal and 1.5 pounds of Viscomix (gelatin by Swift & Co.). Salt (0.35%) was added to the ground cod. Tenox VI or THBP was added at the rate of 50 ppm of the total mix. The ground fish was stuffed in sausage casings and the "sausages" were cooked in a boiling water bath to enzyme-inactivation temperature (160°F, 15 sec.), cooled and held in a 34°F cooler overnight, sliced in 3/8" patties and packed in ½ lb flats for irradiation. Parchment paper separated the patties and protected the 1-gram charcoal packet, which was attached to the underside of the lid. The cans were sealed under 29½" vacuum and held frozen to await shipment for irradiation.

3. Preparation of halibut steaks

Halibut steaks were prepared by cutting the thicker portions of Pacific halibut fillets to fit ½ lb flats, 8 ounces of fish per can. Parchment paper was placed in bottom and top of each can to prevent sticking. An antioxidant mixture, 5 ml of aqueous solution of THBP and citric acid, was added to make a final concentration in the fish of 50 ppm THBP and 100 ppm citric acid. The cans were vacuum sealed (29½") and cooked in a steam

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[1]DCA Food Industries, Inc., 45 West 36th Street, New York 18, New York
[2]Modern Maid Food Products, Inc., 110-160 Dunkirk Street, Jamaica 2, N.Y.
[3]Hydrogenated vegetable oil containing BHA and BHT, Lever Brothers Co., New York, New York

chamber to a minimum internal temperature of 160°F (approximately 18 minutes). The cans were cooled, frozen and held for irradiation.

B. Irradiation procedure.

The frozen samples were irradiated (4.5 Mrad) at the Materials Testing Reactor, Arco, Idaho, or the Co-60 source at Natick, Massachusetts. The samples were shipped to Idaho under dry ice, via Railway Express, and were returned to Oregon State University under the same conditions. Average dose rates at MTR varied from 3.42 to 11.30 $x10^6$ rad/hr., and irradiation was effected in water at ambient temperature. The samples were shipped to Massachusetts under dry ice, via Air Freight, returned to Oregon State University under ambient conditions, and the time interval between irradiation and start of 72°F storage was two weeks. The dose rate at Natick was 3.98 x 10^6 rad/hr., and irradiation was effected in air.

C. Storage conditions.

After irradiation the seafood products were stored in controlled temperature rooms at the Department of Food Science and Technology at 72°F for 0, 3, 6, 9, and 12 months. The non-irradiated, control samples were held at 0°F.

D. Subjective evaluations.

In the organoleptic evaluation of seafood products, large student panels were employed. The students for the panels were neither trained nor pre-selected, but rather a general notice was posted and 132 to 210 responded at various times. The tasters were seated in individual booths which were illuminated with amber lights to mask the color of the samples. The samples were served in randomly coded cups, ¼ patty per treatment. The preference ballot, with a 9-point hedonic scale, was used and went progressively from a score of 1, indicating "dislike extremely" to a score of 9, indicating "like extremely". Statistical analyses were obtained at the 5% significance level. Toxicity tests were conducted on all storage samples prior to presentation for panel evaluations to assure their safety for human consumption.

At the time of serving, the prefried patties were heated in a 400° oven for 15 minutes. The enzyme-inactivated patties were breaded and deep-fried in Spry at 360-365°F for three minutes. The halibut steaks were lightly covered with tomato sauce and heated in a 400°F oven for 15 minutes. The formulation for tomato sauce is given in Table 1.

A number of sauces to be used in combination with radiation-sterilized seafood products were prepared and evaluated. A sufficient quantity of enzyme-inactivated halibut patties, irradiated at 4.5 Mrad and held at 0°F, were available to serve 104 judges for evaluation of four sauces. The sauces served on the oven-heated fish patties were:

1. Medium-thick white sauce with chopped hard-cooked eggs and onion salt added. Paprika was sprinkled on top.
2. Canned mushroom soup, thinned one-half with milk.
3. Imitation sour cream containing dehydrated chopped onion and salt. Dried parsley flakes were sprinkled on top.
4. Tomato sauce, as served on halibut steaks.

Irradiated prefried fish patties were served with tartar sauce for evaluation by a large student panel. Each taster was served one tray containing a prefried halibut patty with tartar sauce, and one tray with a prefried halibut patty without tartar sauce. All patties were irradiated at 4.5 Mrad. The order of serving was changed so that half the tasters received the plain patty first, and half received the patty with tartar sauce first. The samples were scored on a 9-point hedonic ballot by 144 tasters.

E. Objective evaluations.

Objective evaluations by chemical and physical methods were employed. Thiobarbituric acid number (TBA)[1], total volatile bases (TVB)[2] and pH determinations were run on the halibut steaks and enzyme-inactivated cod and halibut patties at each storage time. Chemical tests were not performed on the prefried patties because of the breading which interferred with the determinations. A Photovolt Photoelectric Reflection Meter, Model 610[3], using a tri-green filter, was used to measure color differences between treatments of the prefried and enzyme-inactivated patties. Three readings were taken on the surface of the top patty from fourteen cans of each treatment of the enzyme-inactivated patties. Pre-

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[1]Yu and Sinnhuber, Food Technol., Vol. XI, No. 2, pp 104-108, 1957
[2]M. E. Stansby, Ind. Eng. Chem., Anal. Ed. 16, 593, 1944
[3]Photovolt Corporation, 95 Madison Avenue, New York 16, New York

fried patties were sliced horizontally for a reflectance reading of the fish flesh, and three readings were taken on three patties of each treatment. The readings were averaged for each treatment and presented as mean per cent reflectance readings.

III. Results and Discussion.

A. Subjective evaluations.

Large student panels of 132-210 tasters evaluated the effects of irradiation, storage and the addition of antioxidants on the flavor of the five radiation-sterilized seafood products. Results are given in Table 1.

The irradiated, prefried fish patties were scored significantly lower than the non-irradiated controls after storage for 12 months at 72°F. However, all scores were in the range of acceptability (above 5.0) with the exception of the irradiated, prefried halibut patty, without antioxidant (Lot B). This sample received a score of 4.81 on the 9-point hedonic scale.

There were significant differences between the irradiated, enzyme-inactivated cod and halibut patties, with or without antioxidants, and the controls after twelve months storage at 72°F. The irradiated samples scored significantly lower than the controls although all scores were in the range of acceptability.

The non-irradiated halibut steaks were preferred to the irradiated steaks, with or without THBP added.

The mean flavor scores for irradiated, enzyme-inactivated halibut patties served with four sauces are given below:

White sauce with chopped egg	5.93
Mushroom soup	6.15
Sour cream with onion	5.91
Tomato sauce	5.93

There were no significant differences between treatments. It should be noted that this method of serving is a departure from our usual method of breading and deep-frying. This product was heated and covered with a sauce at time of serving.

Results of the flavor evaluation of irradiated, prefried fish patties served with tartar sauce are as follows:

Halibut patty with tartar sauce	7.5
Halibut patty without tartar sauce	6.2

Table 1. Mean Flavor Scores[a] for Radiation-Sterilized Seafood Products

	Product	Treatment	Rad. Level (Mrad)	Storage Temp (°F)	Storage Time (Months) 0	3	6	9	12
1.	Prefried cod patties	w/o antioxidant	0	0	6.43	6.64	6.53	6.46	6.47
		w/o antioxidant	4.5	72	6.41	6.52	6.22*	6.11*	5.53*
		w Tenox VI	4.5	72	6.30	6.29*	6.17*	6.16*	5.75*
		w THBP	4.5	72	6.37	6.37	6.11*	5.78*	5.47*
2.	Prefried halibut patties Lot A	w/o antioxidant	0	0	6.38	6.30	6.36	6.58	6.29
		w/o antioxidant	4.5	72	6.14*	5.98*	6.32	5.59*	5.14*
		w Tenox VI	4.5	72	6.29	5.91*	6.12	5.89*	5.45*
	Lot B	w/o antioxidant	0	0	6.63	6.56	6.45	6.46	6.40
		w/o antioxidant	4.5	72	5.96*	5.98*	5.61*	5.75*	4.81*
		w THBP	4.5	72	6.03*	5.96*	5.65*	6.01*	5.14*
3.	Enzyme-inact. cod patties	w/o antioxidant	0	0	6.63	6.81	6.35	6.84	6.66
		w/o antioxidant	4.5	72	6.38*	6.49*	6.59	6.72	5.93*
		w Tenox VI	4.5	72	6.20*	6.48*	6.81*	6.82	6.18*
		w THBP	4.5	72	6.37*	6.55*	6.41	6.57*	5.90*
4.	Enzyme-inact. halibut patties	w/o antioxidant	0	0	6.34	6.00	6.33	6.58	6.40
		w/o antioxidant	4.5	72	5.98*	5.85	6.02*	6.24*	5.99*
		w Tenox VI	4.5	72	6.19	5.88	6.17	6.36	5.91*
		w THBP	4.5	72	6.07*	5.90	5.95*	6.13*	5.57*
5.	Halibut steaks	w/o antioxidant	0	0	6.53	6.19	6.47	6.67	6.66
		w/o antioxidant	4.5	72	5.93*	5.51*	5.47*	5.91*	4.76*
		w THBP	4.5	72	5.72*	5.62*	5.71*	6.10*	4.99*

[a]Score 9 high, 1 low
*Significantly different from the control at 5% significance level

The addition of tartar sauce significantly improved flavor scores of irradiated halibut patties. This is the highest flavor score we have ever attained with a radiation-sterilized seafood product, and shows the greater preference that may be attained by the use of a suitable sauce.

B. Objective evaluations.

Results of the chemical tests and pH determinations of enzyme-inactivated cod patties, enzyme-inactivated halibut patties and halibut steaks afer 12 months storage at 72°F are presented in Tables 2, 3, and 4, respectively.

In general, the chemical tests correlated with radiation and the length of storage. TBA number, a measure of the amount of malonaldehyde and a product of oxidative rancidity, increased after radiation, showing that minor oxidation had occurred. As the storage time was extended this value decreased, indicating that further oxidation and the accompanying production of malonaldehyde did not occur, since oxygen was limited in the vacuum-sealed container. The presence of antioxidants further controlled and prevented the formation of malonaldehyde and oxidative rancidity. The generally elevated TBA levels of halibut are a reflection of the fat content which is higher in halibut than in cod. As far as TBA values are concerned, there appears to be little difference between the antioxygenic activity of THBP and Tenox VI in these products, under these conditions.

The TVB values seemed to reflect the length of storage of the enzyme-inactivated cod patties and halibut steaks, and the values, even after 12 months storage, were not excessive. There was a gradual increase in values as can be seen in Table 2. The TVB values of enzyme-inactivated halibut patties, which were initially higher than cod, remained essentially unchanged during the 12 months storage time, as did the pH values.

The color reflectance values, which are a measure of the change in color of the product and the degree of browning, are shown in Tables 5 and 6. Statistical analyses at the 5% level of significance show the significant color differences after storage at 72°F. It is of interest to note that radiation at 4.5 Mrad generally caused no change in initial reflectance values, except for prefried patties which became lighter in color after irradiation. In general, non-enzymatic browning developed and increased gradually with storage. Variable results were obtained with antioxidants. The quite severe brownish discoloration that occurred after 12 months of storage in the prefried cod and halibut patties is considered by us to be a serious problem which must be overcome, if prefried irradiated fish products are to become a commercial possibility.

The problem, although present in the enzyme-inactivated cod and halibut patties, is not of the same degree of magnitude as the prefried samples.

Additional work is definitely indicated on the undesirable "browning" reaction that occurs after storage of 9 to 12 months. It appears that this is a carbonyl-amine reaction that is amenable to solution by control of oxygen and the use of appropriate antioxidants or browning inhibitors.

Table 2. Objective Determinations of Enzyme-Inactivated Cod Patties

Storage Time & Temp.	Rad. Level (Mrad)	Treatment	TVB Mg N/100 g fish	pH	TBA Mg Mal./ Kg fish
0 Months 0°F	0	w/o antioxidant	7.88	6.85	3.60
	4.5	w/o antioxidant	6.83	6.85	2.74
	4.5	w Tenox VI	8.58	6.80	1.36
	4.5	w THBP	7.00	6.90	1.45
3 Months 0°F	0	w/o antioxidant	5.95	6.85	1.65
72°F	4.5	w/o antioxidant	13.48	6.90	1.13
	4.5	w Tenox VI	15.93	6.85	0.75
	4.5	w THBP	13.56	6.90	0.63
6 Months 0°F	0	w/o antioxidant	6.65	6.85	2.23
72°F	4.5	w/o antioxidant	16.63	6.95	0.83
	4.5	w Tenox VI	17.15	6.90	0.58
	4.5	w THBP	15.23	6.90	0.69
9 Months 0°F	0	w/o antioxidant	7.00	6.85	1.94
72°F	4.5	w/o antioxidant	18.38	6.95	3.08
	4.5	w Tenox VI	18.20	6.85	1.07
	4.5	w THBP	19.08	6.90	0.87
12 Months 0°F	0	w/o antioxidant	7.26	6.85	3.35
72°F	4.5	w/o antioxidant	21.44	7.00	1.82
	4.5	w Tenox VI	21.96	6.90	1.22
	4.5	w THBP	18.81	6.95	1.03

Table 3. Objective Determinations of Enzyme-Inactivated Halibut Patties

Storage Time & Temp.	Rad. Level (Mrad)	Treatment	TVB Mg N/100 g fish	pH	TBA Mg Mal./ Kg fish
0 Months 0°F	0	w/o antioxidant	35.35	7.00	4.00
	4.5	w/o antioxidant	33.60	6.95	8.40
	4.5	w Tenox VI	22.75	6.80	1.94
	4.5	w THBP	35.09	6.90	1.74
3 Months 0°F	0	w/o antioxidant	33.86	7.00	3.51
72°F	4.5	w/o antioxidant	36.58	6.95	5.35
	4.5	w Tenox VI	27.74	6.80	2.73
	4.5	w THBP	37.36	6.90	2.79
6 Months 0°F	0	w/o antioxidant	32.99	7.00	3.60
72°F	4.5	w/o antioxidant	37.63	7.00	5.60
	4.5	w Tenox VI	30.10	6.80	1.63
	4.5	w THBP	38.33	6.85	1.59
9 Months 0°F	0	w/o antioxidant	30.80	6.95	1.65
72°F	4.5	w/o antioxidant	35.00	6.85	0.62
	4.5	w Tenox VI	33.78	6.75	1.71
	4.5	w THBP	40.60	6.80	1.02
12 Months 0°F	0	w/o antioxidant	35.00	7.00	0.84
72°F	4.5	w/o antioxidant	40.25	6.90	0.43
	4.5	w Tenox VI	34.30	6.75	1.14
	4.5	w THBP	40.08	6.80	0.86

Table 4. Objective Determinations of Halibut Steaks

Storage Time & Temp.	Rad. Level (Mrad)	Treatment	TVB Mg N/100 g fish	pH	TBA Mg Mal./ Kg fish
2 Weeks 0°F	0	w/o antioxidant	8.23	6.45	6.24
72°F	4.5	w/o antioxidant	8.75	6.60	7.10
	4.5	w THBP	8.49	6.50	5.80
3 Months 0°F	0	w/o antioxidant	8.75	6.45	5.34
72°F	4.5	w/o antioxidant	13.13	6.50	3.20
	4.5	w THBP	12.69	6.40	11.40
6 Months 0°F	0	w/o antioxidant	10.50	6.25	24.20
72°F	4.5	w/o antioxidant	14.88	6.55	2.26
	4.5	w THBP	15.31	6.45	7.50
9 Months 0°F	0	w/o antioxidant	10.50	6.40	15.80
72°F	4.5	w/o antioxidant	21.53	6.50	17.60
	4.5	w THBP	19.43	6.50	0.51
12 Months 0°F	0	w/o antioxidant	11.46	6.20	13.60
72°F	4.5	w/o antioxidant	19.51	6.50	7.40
	4.5	w THBP	23.19	6.50	9.40

Table 5. Mean Color Reflectance Measurements[1] of Prefried Fish Patties

Rad. Level (Mrad)	Treatment	Storage Temp (°F)	Storage Time (Months) 0	3	6	9	12
Prefried Cod Patties							
0	w/o antioxidant	0	48.3	50.7	54.1	56.1	55.0
4.5	w/o antioxidant	72	49.9	43.2*	36.9*	37.9*	32.8*
4.5	w Tenox VI	72	50.3*	44.2*	38.2*	38.8*	32.8*
4.5	w THBP	72	47.3	41.4*	33.4*	34.3*	33.0*
Prefried Halibut Patties							
Lot A 0	w/o antioxidant	0	57.0	61.8	65.0	61.3	63.4
4.5	w/o antioxidant	72	65.1*	54.3*	51.2*	41.4*	38.8*
4.5	w Tenox VI	72	60.1	55.4*	52.6*	47.0*	46.9*
Prefried Halibut Patties							
Lot B 0	w/o antioxidant	0	69.9	64.7	69.1	68.8	66.4
4.5	w/o antioxidant	72	68.4*	59.1*	54.3*	52.9*	49.7*
4.5	w THBP	72	65.3*	57.7*	53.4*	55.8*	50.9*

[1]Per cent reflectance
*Significantly different from the control at 5% significance level.

Table 6. Mean Color Reflectance Measurements[1] of Enzyme-Inactivated Fish Patties

Rad. Level (Mrad)	Treatment	Storage Temp (°F)	Storage Time (Months) 0	3	6	9	12
Enzyme-inactivated Cod Patties							
0	w/o antioxidant	0	55.3	53.1	54.9	55.8	50.5
4.5	w/o antioxidant	72	55.2	45.0*	44.6*	46.6*	40.4*
4.5	w Tenox VI	72	54.0*	46.7*	46.6*	48.2*	37.3*
4.5	w THBP	72	49.8*	41.9*	39.7*	42.0*	37.7*
Enzyme-inactivated Halibut Patties							
0	w/o antioxidant	0	64.2	60.0	65.5	61.2	63.0
4.5	w/o antioxidant	72	63.0*	57.4*	65.6	62.2*	57.1*
4.5	w Tenox VI	72	63.4*	55.4*	53.5*	53.0*	47.6*
4.5	w THBP	72	62.5*	56.4*	60.5*	58.4*	54.6*

[1]Per cent reflectance
*Significantly different from the control at 5% significance level.

Table 7.

Tomato Sauce for Halibut Steaks

1 - 46 oz. can tomato juice
3 - 8 oz. cans tomato sauce
Grind or chop fine - 1 stalk celery, 4 cups
3 medium onions, 2 cups
2 medium cloves garlic
2 - tablespoons catsup
2 - tablespoons Worcestershire Sauce
2 - tablespoons vinegar or lemon juice
4 - tablespoons dehydrated green pepper
2 - tablespoons dehydrated sweet red pepper
1 - tablespoon sugar
2 - teaspoons salt
1 - teaspoon chili powder
¼ - teaspoon black pepper
Dash Tabasco Sauce
2 - bay leaves

Combine all ingredients. Simmer for 2 hours. Remove bay leaves. Press through food mill.