EFFECTS OF THREE COOKING METHODS ON PESTICIDE RESIDUES IN CHINOOK AND COHO SALMON

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ABSTRACT

EFFECTS OF THREE COOKING METHODS ON PESTICIDE RESIDUES IN CHINOOK AND COHO SALMON

By

Waldina E. Smith

The purpose of this study was to compare the effects of baking, poaching and baking in nylon cooking bags on PCBs and pesticide residue levels in chinook and coho salmon. Cooking losses, tenderness and juiciness were also determined on a limited number of samples. Flesh and skin samples, raw and cooked, as well as drip from cooking were analyzed by electron-capture gas chromatography following hexane-acetone extraction and Florisil-Celite column clean-up to determine PCBs and pesticide residues which were calculated on a parts per million fat basis. Percent fat was also determined.

Raw flesh of chinook and coho salmon averaged 2.65 and 3.59% fat, respectively. Raw chinook flesh differed ($P < 0.05$) in fat content among individual fish and position from which the samples were taken with samples from the anterior halves containing more fat.

Cooked chinook flesh differed in fat content ($P < 0.01$) due to cooking method, individual fish and position from

which samples were taken. Poached flesh contained less ($P < 0.05$) fat than baked flesh while samples taken from the anterior halves contained highest percentages of fat. Drip from baked samples contained more ($P < 0.01$) fat than baked-in-bag drip which contained more ($P < 0.01$) fat than poached drip. Skin and drip samples also showed higher amounts of fat in the anterior halves than the posterior halves.

Residues of Aroclors 1248 and 1254, p,p'-DDE, p,p'-DDD and p,p'-DDT were found in chinook and coho salmon flesh, skin and drip samples. AroclOrs 1248 and 1254 levels in raw chinook salmon averaged 18.17 and 273.03 ppm, respectively, while coho salmon averaged 14.35 and 155.41 ppm, respectively. DDT compounds in raw chinook flesh averaged 40.20 ppm of p,p'-DDE, 4.24 ppm of p,p'-DDD and 23.94 ppm of p,p'-DDT. Flesh samples of coho averaged 27.74, 3.25 and 14.57 ppm of p,p'-DDE, p,p'-DDD and p,p'-DDT, respectively.

Cooked flesh samples of chinook salmon showed no significant differences due to cooking method and cooking with and without skin; however, the samples differed ($P < 0.01$) among individual fish. Flesh samples cooked by baking-in-bags reduced PCBS and pesticide residue levels the most while the least reduction occurred in poached samples. Cooked flesh samples of coho did not show the same pattern of pesticide reduction due to cooking method; however, the number of fish was small and only the anterior halves were studied.

Cooked skin and drip samples of chinook and coho showed no consistent pattern for changes in all PCBs and pesticide residues due to cooking methods, individual fish or position from which the samples were taken. The presence of PCBs and DDT compounds in the drip indicated that cooking did reduce residue levels in chinook and coho salmon. The reduction, however, was small.

Objective measurements of quality characteristics showed chinook cooked by poaching required less cooking time, had lower total cooking losses and were more tender and juicy than samples cooked by baking or baking-in-bags. Baked samples were the least tender and juicy and required the longest cooking time. Coho salmon steaks rated higher in all the quality characteristics measured than did chinook steaks.

EFFECTS OF THREE COOKING METHODS ON PESTICIDE RESIDUES IN CHINOCK AND COHO SALMON

By

Waldina E. Elliott Smith

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TABLE OF CONTENTS

TABLE OF CONTENTS--Continued Page

LIST OF TABLES

LIST OF TABLES--Continued

LIST OF TABLES--Continued

LIST OF FIGURES

INTRODUCTION

Samples from selected markets in the United States have shown chlorinated hydrocarbon pesticide residues in virtually all types of food (Duggan et al., 1966; Corneliussen, 1970). More specifically, DDT and its metabolites as well as polychlorinated biphenyls (PCBs) were found in all of the 147 samples of fish obtained from 50 nation-wide stations by the U. S. Bureau of Sport Fisheries and Wildlife in 1967 and 1969. Levels of the DDT compounds ranged from 0.03 to 57.8 ppm (whole fish, wet weight) while PCBs ranged from 0.10 to 14.8 ppm (Henderson et al., 1971). Trout and salmon taken from Lake Michigan have exhibited pesticide residues in excess of 5.0 ppm (Poff et al., 1970). However, raw products do not necessarily reflect the amount of residues in cooked foods and unless the foods are analyzed in the form customarily eaten, the health hazards to humans can not be accurately assessed (Duggan et al., 1966).

In general, pesticide residues are highest in large fish with high percentages of body fat such as salmon (Buhler et al., 1969; Holden, 1962; Reinert, 1970; Hamelink et al., 1971). It was the purpose of this study, therefore, to compare the effect of selected methods of cooking on the levels of PCB and DDT compounds in chinook salmon. These

results were compared with similar data obtained from a limited sample of coho salmon. Because hatchery salmonids have higher body lipid levels than those from the natural environment (Wood et al., 1957) and pesticide residues are generally associated with the fat content, Lake Michigan salmon were selected for the study. Also, long-time exposures to low levels of pesticides, as occurs in the natural environment, give a different pattern of pesticide distribution within the body than occurs when fish are exposed to high levels of pesticides in a short-term experimental feeding situation (Johnson, 1968).

Half steaks were cooked by baking, poaching in salt water and baking in nylon bags. Baking was selected as a basic standard method whereas the other two procedures were new but currently being used by homemakers for cooking chinook and coho salmon. Half of the samples were cooked with the skin and adhering fat layer removed. Flesh and skin samples, raw and cooked, as well as drip were analyzed for residues of PCBs and DDT compounds.

A secondary purpose of this study was to assess the quality characteristics of the two species of fish. Samples, cooked by each of the three methods mentioned above, were subjected to objective measurements to determine tenderness and juiciness.

All data were statistically analyzed for differences attributable to individual fish, anatomical position from

which the sample was taken, cooking with or without skin, species and/or cooking methods. The findings were evaluated for possible recommendations to be used in preparation of salmon steaks to minimize PCBs and pesticides in the cooked fish.

REVIEW OF LITERATURE

All forms of life are accumulating small amounts of those chemicals used to improve life and food (Paul, 1965). The low solubility of chlorinated hydrocarbon pesticides in water and their high solubility in fat indicates these products have a tendency to accumulate in fatty tissue where the opportunity for enzymatic breakdown is absent (O'Brien, 1967). A recent study of 217 human bodies in Alberta, Canada showed accumulations of pesticides in all tissues with adipose tissue having an average of 4.34 ppm of chlorinated hydrocarbon pesticide residues. However, PCBs were not detected in the tissues despite their extensive use in that area (Kadis et al., 1970). Bīros et al. (1970), on the other hand, found PCBs (Aroclors 1254, 1260) in two samples of human tissue in the United States. Market basket surveys have shown that 13 chlorinated hydrocarbon pesticides were present in foods in 29 of the 30 areas studied (Corneliussen, 1970).

Residues in Fish

For a fish monitoring program carried out by the Bureau of Sport Fishery & Wildlife in 1967-69, 147 composite fish

samples were collected at 50 nationwide stations. DDT and its metabolites were found in all samples (Henderson et al., 1971). Fish may acquire residues either from eating contaminated food or directly from the water via their gills. Fromm et al. (1969) suggested, after a study with isolated perfused gills of rainbow trout, that dieldrin and related insecticides diffuse through the gills of fish and are dissolved in the lipid portion of plasma lipoproteins. In this form they are transported to and become dissolved primarily in the lipid portion of various tissues.

In fish, the whole body residue concentration increases as body fat increases. Individual fish size, food habits, fat content and fish movement are all factors influencing residue levels (Hamelink et al., 1971; Macek et al., 1970; Henderson et al., 1969). In salmonids, lipids are distributed throughout the muscle rather than in large fat deposits (Holden, 1966).

In 1966, coho salmon (Oncorhychus kisutch) and in 1967, chinook salmon (Oncorhychus tshawytscha) were introduced into Lake Michigan. About the same time, large concentrations of pesticides were discovered in Lake Michigan. Hickey et al. (1966) studied the residue concentrations of DDT in a Lake Michigan ecosystem and found that the levels increased greatly in higher trophic levels from the bottom sediment (0.014 ppm), invertebrates (0.54 ppm), white fish and salmon (5.6 ppm) to gulls (98.8 ppm). Reinert (1970) reported the pesticide

residue concentration in Lake Michigan fish was 2 to 4 times higher than in the other Great Lakes because of the large drainage basin which is subject to contamination from agricultural and urban areas.

In 1967, the progeny of mature coho salmon in Lake Michigan was lost at the rate of 11%. A study of the eggs showed concentrations of DDT compounds 60 times higher than similar uncontaminated Oregon samples. The DDT was found in the glyceride fats remaining in the yolk of the fry and when these lipids were metabolized, DDT was absorbed across the gut in high concentrations (Johnson et al., 1969). Later, 3000 coho salmon eggs suffered an excessive mortality rate of 30%. The eggs were checked for chlorinated hydrocarbon insecticides and it was found they contained 3.4 ppm DDT and related compounds as well as 0.07 ppm dieldrin. The fish which survived excreted very little pesticide and apparently diluted initial residues with growth (Willford et al., 1969).

Analysis of fish indicates that often they contain DDT and its metabolites DDE and DDD. Dehydrochlorination of DDT to DDE can occur within 9 hr and the latter product tends to accumulate in tissues. DDD is eliminated if the DDT is absorbed in small doses (Greer et al., 1968). Dechlorination of DDT is aided by microorganisms and enzymes (Menzie, 1969). In salmon, intestinal microflora play a major role in this detoxification. Because the presence of microflora in salmon depends upon the recent intake of food, the rate of

detoxification depends on the available food supply (Wedemeyer, 1968). Fish of low fat content are most susceptible to DDT because lean fish can store less and are therefore exposed to levels in the blood stream that affect the brain, gills, kidneys and liver (Holden, 1962; Buhler et al., 1969; Cope, 1961).

Fish can develop resistance to possible toxic effects of pesticides and hence, may accumulate levels dangerous as food to man (Ferguson et al., 1964). DDT and dieldrin concentrations in lake trout and walleye increase with the size of the fish (Reinert, 1970). According to Macek et al. (1970), rainbow trout showed increased lipogenesis during a period of DDT and dieldrin intake. The presence of dieldrin increased the rate of accumulation of DDT but the presence of DDT decreased the rate of accumulation of dieldrin. The half-life of DDT was significantly lengthened by the presence of dieldrin according to the report.

Though PCBs are widely distributed throughout the world and fairly persistent, attention has only recently been drawn to their presence after the realization that they interfer in gas chromatographic readings of DDT and its analogs (Schechter, 1971). PCBs were also unnoticed because they are only accidentally admitted into the environment and their acute toxicity to rodents and fish is relatively low (Gustafson, 1970). Kelly (1970), in a report to Monsanto Chemical Co., stated that in general, Aroclors 1242, 1254

and 1260 did not affect rats and beagles except that liver and kidney weights were elevated when the animals had been fed levels of 100 ppm of 1254 and 1260. It has been shown, however, that there is some chronic effects to chickens and wild fowl as evidenced by enlarged liver and kidneys as well as thin egg shells. In kestrels fed levels of 0.5 and 5 ppm of Aroclors 1254 and 1262, there was increased hepatic enzyme activity, a physiological reaction similar to that caused by DDT and its metabolites (Lincer et al., 1970).

In general, PCBs are found in higher levels in aquatic raptorials and in the presence of high levels of organochlorine pesticides (Reynolds, 1971). Duke et al. (1970) found Aroclor 1254 in the sediment of Escambia Bay, Florida, 6 mi from the point of initial pollution, in a concentration of 486 ppm. Speckled trout from the same area contained 20 ppm of PCBs. Holden (1970) examined the waters in an estuary in Scotland and found no PCBs; however, zooplankton and fish in the area contained 0.03 to 2.6 ppm of these residues. He suggested that industrial sludge, containing 1 to 14 ppm of PCBs, which was dumped into the estuary was the major source of contamination. PCBs were also found in 200 pike from different areas of Sweden (Jensen, 1966). Koeman et al. (1969) found PCBs in fish, mussels and birds from the River Rhine and the Netherlands coastal area. He also reported that in a laboratory experiment on quail, some compounds, particularly the lower chlorinated PCBs, were metabolized and therefore perhaps less persistent in the environment.

Removing Residues by Cooking

In an early study, Carter et al. (1948) used five cooking methods, roasting, broiling, pressure cooking, braising and frying, to cook cuts of beef taken from animals fed DDT-contaminated rations. After analyses of the cooked portion and drippings together, the authors concluded that there was no reduction of the DDT level due to cooking. Ritchey et al. (1969), reporting on chickens, found the greatest losses of DDT occurred when cooking procedures leached the fat from the poultry. Another study on the effect of cooking on chlorinated pesticide residues in chicken tissue indicated that heptachlor, DDT and dieldrin were removed from white meat faster than from the abdominal fat. Dieldrin was removed from dark meat slower than from the abdominal fat, therefore indicating a difference in the retention of chlorinated pesticides (Liska et al., 1967).

Maul et al. (1971), Yadrick et al. (1971) and Funk et al. (1971) reported studies on pork loins, bacon and sausage, respectively, showing that cooking reduced the pesticide residues in these products. However, no significant differences attributable to cooking methods of roasting, broiling, microwaves and braising were found.

Recently, Wanderstock et al. (1971) examined the effect of several cooking methods on DDT residues in lake trout and coho salmon. According to the report, DDT residue levels from raw to cooked appeared to increase or remain fairly

constant due to evaporation losses during cooking. Reinert et al. (1971) also found that due to water loss, DDT residues in smoked chubs did not vary significantly from those of raw or brined fish even though fat content was reduced 36% during smoking. Subsequent cooking methods had no effect on loss of DDT according to the study. In perch, DDT was removed in the offal and was not influenced by cooking method (Reinert et al., 1971). On the other hand, a report from the Wisconsin Department of Natural Resources stated that deep-fat frying fish reduced DDT 55%; broiling, 36%; pan frying, 25% and baking, 11% (Anonymous, 1969). Maul et al. (1971) reported that, in general, cooked pork samples showed lower dieldrin levels than uncooked samples after taking evaporative and drip losses into account.

Cooking and Quality Characteristics of Fish

Research studies concerned with cooking and the subsequent quality of fish are few. Cooking methods and selected quality characteristics will be reviewed.

Preparation for cooking

According to the Fish and Wildlife Service of the U. S. Department of Interior (1964), fresh fish are best kept in crushed ice until refrigeration is available. Stansby (1956) stated it was possible to freeze whole fish and then slice and repackage in aluminum foil at a later time without

deterioration of the product. Thawing samples before cooking yielded 5% less drip loss due to partial reabsorption of the drip and/or fixing of water by cellular proteins (Sumerwell, 1955).

Cooking methods

Chinook salmon steaks baked to an internal temperature of 75°C in a 149°C oven produced a moist and palatable product (Kerr, 1959; Charley, 1952). However, similar steaks baked to an internal temperature of 85°C were judged higher in flavor, lower in moistness and no difference in palatability. Charley (1952) reported that using four different oven temperatures made no difference in palatability scores.

In a study by McKay (1965), defrosted trout were cooked by broiling and deep-fat frying in various fats. According to the report, no difference was found in the moisture content of the fish cooked by the two methods.

Cooking losses

Salmon steaks were baked at oven temperatures of 177, 204, 232 and 260°C to a constant internal temperature of 75°C and to internal temperatures of 70, 75, 80 and 85°C at a constant oven temperature of 204°C (Charley, 1952). She reported that increasing the oven temperatures to 260°C caused higher drip losses when fish were cooked to a constant internal temperature than occurred at the three other oven temperatures. Total cooking losses did not differ significantly

due to oven temperature but did vary from fish to fish. When steaks were baked to different internal temperatures, total cooking losses differed significantly; those cooked to the lowest temperature having the smallest loss.

Armstrong et al. (1960) reported increased moisture in samples of codfish cooked uncovered as compared to covered samples.

Tenderness

Szczeniak et al. (1965) reviewed objective methods of measuring meat tenderness, including the use of a Kramer shear press. Dassaw (1962) developed an instrument similar in concept to the Kramer shear press, but portable, to evaluate fish tenderness. The validity of the instrument was not tested.

Juiciness

The amount of expressable fluid in meat objectively determines juiciness. The Carver Press has been used extensively for extracting fluid by the use of pressures up to 24,000 psi. Some researchers have reported significant correlations between press fluid and juiciness scores of meat (Boyle et al., 1970; Tanner et al., 1943). A study on chinook salmon steaks by Charley (1952) pointed out that an increased end cooking temperature decreased the amount of press fluid.

EXPERIMENTAL PROCEDURE

To compare the effects of cooking method on PCBs and pesticide residues in chinook and coho salmon as well as selected quality characteristics, steaks were cooked by baking, poaching and baking in nylon cooking bags.

Sample

Mature salmon were collected at the Manistee River weir, above Manistee, Michigan, on September 27, 1971 as the fish were passing upstream to spawn. The five chinook were males and the two coho were a male and a female. All were immediately surrounded with ice and, within 4 hr, were wrapped whole in aluminum foil and plastic-coated freezer paper before freezing at -20°C. Approximately 2 wk later, the whole frozen fish were sliced with a power meat saw into 1-in steaks, rewrapped as described above, coded and quickly returned to the freezer. The fish were not eviserated at capture because the whole frozen body permitted more uniform slicing. Steaks were used from 1 in behind the gills to the end of the body cavity.

Following a randomized schedule as illustrated in Figure 1, steaks were selected so that all areas of the body

Position	Slice Number	Type of Analyses[1]	Cooking Method[2]	State[3]
Anterior half	1	R	B	W
	2	R and Raw	B	W/O
	3	O	B	W
	4	R	P	W
	5	R	P	W/O
	6	O	P	W
	7	R	BB	W
	8	R	BB	W/O
	9	O	BB	W
Posterior half	10	R	B	W
	11	R and Raw	B	W/O
	12	O	B	W
	13	R	P	W
	14	R	P	W/O
	15	O	P	W
	16	R	BB	W
	17	R and Raw	BB	W/O
	18	O	BB	W

1 R designates samples cooked for analysis of pesticide residue content.
O designates samples cooked for objective measurements.

2 Cooking methods are designated as B, baked; P, poached; BB, baked-in-bag.

3 W designates samples cooked with skin.
W/O designates samples cooked without skin.

Figure 1. Illustration of the rotation pattern used to designate slices of five chinook and two coho salmon steaks for the appropriate analyses.

of the fish were analyzed raw and cooked by baking, poaching in a 5% NaCl solution and baking in nylon bags. Half slices, designated as anterior for samples taken before the dorsal fin and posterior for samples after the dorsal fin, were used for each cooking method. Two of the four half-slices from each fish that were cooked by each cooking method were done with skin and two without skin to determine if removal of skin and adhering fat layer would affect the amount of fat soluble residues in the edible flesh. Three half-slices from the anterior and posterior halves of each fish were selected for residue analyses of uncooked salmon. The pattern (Figure 1) was rotated for each fish so that half-slices from different positions were cooked by each method or analyzed in the raw state. Right and left sides of the fish were not considered.

Cooking Procedures

Approximately 2 hr prior to cooking, steaks were removed from the freezer. They were allowed to partially thaw for approximately 1 hr before the body cavity contents were removed. The steaks were halved and the samples designated for raw analyses were rewrapped as described above and returned to the freezer. The skin and adhering fat layer were removed from the appropriate samples. Each slice was rinsed with distilled water and the skin, if present, was scrubbed. After blotting excess water from the surfaces, the samples

were allowed to completely thaw at room temperature. For samples cooked without skin, one in was cut from the ventral end of the half-steak to eliminate that fatty area; therefore only flesh tissue was cooked.

Based on the studies of Charley (1952) all samples were cooked to an internal temperature of 75°C using a Brown Electronic Potentiometer High Speed Multiple Recorder equipped with iron constantan thermocouples to record the end cooking temperature and time. A heavy duty Hotpoint oven, Model HJ225 equipped with a Versatronic controller set at 177°C ± 2° and the grids set on medium with the damper half closed, was used for all baking.

Baking

Samples were positioned on a rack in a 9x11x3/4 in aluminum pan. The 4-in immersion length potentiometer leads were inserted horizontally to the center of the dorsal muscle and clamped to the pan. Upon removal from the oven, each steak was allowed to stand undisturbed for 10 to 15 min before the potentiometer lead was removed and the sample prepared for residue analyses.

Poaching

Steaks, containing a potentiometer lead and positioned in a deep-fat frying basket, were placed in rapidly boiling water (125 g NaCl/2200 g distilled water) in a 4-qt stainless steel saucepan. They were cooked to an internal temperature of 75°C and subsequently cooled as outlined above.

Baking-in-bags

Samples were placed in nylon "Cooking Magic" bags. Following the recommendations of the manufacturer,[1] five 1/16-in holes were punched in each bag. After a potentiometer lead had been positioned through one of the holes and into the fish as outlined above, samples were cooked and cooled as detailed for baked steaks.

Analyses for PCBs, Pesticides and Fat

Skin and flesh were physically separated for all raw and cooked samples before each was analyzed for PCBs, pesticides and fat. Drip from samples baked with and without bags and cooking liquid from the poached samples were also analyzed. Duplicate determinations were made for flesh and cooking liquid samples while single samples of skin and drip were analyzed.

Preparation for analyses

To prevent possible contamination, all glassware and equipment used for the analyses were thoroughly washed in tap water before rinsing in tap water, distilled water and finally in acetone. Pans and utensils used for cooking were cleaned in the same manner. A mixture of hexanes was used in all extraction and clean-up procedures and for rinsing

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[1]Cooking Magic Bags. Distributed by the Drackett Products Co., Cincinnati, Ohio, 45232.

all containers to insure inclusion of all samples being transferred for the next step of the procedure.

Skin samples were cut into small pieces with scissors and blended with dry ice to facilitate extraction (Bennville et al., 1970). Flesh samples were blended for 15 sec in an Oster blender to obtain a homogenous mixture immediately after cooking and subsequent cooling. All drip was scraped from the pans, racks and bags used in baking before rinsing with hexanes. After evaporation of the hexanes, the samples were frozen for later analyses as were all skin and flesh samples. Using a Mettler balance, Model H15, approximately 10 g samples of thawed flesh were weighed to the nearest 0.001 g. Thirty ml aliquots of the poaching liquid, which had been blended in a Waring 6-qt blender, were used and all of the skin and drip samples from each steak.

Extraction and clean-up

Extraction and clean-up procedures were as outlined by Yadrick et al. (1971) except that skin samples were mixed with an equal amount of Na_2SO_4 before extraction with a 1:1 mixture of hexane and acetone (Earnest et al., 1971).

Fat analysis

The 10-ml aliquot, removed during the extraction process (Yadrick et al., 1971) was transferred to a dried and tared Erlenmeyer flask before it was dried in a vacuum oven at 75°C for 2-1/2 hr. After cooling for 30 min in a dessicator,

the sample was weighed and the percentage of fat was calculated using the following formula.

$$\% \text{ fat} = \frac{\frac{\text{ml extract obtained}}{\text{10 ml aliquot size}} \times \text{Dried sample wt}}{\text{Sample size (g)}} \times 100$$

Gas chromatographic analyses

PCB and pesticide analyses were carried out using a Beckman GC-4 gas chromatograph equipped with a discharge electron capture detector. It was fitted with a 6-ft (1.83 m) by 1/8-in (3.5 mm) stainless steel column packed with 4% DC-11 on Gas Chrom Q (60/80 mesh) and was operated at column, inlet and detector temperatures of 175, 230 and 255°C, respectively. Helium flow rates were 40 ml/min for the column and 120 ml/min for the discharge side of the detector. Using the technique of placing one microliter samples between two air blocks of one microliter each, samples were injected. Standards of Aroclors 1248 and 1254,[1] p,p'-DDT,[2] p,p'-DDE[3] and p,p'-DDD were prepared using nanograde hexane.

The substances contaminating the fish were determined after consultation with personnel at the Pesticide Research Center, Michigan State University; the presence of DDT

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[1]Monsanto Chemical Co., St. Louis, Mo.

[2]City Chemical Corp., New York; 99+% ESA pesticide reference standard.

[3]Pesticide Research Laboratory, Perrine, Florida, 98+% Analytical Standard.

compounds was also confirmed through thin layer chromatography. Aluminum Oxide G impregnated with silver nitrate was used to coat the plates. After using the solvent system of 5% benzene in hexane, the plates were developed for 1 hr under ultra violet light. It was concluded that in addition to p,p'-DDT and its analogs, p,p'-DDE and p,p'-DDD, the Aroclors 1248 and 1254 were also present. Because Aroclor 1254 interferred with gas chromatographic readings of DDT and its analogs with like retention times, a method of separating the substances was necessary. Therefore, standard curves of 1254 were run and from the retention times, portions of the curves of DDE, DDD and DDT attributed to 1254 were determined.

Ratios were calculated of the heights of the peaks of 1254 (at like retention times to DDE, DDD and DDT) to the height of the only independently occurring 1254 peak in the sample. These values were 1.25, 0.81 and 0.44 for DDE, DDD and DDT, respectively. Amounts of interference were determined by multiplying the height (mm) of the independent 1254 peak by the appropriate ratio. This value was then subtracted from the corresponding height occurring in the sample ... i.e., if the peak height at DDE was 100 mm and the independent 1254 peak, 40 mm; then 100 - (40x1.25) = "true" height of DDE. The limitations of this approach were recognized; however, the same techniques were applied to raw and cooked samples. Relative changes would therefore still be evident.

After the corrections were made for the peak heights, the parts per million of each substance, 1248, 1254, DDE, DDD and DDT based on percentage fat were calculated using the following formula.

$$\frac{\text{Ml extract obtained}}{\text{Correction term}^1} \times \frac{\text{Graph reading, corrected (ppm)} \times \text{Sample size (ml)}}{\text{Sample weight (g)} \times \text{Percent fat}}$$

Objective Measurements

Half steaks used for objective measurements were taken from each fish so that all areas of the body were exposed to each cooking method. Following cooking as detailed above, samples were loosely covered with aluminum foil and held for 1 hr before juiciness and tenderness were determined. Skin was not removed from these samples.

Cooking losses

Total, drip and volatile losses were calculated for samples baked with and without bags and converted to percentages based on the raw weight of the sample (Funk et al., 1966). Only total losses were calculated for poached samples. Weights were obtained using a Mettler balance, Model P-1000.

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[1]Correction to account for sample removed for fat analysis.

Juiciness

A Carver Laboratory Press was used to determine the juiciness of the samples. Two samples, weighing approximately 5 g each, were cut from the small muscle in the ventral half of the steak and placed on two gauze squares. After weighing to the nearest 0.1 g using a Mettler balance, Model P-1000, a pressure of 15,000 psi was applied for 10 min to the two gauze wrapped samples placed between canvas and felt pads. The samples were then removed from the pads and reweighed. After conversion to percentages of press fluid, the two values for each steak were averaged.

Tenderness

An Allo-Kramer shear press, Model SP12, was used to measure the tenderness of the fish. The whole dorsal muscle of each half-steak was weighed to the nearest 0.1 g. The sample was placed in the center of the standard shear compression cell and sheared using a 30 sec downstroke, 20% range, 250 lb pressure and a 3000 lb proving ring. The pounds of force required to shear the sample were recorded on a time force curve by a Varian electronic indicator, Model E2EZ. The maximum pounds force per gram was calculated as

$$\frac{\text{Maximum peak reading (\%) X Range (\%) X Ring}}{\text{Sample weight (g)}}$$

Analyses of the Data

Duplicate determinations of residue analyses were averaged before means and standard deviations were calculated. Data were analyzed for variance due to cooking method, fish, position from which the sample was taken and cooking with and without skin. Duncan's multiple range test (Duncan, 1957) was used to pinpoint appropriate sources of significant differences. A Z test statistic (Dixon et al., 1957) was used to compare species differences as well as cooked and raw sample differences.

RESULTS AND DISCUSSION

The purpose of this study was to investigate the effects of three cooking methods on PCB and DDT compounds and selected quality characteristics in chinook and coho salmon. Fish containing unknown amounts of PCBs and pesticides were acquired from natural waters and analyzed for fat and residue content in both the raw and cooked state. Cooking losses, defined as total, drip and volatile, were also determined for all cooking methods in addition to shear press and Carver press measurements for a limited number of samples. Data were analyzed for variance due to cooking method, fish, position in the fish from which the sample was taken and species.

Percent Fat

The results of duplicate determinations for fat content of raw and cooked chinook salmon samples of skin and flesh as well as drip from cooked samples were averaged and analyzed for variance (Table 1). Grand averages were calculated for raw flesh and skin by position and for cooked flesh, skin and drip by position, cooking method and whether cooked with or without skin (Table 2). Data upon which

Table 1. Analyses of variance for fat content in raw flesh and skin and flesh, skin and drip samples taken from anterior and posterior halves of five chinook salmon cooked by three methods with and without skin.

Source of Variance	Mean Square				
	Raw[1]		Cooked		
	Flesh	Skin	Flesh[2]	Skin[3]	Drip[2]
Total	. . .	. . .	. . .	. . .	. . .
Method	. . .	. . .	1.73*	47.31**	304.84**
Fish	1.82*	11.66	22.62**	18.64**	36.77
Position	1.20*	43.85	17.59**	62.06**	151.18**
W, W/O Skin	. . .	. . .	0.14	. . .	17.87
Error	.15	5.70	0.47	2.83	20.07

[1]Degrees of freedom are Total 9, Fish 4, Position 1, Error 4.

[2]Degrees of freedom are Total 59, Method 2, Fish 4, Position 1, W, W/O Skin 1, Error 51.

[3]Degrees of freedom are Total 29, Method 2, Fish 4, Position 1, Error 22.

**Significant at the 1% level of probability.

*Significant at the 5% level of probability.

Table 2. Averages and standard deviations for percent fat in raw flesh and skin and flesh, skin and drip samples taken from anterior and posterior halves of five chinook salmon cooked by three methods with and without skin.

Position, Cooking Method and W or W/O skin	Component		
	Flesh	Skin	Drip
		RAW	
Anterior	3.04±1.41	8.51±3.70	. . .
Posterior	2.35±0.87	4.26±1.58	. . .
Average	2.65±1.00	6.39±3.54	. . .
		COOKED	
Baked	4.00±1.61	7.93±3.50	7.18±8.46
Poached	3.43±1.50	4.84±2.50	0.03±0.01
Baked-in-Bag	3.61±1.45	3.74±1.90	0.89±1.02
Anterior	4.22±1.61	6.94±3.18	4.29±7.77
Posterior	3.14±1.21	4.06±2.55	1.11±1.74
W skin	3.73±1.54	. . .	3.24±7.29
W/O skin	3.63±1.51	. . .	2.15±3.86

these averages are based appear in the Appendix (Tables 17, 18, 19 and 20).

Raw samples

The fat content of raw chinook and coho flesh averaged 2.65 and 3.59%, respectively. The values for chinook flesh are considerably lower than those reported in the literature (Stansby, 1967; Buhler et al., 1969). The salmon used in this study, however, were on a spawning run and according to reports, spawning fish live entirely on stored body fat. Fat content may therefore vary from 1 to 16% in salmon flesh (Castell et al., 1963; Lovern, 1934; Mannan et al., 1961 and Stansby, 1967). Values determined for coho were lower than those reported by Reinert et al. (1971) for fish taken from Lake Michigan; however, the fish in his study were not spawning.

Raw flesh samples of chinook differed in percent fat among fish ($P<0.05$) and in position ($P<0.05$) from which the sample was taken. Samples from the anterior halves contained an average of 3.04% fat while samples taken from posterior halves averaged 2.35% in fat content. In agreement, Thurston (1958) reported Alaskan pink salmon steaks varied in fat content from 4.8% at the nape to 2.6% at the caudal end. Differences among fish due to sex, stage of maturity, season and place of capture have been noted (Mannan et al., 1961; Thurston, 1958).

The data indicated coho flesh contained more fat than chinook flesh. However, these differences were not significant according to a comparison of means using a Z test statistic.

Skin samples from the anterior halves of chinook samples contained more fat than samples from the posterior halves (Table 2); however, the differences were not significant. The fat in the skin of chinook and coho averaged 6.39 and 6.29%, respectively. These values did not differ significantly.

Cooked samples

Chinook flesh samples cooked by baking, poaching and baking-in-bags yielded averages of 4.00, 3.43 and 3.61% fat, respectively. These values differed ($P < 0.05$) due to cooking method with poached samples containing less fat than baked samples. Total cooking losses averaging 30.0, 14.2 and 16.9% for baking, poaching and baking-in-bags, respectively, indicate that perhaps fat was concentrated in the flesh as total cooking losses increased. The inverse relationship between fat and moisture content has been noted by Murphy et al. (1961).

There was no significant difference in the fat content between flesh samples cooked with and without skin. According to Lowe (1955), the fat molecule is too large to migrate from the surface into flesh tissues. Also, the position of the fatty skin on the side of the steak would cause fat to drip down the sides of the samples into the pan rather than move laterally into the flesh. Differences ($P < 0.01$) did

occur, however, among the fat contents of the flesh of individual fish and in samples from different positions. The anterior half showed an average fat level of 4.22% while samples from the posterior half averaged 3.14% fat.

Skin samples yielded 7.93, 4.84 and 3.74% fat when cooked by baking, poaching and baking-in-bags, respectively. Baked-in-bag skin samples contained less fat than poached ($P<0.05$) and baked ($P<0.01$) skin. The fat content of skins differed ($P<0.01$) among individual fish and position from which the samples were taken with anterior halves averaging 6.94% and posterior halves averaging 4.06%.

Drip from fish cooked by baking, poaching and baking-in-bags contained 7.18, 0.03 and 0.89% fat, respectively. Poached drip contained less ($P<0.01$) fat than drip from baked-in-bag samples which in turn were less ($P<0.01$) than drip from baked samples. It should be noted that the total amount of drip from the three cooking methods varied greatly. During baking, any moisture losses occurring as drip evaporated from the hot surface of the pan; hence, drip losses were small. For poached samples, values are based on the cooking liquid which greatly diluted the drip which occurred during cooking. Moisture evaporation was partially prevented when samples were baked in bags; thus, the amount of fat was diluted by the presence of moisture in the drip. Drip from samples from the anterior halves contained less ($P<0.01$) fat than drip from the posterior halves with averages of 4.29

and 1.11%, respectively. However, no significant differences due to individual fish or cooking with or without skin were noted.

Averages for percent fat in cooked coho flesh, skin and drip are listed in Table 3. Although the values for coho are higher than those for chinook, the differences are not significant.

Table 3. Averages and standard deviations for percent fat in cooked flesh, skin and drip samples taken from the anterior halves of two coho salmon.

Cooking Method	Component		
	Flesh	Skin	Drip
Baked	4.53±1.37	11.13±6.64	16.17±20.33
Poached	4.08±1.52	7.49±6.49	0.02±00.00
Baked-in-bag	3.96±1.14	5.96±4.72	6.28±10.48

PCB and DDT Compounds

Analyses of residues extracted from raw and cooked samples of flesh and skin as well as drip from cooked samples revealed the presence of the PCBs identified as Aroclors 1248 and 1254 and the pesticide residues of p,p'-DDE, p,p'-DDD and p,p'-DDT. In agreement, Henderson *et al.* (1971) found these same substances in fish from Lake Michigan. Reinert *et al.* (1971), Wanderstock *et al.* (1971) and Poff *et al.* (1970)

listed totals for only DDT and its metabolites in Lake Michigan coho.

The results of duplicate determinations for PCB and DDT compounds in various components of raw and cooked salmon (calculated in parts per million, ppm, based on fat) were averaged and analyzed for variance (Tables 4 and 5). Grand averages of the data for raw samples are in Tables 6 and 8 while the averages for cooked samples are found in Tables 7 and 9. Data on which the analyses and averages are based appear in the Appendix (Tables 17, 18, 19 and 20).

PPM (fat basis) of PCBs in chinook

Raw samples. No significant differences in the PCB content occurred due to position or individual fish from which raw flesh and skin samples were taken. However, high standard deviations were evident (Table 6). One of the five chinook had fat and pesticide values which were at extreme variance with the others. Its flesh contained 1.10% fat whereas the average of the four other fish was 3.04% with a range of 2.37 to 3.79%. Aroclor 1254 showed an average of 489.73 ppm in its flesh in comparison to an average of 196.75 ppm, ranging from 154.97 to 236.05 ppm for the other fish. Similar disparities were present in other PCB and pesticide data.

Table 4. Analyses of variance for pesticide residues in raw flesh and skin samples taken from anterior and posterior halves of five chinook salmon.

Source of Variance	DF	Mean Squares				
		PCBs		DDT Compounds		
		1248	1254	p,p'-DDE	p,p'-DDD	p,p'-DDT
				FLESH		
Total	9	. . .	. . .	. . .	. . .	. . .
Fish	4	317.53	53040.27	932.43	13.47	595.74
Position	1	83.70	8704.68	187.89	0.98	112.66
Error	4	63.73	26263.46	314.27	9.27	215.88
				SKIN		
Total	9	. . .	. . .	. . .	. . .	. . .
Fish	4	101.58	12254.09	351.84	11.52*	311.45
Position	1	225.83	3599.22	0.06	0.06	38.91
Error	4	93.25	6034.10	58.03	1.40	85.75

*Significant at the 5% level of probability.

Table 5. Analyses of variance for pesticide residues in flesh, skin and drip samples taken from anterior and posterior halves of five chinook salmon cooked by three methods with and without skin.

Source of Variance	DF	Mean Squares: PCBs 1248	PCBs 1254	DDT Compounds p,p'-DDE	DDT Compounds p,p'-DDD	DDT Compounds p,p'-DDT
			FLESH			
Total	59	. . .	. . .	. . .	. . .	. . .
Method	2	110.27	15352.35	61.30	4.74	67.62
Fish	4	946.68**	217386.90**	4457.51**	220.79**	4588.37**
Position	1	525.99**	2078.79	442.95*	16.42	262.45
W, W/O skin	1	87.61	10271.78	154.88	18.76	370.31
Error	51	68.66	15261.16	153.31	11.13	172.54
			SKIN			
Total	29	. . .	. . .	. . .	. . .	. . .
Method	2	617.77	1178.93	760.87	57.19	538.23
Fish	4	277.09	105835.35**	1346.03	154.35**	1425.07*
Position	1	431.40	5966.08	360.70	15.05	1.18
Error	22	193.70	21593.22	201.31	24.93	200.71
			DRIP			
Total	59	. . .	. . .	. . .	. . .	. . .
Method	2	1507038.49**	33618529.54**	52331.37	16206.23	33431.72
Fish	4	370441.92*	15412006.20	31281.63	5365.95	25614.42
Position	1	788418.72*	19179141.50	28006.39	107.72	62075.81
W, W/O skin	1	75564.74	18687257.46	5972.11	2511.95	27298.26
Error	51	140209.45	6179838.61	28812.18	1351.00	34591.20

**Significant at the 1% level of probability.

*Significant at the 5% level of probability.

Table 6. Averages and standard deviations for parts per million (fat basis) of PCBs in raw flesh and skin samples taken from anterior and posterior halves of five chinook salmon.

Position	Aroclor 1248	Aroclor 1254
	FLESH	
Anterior	15.28±7.47	243.53±50.79
Posterior	21.06±18.04	302.53±276.99
Average	18.17±13.37	273.03±190.30
	SKIN	
Anterior	11.22±6.41	242.46±120.59
Posterior	20.72±12.40	204.52±61.25
Average	15.97±10.57	223.49±92.34

Cooked samples. Aroclor 1248 was more concentrated ($P < 0.01$) in flesh samples taken from the posterior halves with an average of 18.82 ppm than in samples from the anterior halves with an average of 12.89 ppm (Table 7). The amounts of Aroclor 1254 did not differ significantly due to position from which the sample was taken. No significant differences in amounts of Aroclors 1248 and 1254 due to cooking method or cooking with or without skin were noted. However, flesh samples differed ($P < 0.01$) among individual fish in levels of 1248 and 1254.

Aroclor 1254 concentration varied ($P < 0.01$) in skin samples among individual fish although 1248 did not. No other significant differences occurred due to position or cooking method for skin samples (Table 7).

Table 7. Averages and standard deviations for parts per million (fat basis) of PCBs in flesh, skin and drip samples taken from anterior and posterior halves of five chinook salmon cooked by three methods with and without skin.

Position, Cooking Method and W or W/O skin	Aroclor 1248	Aroclor 1254
	FLESH	
Anterior	12.89±11.11	249.46±200.76
Posterior	18.82±19.42	261.23±133.90
Baked	15.40±12.18	274.34±212.13
Poached	18.40±13.16	268.15±155.19
Baked-in-Bag	13.77± 9.72	223.55±135.26
With skin	14.65±10.48	242.26±128.80
Without skin	17.06±12.93	268.43±203.38
	SKIN	
Anterior	12.91±10.27	278.47±225.73
Posterior	20.49±19.14	250.26±122.07
Baked	9.42± 7.76	235.58±131.46
Poached	15.64±14.99	255.16±155.43
Baked-in-Bag	25.04±18.97	302.35±242.99
	DRIP	
Anterior	323.08±393.23	2038.20±6437.12
Posterior	552.34±499.60	3168.95±3043.90
Baked	319.68±389.71	1968.62±1859.74
Poached	751.49±407.62	4095.17±2641.15
Baked-in-Bag	241.97±426.37	1746.93±3375.10
With skin	473.20±265.85	3161.65±3487.01
Without skin	402.23±423.79	2045.49±1955.68

Drip samples from baked-in-bag samples contained less ($P < 0.01$) Aroclors 1248 and I254 with averages of 241.97 and 1746.93 ppm, respectively, than poached samples with averages of 715.49 and 4095.17 ppm 1248 and 1254, respectively. The PCBs in drip from baked samples with intermediate values did not differ significantly from those in baked-in-bag or poached samples (Table 7). These data show that drip from poached samples with the lowest percent fat showed the highest residue levels. Aroclor 1248 also differed ($P < 0.05$) in concentration among individual fish and due to position with drip samples from the anterior halves averaging 323.08 ppm while that from the posterior halves averaged 552.34 ppm. These values show the same relationship as those for percent fat which were also higher in the anterior halves.

PPM (fat basis) of DDT compounds in chinook

Raw samples. No significant differences in p,p'-DDE and p,p'-DDT occurred due to the position or among individual fish from which the samples of flesh or skin were taken (Table 8). Levels of p,p'-DDD in the skin varied ($P < 0.05$) among individual fish although flesh did not. Neither flesh nor skin differed significantly in amounts of p,p'-DDD due to the position from which the samples were taken.

Cooked samples. p,p'-DDE concentrations was less ($P < 0.05$) in the flesh of samples taken from the anterior halves with an average of 31.38 ppm than in flesh from the posterior halves with an average of 36.81 ppm (Table 9).

Table 8. Averages and standard deviations for parts per million (fat basis) of DDT compounds in raw flesh and skin samples taken from anterior and posterior halves of five chinook salmon.

Position	DDT Compounds		
	p,p'-DDE	p,p'-DDD	p,p'-DDT
		FLESH	
Anterior	36.87±12.39	3.92±2.99	20.59±9.60
Posterior	45.54±33.06	4.55±3.72	27.30±26.69
Average	40.20±23.98	4.24±3.19	23.94±19.33
		SKIN	
Anterior	27.44±15.81	3.94±3.11	21.81±17.39
Posterior	27.60±12.65	3.79±1.80	17.87± 9.73
Average	27.52±13.50	3.87±2.40	19.84±13.44

No significant differences due to position were noted for p,p'-DDD and p,p'-DDT. Also, there were no significant differences in any of the residues of the DDT compounds due to cooking method. Amounts of p,p'-DDD appeared to increase during cooking. In agreement, Ritchey et al. (1969) stated that DDT is converted to DDD during cooking. Flesh samples cooked with skin contained less of each of the DDT compounds; however, the differences were not significant (Table 9). All cooked flesh samples differed ($P < 0.01$) in residue levels among individual fish.

Skin from samples cooked by baking contained less ($P < 0.05$) p,p'-DDE with an average of 28.50 ppm than skin samples cooked by baking-in-bags which averaged 45.69 ppm.

Table 9. Averages and standard deviations for parts per million (fat basis) of DDT compounds in flesh, skin and drip samples taken from anterior and posterior halves of five chinook salmon cooked by three methods with and without skin.

Position, Cooking Method and W or W/O skin	DDT Compounds		
	p,p'-DDE	p,p'-DDD	p,p'-DDT
		FLESH	
Anterior	31.38±22.06	5.70±5.59	25.35±25.76
Posterior	36.81±20.19	4.65±4.44	21.17±17.03
Baked	34.32±23.13	5.69±5.74	25.37±26.29
Poached	35.72±22.05	4.72±4.23	22.34±18.88
Baked-in-Bag	32.24±18.98	5.11±5.23	22.06±20.36
With skin	32.49±17.92	4.61±3.89	20.77±17.29
Without skin	35.70±24.14	5.73±5.98	25.74±25.52
		SKIN	
Anterior	32.77±16.23	4.48±6.02	27.15±15.07
Posterior	39.70±23.37	6.19±7.63	26.75±23.92
Baked	28.50±16.46	4.44±4.47	22.42±17.86
Poached	34.52±15.72	3.79±3.55	23.02±13.13
Baked-in-Bag	45.69±24.76	8.22±9.93	35.42±25.16
		DRIP	
Anterior	105.63±136.62	37.03±140.89	79.18±130.70
Posterior	148.84±200.34	34.35± 76.55	143.51±224.79
Baked	185.93±211.53	28.15± 67.45	76.32±194.23
Poached	103.62±126.90	67.17±180.07	156.27±161.11
Baked-in-Bag	92.16±147.68	11.75± 23.79	101.43±198.15
With skin	137.21±176.10	42.16±149.30	90.01±151.22
Without skin	117.26±168.96	29.22± 57.74	132.67±214.35

Poached skin samples with an intermediate value of 34.52 ppm p,p'-DDE were not significantly different from either baked or baked-in-bag skin samples. Differences in amounts of p,p'-DDD ($P < 0.01$) and p,p'-DDT ($P < 0.05$) among individual fish were also observed.

Values for the DDT compounds present in drip were inconsistent. The data showed no significant differences due to cooking method, individual fish, position from which samples were taken or cooking with or without skin (Table 9).

PPM (fat basis) of PCB and DDT compounds in coho

Because the coho sample consisted of only the anterior halves of two fish, general tendencies only can be noted. The coho contained less PCB and DDT compounds in raw flesh than the chinook and therefore, less in cooked samples (Table 10). A comparison of means using a Z test statistic indicated the baked coho flesh contained less p,p'-DDD ($P < 0.01$) with an average of 1.10 ppm than baked chinook averaging 5.69 ppm. Amounts of p,p'-DDE and p,p'-DDT were also less ($P < 0.05$) in coho baked flesh with averages of 20.97 and 10.20 ppm, respectively, than in chinook baked flesh with averages of 34.32 and 25.37 ppm p,p'-DDE and p,p'-DDT, respectively.

PPM (wet basis) of PCB and DDT compounds in raw flesh

Because PCB and pesticide residue levels are frequently reported as ppm, wet basis, these values were calculated for

Table 10. Averages and standard deviations for parts per million (fat basis) of PCB and pesticide residues in raw flesh and skin and flesh, skin and drip of samples from the anterior halves to two coho salmon cooked by three methods.

Cooking Method	Aroclors		DDT Compounds		
	1248	1254	p,p'-DDE	p,p'-DDD	p,p'-DDT
			RAW FLESH		
	14.35±7.02	I55.41±61.27	27.74±9.55	3.25±2.64	14.57±6.74
			COOKED FLESH		
Baked	13.85±6.11	170.69±68.12	20.97±2.56	1.10±1.24	10.20±3.49
Poached	15.60±8.46	176.49±110.87	27.86±18.28	2.61±1.25	15.18±12.97
Baked-in-Bag	13.48±1.50	I65.77±43.25	24.95±2.99	13.11±0.87	14.95±3.80
			RAW SKIN		
	24.14±16.I9	176.73±108.02	37.93±10.00	3.51±0.91	19.91±5.47
			COOKED SKIN		
Baked	7.56±2.32	124.73±35.84	22.65±1.70	2.77±0.90	10.98±2.64
Poached	14.62±11.75	148.25±33.65	30.67±18.27	3.86±3.13	13.16±7.30
Baked-in-Bag	25.77±14.53	204.83±107.08	44.78±21.69	7.38±3.18	23.27±12.43
			DRIP		
Baked	206.21±163.76	863.48±752.02	33.50±27.51	0.00±0.00	50.03±84.41
Poached	575.13±297.15	1892.96±771.02	21.25±36.14	27.50±55.0	75.13±109.70
Baked-in-Bag	96.20±35.69	484.03±320.53	64.67±37.33	0.00±0.00	34.22±39.78

the flesh of raw chinook and coho salmon (Table 11). Total PCBs in chinook and coho averaged 7.99 and 5.94 ppm, respectively, while total DDT compounds averaged 1.90 and 1.59 ppm for chinook and coho, respectively. These values are within the ranges reported by Henderson et al. (1971); however, their data showed values for whole fish. The data showed higher levels of all residues in the chinook than were present in the coho.

Table 11. Averages for parts per million (wet basis) of PCB and DDT compounds in raw flesh samples from five chinook and two coho salmon.

Species	1248	1254	p,p'-DDE	p,p'-DDD	p,p'-DDT
Chinook	0.50	7.49	1.11	0.12	0.67
Coho	0.50	5.44	0.97	0.11	0.51

Micrograms of PCB and DDT compounds in chinook flesh

The micrograms of PCB and DDT compounds in raw and cooked chinook flesh were calculated from averages (Table 12). The data show small reductions in the micrograms of PCB and DDT compounds when samples were cooked by baking and baking-in-bags. Small reductions also occurred in the total DDT compounds present in poached samples. However, increased micrograms of PCBs are shown for samples cooked by poaching. These data probably reflect sampling errors and/or the fact

Table 12. Total micrograms of PCBs and DDT compounds in the flesh of five chinook salmon, raw and cooked by three methods.

Cooking Method	PCBs		DDT Compounds		
	1248	1254	p,p'-DDE	p,p'-DDD	p,p'-DDT
			RAW		
	62.2	932.2	138.1	14.9	83.4
			COOKED		
Baked	51.2	911.7	114.1	18.9	84.3
Poached	68.1	991.7	132.1	17.4	82.7
Baked-in-Bag	48.7	791.0	114.0	18.1	78.0

that calculations were based on averages. According to these data, baking-in-bags is the most effective cooking method in reducing total contamination in chinook salmon; however, it should be noted that reductions were small.

Summary of data from PCB and DDT compound analyses

The data of this study confirm that reported by Henderson et al. (1971) in that chinook and coho salmon from Lake Michigan are contaminated with PCBs and DDT compounds. It has been suggested that this contamination of fish could be reduced and/or removed by cutting out fatty areas while preparing the fish for cooking and then cooking by methods which leach fat from the tissues (Dice, 1969). The studies of Ritchey et al. (1969) and Reinert et al. (1971) support this conclusion. In contradiction, the results of this study show no definite relation between lipid content and residue

levels in fish. Henderson et al. (1971) reported the same conclusion.

Although the fat content decreased approximately 22.6% from the anterior to the posterior positions in raw chinook flesh, the residue concentration in the posterior halves showed higher levels than in the anterior halves (Table 13). If there were a correlation between the two, highest residue levels would be present in the anterior halves along with the increased fat content. Cooked samples showed similar trends.

Table 13. Percent fat and parts per million (fat basis) of PCB and DDT compounds in anterior and posterior halves of raw chinook salmon flesh and percentage difference.

Fat (%) or Residue (ppm)	Anterior	Posterior	Difference (%)
Fat	3.04	2.35	-22.6
Aroclor 1248	15.28	21.06	37.8
Aroclor 1254	243.53	302.53	24.2
p,p'-DDE	36.87	45.54	23.5
p,p'-DDD	3.92	4.55	16.0
p,p'-DDT	20.59	27.30	32.5

Also in support of this conclusion, samples of flesh cooked with skin were compared with those cooked without skin. Although the amount of fat was 2.7% more in samples cooked with skin, the levels of PCB and DDT compounds were

lower. Percents of difference were calculated and the results are shown in Table 14.

Table 14. Percent fat and parts per million (fat basis) of PCB and DDT compounds in chinook salmon flesh cooked with and without skin and percentage difference.

Fat (%) or Residue (ppm.)	Cooking State		Difference (%)
	With Skin	Without Skin	
Fat	3.73	3.63	-2.7
Aroclor 1248	14.65	17.06	14.2
Aroclor 1254	242.26	268.43	9.7
p,p'-DDE	32.49	35.70	9.0
p,p'-DDD	4.61	5.73	19.5
p,p'-DDT	20.77	25.74	19.3

Cooking does reduce levels of PCB and DDT compounds in chinook and coho salmon as evidenced by the presence of these residues in the drip. The reduction is small, however. The data do not statistically point to any one of the three cooking methods as being superior for reducing all residue levels.

Thus, the results of this study show no statistically significant pattern for effectively reducing all levels of PCB and DDT compounds in chinook and coho salmon. Small reductions do occur during cooking and because residues are present in the drip, total consumption of these compounds can be reduced by discarding the cooking drip.

Quality Characteristics of Cooked Salmon

To assess the quality characteristics of the fish, two half-steaks, one from the anterior and one from the posterior half, from each of five chinook salmon and one half-steak from the anterior half of each of two coho salmon were cooked by each of the three methods. No skin was removed from the samples. Cooking times, total, volatile and/or drip losses, tenderness and juiciness were determined for each sample Tables 21 and 22, Appendix). All data were analyzed for variance (Table 15) while Duncan's multiple range test was used to pinpoint sources of significant differences. Using a Z test statistic (Dixon et al., 1957), appropriate means of the two species of fish were compared.

Cooking times

Baked chinook salmon steaks required an average of 45.6 min to cook to an end temperature of 75°C, longer ($P < 0.01$) than was needed to cook either bake-in-bag or poached samples to the same temperature. The average of 14.5 min cooking time for bake-in-bag samples was longer ($P < 0.05$) than the average of 7.0 min required to poach samples (Table 16). Cooking times did not differ significantly due to position or among fish.

Cooking times for the limited number of coho salmon steaks were 35.5, 6.2 and 10.9 min for baked, poached and bake-in-bag samples, respectively. These values did not differ significantly from those of the chinook salmon.

Table 15. Analyses of variance for cooking times and losses, shear press and press fluid of samples from five chinook salmon cooked by three methods.

Source of Variance	DF	Mean Square Values					
		Cooking Time	Cooking Losses			Shear Press	Press Fluid
			Total	Volatile[1]	Drip[1]		
Total	29	. . .	. . .	. . .	. . .	. . .	. . .
Cooking method	2	4192.93**	696.75**	3077.68**	684.45**	4.86**	133.75**
Fish	4	94.89	29.43*	26.06	1.93	1.94*	7.40
Position	1	80.03	18.41	6.38	9.52*	0.00	5.32
Error	22	46.90	7.00	10.29	1.58	0.46	2.68

[1] Degrees of freedom are Total 19, Method 1, Fish 4, Position 1, Error 13

** Significant at the 1% level of probability.

* Significant at the 5% level of probability.

Table 16. Cooking times and losses, shear press and press fluid averages, standard deviations and statistical analyses of samples from five chinook salmon cooked by three methods.

Measurement	Cooking Method			Statistical Significance[1]	
	Baked B	Poached P	Bake-in-Bag BB	P< 0.01	P < 0.05
Cooking time (min)	45.6±12.4	7.0±1.3	14.5±3.0	P, BB < B	P < BB
Cooking losses					
Total (%)	30.0± 5.2	14.2±1.5	16.9±1.9	P, BB < B	
Volatile (%)	29.2± 5.2	. . .	4.4±1.2	BB < B	
Drip (%)	0.8± 0.2	. . .	12.5±1.7	B < BB	
Tenderness (lb force/g)	8.83±0.87	7.60±0.79	8.77±0.74	P < B, BB	
Press fluid (%)	44.09±1.93	50.76±1.83	50.01±2.01	B < BB, P	

[1]Values underscored by the same line are not significantly different (Duncan, 1957).

Cooking times are dependent on the speed with which heat is conducted in the cooking medium (Lowe, 1955). Moist heat, as used in poaching and to a lesser extent in bake-in-bag cooking decreased cooking times. These findings are in agreement with those reported by meat cooking researchers, Cover (1941) and Clark et al. (1949).

Cooking losses

Total cooking losses were calculated for samples cooked by three methods. Volatile and drip losses were determined only for samples cooked by baking and baking-in-bags.

Total cooking losses. These losses averaged 30.0, 14.2 and 16.9% for baked, poached and baked-in-bag chinook salmon samples (Table 16). The losses for baked steaks were significantly ($P<0.01$) larger than those for steaks cooked by the other methods. Significant differences ($P<0.05$) were noted among individual fish although none attributable to position were evident.

For coho salmon steaks, total cooking losses averaged 24.6±1.5, 9.8±1.0 and 13.8±3.7% for samples cooked by baking, poaching and baking-in-bags, respectively. These losses for coho were lower than chinook cooked by baking ($P<0.05$) and poaching ($P<0.01$) although only a limited number of coho steaks were cooked for this study.

As stated by Lowe (1955), the cooking method affects the total percentage of constituents lost during cooking. In meat studies (Hood, 1960), dry heat methods of cooking

have resulted in greater cooking losses than occur in moist heat methods.

Volatile cooking losses. Baked chinook salmon steaks averaging 29.2% lost more ($P < 0.01$) volatile components than did bake-in-bag samples which averaged 4.4% (Table 16). No significant differences due to position or individual fish were noted.

For coho samples, volatile losses for baked and bake-in-bag samples of 24.0±2.8 and 3.7±1.1%, respectively, did not differ significantly from chinook samples.

The high losses from the baked samples would be expected because of the length of the cooking time. The nylon cooking bags prevented much of the evaporation of moisture from the bake-in-bag samples.

Drip cooking losses. Bake-in-bag chinook samples had greater ($P < 0.01$) cooking losses of 12.5% than baked samples which averaged 0.8% (Table 16). As indicated, the nylon cooking bags prevented moisture evaporation whereas moisture would readily evaporate from the hot surface of the pan used for cooking samples by baking. Samples from the anterior halves had higher ($P < 0.05$) drip losses than samples from the posterior halves, probably because of differences in the fat content of each half.

Coho salmon steaks averaged 0.6±0.3 and 10.2±3.1% for baked and bake-in-bag samples respectively. These values did not differ significantly from those reported for chinook samples.

Tenderness

Poached samples of chinook salmon, averaging 7.60 lb force per g to shear, were more tender ($P < 0.01$) than samples cooked by baking or baking-in-bags which averaged 8.83 and 8.77 lb force per g to shear, respectively (Table 16). These data suggest the proteins were perhaps over-coagulated and hence, toughened by baking or baking-in-bags. Significant differences in tenderness ($P < 0.05$) were also noted among individual fish but not due to position from which the samples were taken.

The lb force per g to shear for baked, poached and baked-in-bag coho samples were 7.67±0.62, 6.40±0.62 and 7.71±0.08, respectively. A comparison of means on the basis of cooking method showed significant species differences for baking ($P < 0.05$), poaching ($P < 0.05$) and baking-in-bags ($P < 0.01$). However, only a limited number of coho samples were used in this investigation.

Juiciness

Baked samples of chinook salmon contained less ($P < 0.01$) press fluid, averaging 44.09%, than either poached or bake-in-bag samples averaging 50.76 and 50.01%, respectively (Table 16). These differences probably reflect the high cooking losses incurred during the long cooking period of baked samples.

Average press fluid values of 50.34±0.66, 53.66±2.64 and 50.52±0.85 were noted for coho salmon steaks cooked by

baking, poaching and baking-in-bags, respectively. When compared with values for chinook salmon, the limited number of baked coho samples had more ($P < 0.01$) press fluid while poached and bake-in-bag samples did not differ significantly.

SUMMARY AND CONCLUSIONS

The purpose of this study was to compare the effects of selected cooking methods on the PCB and pesticide residue levels in chinook and coho salmon steaks. Cooking losses, tenderness and juiciness were also determined on a limited number of samples. The residue content of raw flesh and skin from salmon taken from Lake Michigan were compared with cooked samples from the same fish. Drip from cooking was also analyzed.

Half-steaks of chinook and coho were cooked by baking, poaching and baking in nylon bags to an internal temperature of 75°C. PCB and pesticide residues, calculated on a percentage of fat basis, were determined using hexane-acetone extraction, Florisil-Celite column clean-up and electron capture gas chromatography. All samples were analyzed for variance due to individual fish, cooking method, position from which the samples were taken and whether samples were cooked with or without skin. Percent fat was also calculated for all samples.

The fat content of raw chinook and coho flesh averaged 2.65 and 3.59%, respectively. Skin samples averaged 6.36 and 6.29% fat for chinook and coho, respectively. Raw chinook

flesh differed ($P < 0.05$) in fat content among individual fish and position from which the samples were taken with samples from the anterior halves containing more fat.

Cooked chinook flesh differed in fat content ($P < 0.01$) due to cooking method, individual fish and position from which samples were taken. Poached flesh contained less ($P < 0.05$) fat than baked flesh while samples taken from the anterior halves contained highest percentages of fat. Ranked in order of decreasing fat content were skin samples cooked by baking, poaching and baking-in-bags. Samples of skin from anterior halves showed a higher fat content than samples from posterior halves. Drip from baked samples contained more ($P < 0.01$) fat than baked-in-bag drip which contained more ($P < 0.01$) than poached drip. The anterior halves also yielded more fat in the drip than posterior halves.

The data of this study showed that the chinook and coho were contaminated with Aroclors 1248 and 1254 as well as p,p'-DDE, p,p'-DDD and p,p'-DDT. The PCB residue levels of raw chinook flesh averaged 18.17 ppm of Aroclor 1248 and 273.03 ppm of Aroclor 1254 while the raw flesh of coho salmon contained 14.35 ppm of Aroclor 1248 and 155.41 ppm of Aroclor 1254. Skin samples of chinook averaged 15.97 and 223.49 ppm of Aroclors 1248 and 1254, respectively. Coho skin samples averaged 24.14 and 176.73 ppm of Aroclors 1248 and 1254, respectively.

DDT compounds in raw chinook flesh averaged 40.20 ppm of p,p'-DDE, 4.24 ppm of p,p'-DDD and 23.94 ppm of p,p'-DDT. Skin samples contained 27.52, 3.87 and 19.84 ppm of p,p'-DDE, p,p'-DDD and p,p'-DDT, respectively. Flesh samples of coho averaged 27.74, 3.25 and 14.57 ppm while skin samples averaged 37.93, 3.51 and 19.91 ppm of p,p'-DDE, p,p'-DDD and p,p'-DDT, respectively.

Cooked flesh samples of chinook showed no significant differences due to cooking method and cooking with or without skin; however, the samples differed ($P < 0.01$) among individual fish. No consistent pattern was noted for changes in all of the pesticide residues due to position from which samples were taken.

Cooked skin samples showed no consistent pattern for changes in all PCB and pesticide residues among individual fish and cooking method. Skin samples from anterior and posterior halves did not differ significantly in any of the PCB and pesticide residues.

Values for the PCB and DDT compounds present in drip were inconsistent. The presence of these residues in the drip does indicate that cooking can reduce PCB and pesticide levels in chinook and coho salmon. Although the data does not point to the superiority of any one of the three cooking methods, total consumption of the pesticides can be reduced by discarding the cooking drip. The reduction, however, which occurs during cooking is small.

Objective measurements of quality characteristics showed chinook cooked by poaching required less cooking time, had lower total cooking losses and required fewer pounds of force per gram to shear. Poached samples also retained more moisture as indicated by press fluid values than salmon half-steaks cooked by baking or baking-in-bags. Baked-in-bag samples cooked in less time and had lower total cooking losses than baked samples. The data also indicated that baked-in-bag samples were more tender and juicier than baked samples. Coho salmon steaks rated higher in all the quality characteristics measured than did chinook steaks. On the basis of the data for quality characteristics, cooking methods ranked in order of decreasing preference, would be poaching, baking-in-bags and baking.

Areas of further investigation could include other cooking methods and other species of fish. Extensions of the cooking times of the samples might indicate that further reductions of PCB and pesticide levels occur. Also, a comparison of any differences between sexes of fish in residue levels and cooking methods could be explored.

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APPENDIX

Table 17. Percent fat and parts per million (fat basis) of PCB and DDT compounds in raw flesh and skin samples taken from anterior and posterior halves of five chinook and two coho salmon.

Fish	Position	Component	Fat	PCBs		DDT Compounds		
				1248	1254	p,p'-DDE	p,p'-DDD	p,p'-DDT
					CHINOOK			
1	A	F	3.02	13.47	209.94	28.40	0.00	5.53
		S	9.72	10.42	182.42	19.54	2.60	9.37
	P	F	2.87	13.15	220.22	37.05	3.37	9.11
		S	5.57	7.51	171.02	21.03	2.70	13.86
2	A	F	1.22	28.11	329.90	51.40	7.31	31.67
		S	3.18	21.01	429.62	42.01	9.12	50.38
	P	F	1.04	53.21	792.45	103.12	9.73	74.54
		S	1.93	31.08	290.44	48.35	6.38	31.28
3	A	F	4.13	11.42	202.92	20.92	5.62	25.62
		S	6.91	5.58	151.23	11.48	0.87	16.93
	P	F	3.12	11.22	125.61	20.27	0.00	16.34
		S	5.82	35.78	238.51	14.89	2.37	4.75
4	A	F	3.55	14.41	239.15	38.05	4.98	23.34
		S	9.69	5.65	151.84	17.48	6.33	7.47
	P	F	2.83	12.25	154.04	28.02	3.06	19.51
		S	3.80	18.63	189.53	25.59	2.52	10.57
5	A	F	3.30	8.96	235.73	45.56	1.72	16.78
		S	13.06	13.45	297.18	46.70	3.96	24.91
	P	F	1.90	15.48	220.35	39.23	6.57	17.02
		S	4.19	10.62	133.08	28.14	5.01	18.29
					COHO			
1	A	F	4.30	8.81	133.62	20.97	1.27	9.57
		S	9.05	16.55	136.88	36.22	3.81	22.59
2	A	F	2.87	19.89	177.19	34.51	5.22	19.57
		S	3.48	31.71	211.58	39.63	3.20	17.23

Table 18. Percent fat and parts per million (fat basis) of PCB and DDT compounds in flesh samples taken from anterior and posterior halves of five chinook and two coho salmon cooked by three methods with and without skin.

Cooking Method	Position	Cooking State	Chinook 1	Chinook 2	Chinook 3	Chinook 4	Chinook 5	Coho 1	Coho 2
					PERCENT FAT				
Baked	A	W	5.38	1.89	7.96	4.72	4.02	6.40	4.05
		W/O	3.67	1.63	6.86	4.91	4.64	4.55	3.10
	P	W	3.99	2.02	3.88	3.82	2.96		
		W/O	4.48	1.59	3.53	4.33	3.78		
Poached	A	W	4.11	1.63	5.59	4.06	3.26	5.14	5.22
		W/O	4.04	2.79	7.12	3.88	3.99	4.01	1.94
	P	W	2.09	1.36	5.55	2.72	2.85		
		W/O	3.06	1.45	4.46	2.39	2.17		
Bake-in-Bag	A	W	4.28	2.06	5.98	4.99	3.99	5.39	3.14
		W/O	3.36	1.67	6.02	4.10	4.03	4.37	2.94
	P	W	3.81	1.54	5.42	3.27	2.65		
		W/O	4.47	1.02	4.29	3.25	1.94		
					AROCLOR 1248				
Baked	A	W	7.65	22.99	7.36	9.59	10.35	7.51	18.59
		W/O	10.54	54.58	7.87	9.35	6.46	19.54	9.78
	P	W	13.00	20.87	7.88	11.77	13.58		
		W/O	16.54	41.38	16.09	8.72	11.44		
Poached	A	W	11.46	38.88	6.15	9.67	13.02	5.60	19.98
		W/O	14.25	15.47	2.96	6.84	4.72	12.08	24.74
	P	W	51.88	32.08	9.31	13.51	17.49		
		W/O	15.05	34.61	11.72	30.73	28.09		
Bake-in-Bag	A	W	9.23	24.27	8.41	6.06	5.80	12.54	14.13
		W/O	9.42	29.28	12.14	6.28	5.74	12.05	15.21
	P	W	7.54	15.91	6.15	11.42	16.11		
		W/O	15.38	44.07	7.83	21.56	12.79		

continued

Table 18--Continued

Cooking Method	Position	Cooking State	Chinook 1	Chinook 2	Chinook 3	Chinook 4	Chinook 5	Coho 1	Coho 2
			AROCLOR 1254						
Bake	A	W	180.96	302.85	175.26	261.05	217.12	87.86	251.75
		W/O	207.72	1091.42	182.67	222.34	164.32	195.00	148.64
	P	W	134.23	405.22	106.55	225.79	289.41		
		W/O	264.55	488.58	189.68	161.07	215.16		
Poach	A	W	237.34	556.88	121.00	228.72	252.66	82.49	199.77
		W/O	220.09	295.11	65.21	149.65	100.14	100.05	323.64
	P	W	551.68	400.31	244.51	179.87	183.74		
		W/O	132.98	590.97	184.87	256.11	411.10		
Bake-in-Bag	A	W	182.89	542.68	103.28	95.37	124.38	189.14	191.32
		W/O	257.67	489.90	242.14	85.76	127.42	101.17	81.44
	P	W	231.10	229.28	137.63	174.98	190.32		
		W/O	231.54	483.62	106.84	145.08	289.20		
			DDE						
Bake	A	W	24.34	55.96	9.96	32.39	28.12	19.11	24.27
		W/O	28.98	105.87	8.80	21.60	25.99	21.58	18.94
	P	W	37.35	45.30	10.62	25.21	41.68		
		W/O	44.70	73.29	25.75	18.11	22.38		
Poach	A	W	32.53	68.58	13.93	20.37	31.31	14.25	20.08
		W/O	43.62	37.26	10.23	19.11	19.41	22.32	54.80
	P	W	76.11	59.24	10.51	27.19	29.08		
		W/O	25.39	85.16	14.12	43.61	47.68		
Bake-in-Bag	A	W	24.94	65.69	17.14	12.27	29.27	27.16	26.18
		W/O	37.40	69.60	12.54	15.19	18.92	20.52	25.94
	P	W	41.53	36.23	10.37	29.71	27.70		
		W/O	38.80	71.48	13.52	26.67	45.91		

continued

Table 18--Continued

Cooking Method	Position	Cooking State	Chinook 1	Chinook 2	Chinook 3	Chinook 4	Chinook 5	Coho 1	Coho 2
					DDD				
Bake	A	W	8.65	13.91	4.57	6.48	3.97	2.77	1.29
		W/O	3.93	23.94	2.30	0.00	2.72	0.00	0.36
	P	W	7.38	3.72	1.22	5.59	0.68		
		W/O	9.50	10.98	0.00	3.44	0.76		
Poach	A	W	4.46	10.57	0.88	0.00	0.91	.99	3.79
		W/O	4.25	9.39	1.48	3.98	1.48	2.31	3.35
	P	W	5.54	11.35	2.96	4.05	1.37		
		W/O	1.52	16.59	4.39	4.65	4.57		
Bake-in-Bag	A	W	2.26	14.85	5.50	2.42	2.75	3.81	3.24
		W/O	5.50	17.71	6.01	4.59	1.41	1.85	3.53
	P	W	3.41	1.43	.83	4.75	1.91		
		W/O	1.08	16.90	0.00	5.60	3.26		
					DDT				
Bake	A	W	14.23	65.36	18.28	26.66	21.73	14.56	10.39
		W/O	17.87	122.19	14.66	11.52	8.48	6.03	9.82
	P	W	19.40	29.67	5.46	10.81	13.78		
		W/O	23.86	38.17	14.81	20.07	10.49		
Poach	A	W	22.38	44.77	1.78	16.31	5.88	6.47	20.38
		W/O	27.11	46.53	5.28	6.43	7.51	9.44	24.43
	P	W	16.42	51.37	21.28	20.31	9.70		
		W/O	11.72	76.65	19.10	17.20	18.26		
Bake-in-Bag	A	W	9.70	73.01	26.92	8.32	7.60	16.40	17.51
		W/O	24.73	55.71	25.59	17.54	5.59	9.32	16.58
	P	W	7.94	24.48	1.67	17.32	10.65		
		W/O	8.05	68.39	11.14	19.43	17.38		

Table 19. Percent fat and parts per million (fat basis) of PCB and DDT compounds in skin samples taken from anterior and posterior halves of five chinook and two coho salmon cooked by three methods.

Cooking Method	Position	Chinook 1	Chinook 2	Chinook 3	Chinook 4	Chinook 5	Coho 1	Coho 2
				PERCENT FAT				
Baked	A	10.93	4.91	9.45	11.72	12.23	15.83	6.42
	P	10.36	2.49	3.95	7.67	5.62		
Poached	A	8.65	2.65	9.04	6.21	5.15	12.08	2.90
	P	3.07	1.58	5.00	3.32	3.71		
Baked-in-Bag	A	5.79	2.37	4.84	5.84	4.34	9.30	2.61
	P	3.40	1.12	6.13	1.92	1.63		
				1248				
Baked	A	2.38	24.32	11.30	1.38	9.54	9.22	5.89
	P	2.89	12.33	19.98	4.36	5.77		
Poached	A	5.40	20.16	11.41	4.27	5.18	6.30	22.93
	P	20.42	19.49	8.86	54.15	7.06		
Baked-in-Bag	A	16.79	30.72	9.36	34.45	6.96	15.48	36.05
	P	5.35	46.25	9.56	28.65	62.27		
				1254				
Baked	A	119.40	504.18	349.02	108.16	372.36	99.36	150.09
	P	125.31	236.39	199.77	180.52	160.66		
Poached	A	169.23	512.09	86.83	166.15	157.92	124.42	172.07
	P	275.60	462.03	149.32	431.11	141.35		
Baked-in-Bag	A	210.00	926.50	177.15	143.58	174.42	129.13	280.54
	P	227.35	347.41	220.29	122.87	473.93		

continued

Table 19--Continued

Cooking Method	Position	Chinook 1	Chinook 2	Chinook 3	Chinook 4	Chinook 5	Coho 1	Coho 2
				DDE				
Baked	A	16.71	62.57	14.74	9.32	36.28	23.85	21.45
	P	22.16	48.07	31.22	23.40	20.55		
Poached	A	29.02	54.41	29.76	24.43	15.05	17.75	43.59
	P	44.89	49.81	18.52	57.61	21.67		
Baked-in-Bag	A	51.59	47.26	26.36	28.70	45.35	29.44	60.12
	P	43.12	111.07	24.42	38.49	40.55		
				DDD				
Baked	A	3.82	9.72	0.0	0.0	6.87	3.41	2.13
	P	2.31	13.17	0.0	5.97	2.56		
Poached	A	3.30	6.09	1.98	2.56	1.48	1.66	6.07
	P	8.96	10.25	3.28	0.00	0.00		
Baked-in-Bag	A	16.79	17.51	0.00	0.00	1.52	5.15	9.62
	P	0.00	27.77	5.53	13.07	0.0		
				DDT				
Baked	A	14.32	44.50	25.16	3.99	35.13	9.08	12.87
	P	1.54	55.90	20.33	8.96	14.38		
Poached	A	16.96	53.64	25.80	28.28	12.62	7.96	18.35
	P	34.30	18.48	12.34	12.67	15.07		
Baked-in-Bag	A	28.81	56.54	19.26	14.35	27.88	14.46	32.07
	P	23.29	92.59	11.06	26.20	54.17		

Table 20. Percent fat and parts per million (fat basis) of PCB and DDT compounds in drip samples taken from anterior and posterior halves of five chinook and two coho salmon cooked by three methods with and without skin.

Cooking Method	Position	Cooking State	Chinook 1	Chinook 2	Chinook 3	Chinook 4	Chinook 5	Coho 1	Coho 2
			PERCENT FAT						
Baked	A	W	19.62	0.93	34.71	5.16	12.15	44.69	1.59
		W/O	4.37	1.28	17.12	9.91	9.53	16.84	1.56
	P	W	3.16	0.21	6.96	2.32	3.14		
		W/O	1.95	0.44	5.77	2.55	2.28		
Poached	A	W	0.01	0.02	0.03	0.01	0.01	0.02	0.03
		W/O	0.03	0.05	0.03	0.04	0.04	0.03	0.01
	P	W	0.03	0.02	0.04	0.02	0.01		
		W/O	0.02	0.02	0.06	0.00	0.01		
Baked-in-Bag	A	W	1.03	0.10	1.39	3.58	0.71	21.97	0.89
		W/O	3.71	0.14	1.40	0.49	0.95	1.95	0.30
	P	W	0.42	0.02	0.79	0.43	0.27		
		W/O	0.58	0.04	0.58	0.77	0.40		
			1248						
Baked	A	W	20.12	626.56	10.21	156.82	54.17	29.83	352.52
		W/O	50.71	785.55	43.24	49.82	89.66	104.03	338.46
	P	W	16.47	1642.38	356.12	244.31	159.42		
		W/O	594.62	535.46	346.08	405.77	206.14		
Poached	A	W	1075.00	1182.50	594.17	1380.00	970.00	655.00	308.00
		W/O	444.17	296.00	438.75	385.00	297.50	377.50	960.00
	P	W	770.00	387.50	483.33	642.50	605.00		
		W/O	881.25	955.00	312.14	1740.00	1190.00		
Baked-in-Bag	A	W	96.80	190.00	10.43	172.60	30.14	92.38	88.09
		W/O	9.27	90.71	20.07	107.14	15.37	59.33	145.00
	P	W	31.91	1685.00	106.71	81.63	414.25		
		W/O	34.66	475.00	1122.93	66.23	78.52		

continued

Table 20--Continued

Cooking Method	Position	Cooking State	Chinook 1	Chinook 2	Chinook 3	Chinook 4	Chinook 5	Coho 1	Coho 2
					1254				
Baked	A	W	172.50	3916.24	182.25	1147.52	948.05	135.60	1652.20
		W/O	281.88	2499.77	531.26	332.12	597.78	313.10	1354.04
	P	W	89.89	6569.52	4135.72	3941.03	845.68		
		W/O	1189.33	3652.73	2076.60	4422.24	1840.40		
Poached	A	W	4585.00	7837.50	3163.33	10930.00	7235.00	1660.00	1296.00
		W/O	1756.67	1146.00	3148.75	2503.33	2096.25	1590.84	3025.00
	P	W	3765.00	2367.50	2829.00	4125.00	3835.00		
		W/O	3045.00	4790.00	1050.00	2890.00	8805.00		
Baked-in-Bag	A	W	888.54	839.00	376.69	674.20	644.37	142.12	440.79
		W/O	99.43	532.86	525.14	1256.74	297.58	436.56	916.67
	P	W	344.52	14985.00	339.75	546.74	2590.00		
		W/O	217.76	3465.00	5312.07	784.94	218.15		
					DDE				
Baked	A	W	30.90	492.37	14.58	76.49	81.26	9.94	43.96
		W/O	70.48	542.81	38.29	36.54	101.62	12.48	67.63
	P	W	16.47	131.43	0.0	394.10	120.76		
		W/O	69.33	730.23	149.98	436.98	183.99		
Poached	A	W	370.00	0.00	60.00	40.00	115.00	75.00	0.00
		W/O	83.33	0.00	0.00	185.00	243.33	10.00	0.00
	P	W	70.00	172.50	433.33	0.00	190.00		
		W/O	0.00	0.00	40.00	70.00	0.00		
Baked-in-Bag	A	W	129.22	111.00	29.21	21.54	90.85	25.58	66.07
		W/O	19.87	57.86	10.93	87.38	39.16	52.36	114.67
	P	W	75.48	0.0	77.47	26.95	745.50		
		W/O	53.45	60.00	60.52	69.74	87.04		

continued

Table 20--Continued

Cooking Method	Position	Cooking State	Chinook 1	Chinook 2	Chinook 3	Chinook 4	Chinook 5	Coho 1	Coho 2
					DDD				
Baked	A	W	0.71	0.00	0.00	0.00	0.00	0.00	0.00
		W/O	5.61	85.70	0.00	0.00	0.00	0.00	0.00
	P	W	0.00	0.00	0.00	78.79	4.81		
		W/O	19.85	292.05	46.14	0.00	29.39		
Poached	A	W	770.00	0.00	30.00	0.00	0.00	110.00	0.00
		W/O	34.17	0.00	0.00	82.50	86.67	0.00	0.00
	P	W	0.00	0.00	310.00	0.00	0.00		
		W/O	0.00	0.00	0.00	30.00	0.00		
Baked-in-Bag	A	W	6.31	0.00	0.00	0.00	6.06	0.00	0.00
		W/O	3.18	0.00	0.00	0.00	0.00	0.00	0.00
	P	W	0.00	0.00	54.12	0.00	82.75		
		W/O	0.00	0.00	30.35	0.00	52.22		
					DDT				
Baked	A	W	25.87	89.57	0.00	0.00	15.25	7.23	176.23
		W/O	11.24	457.03	0.00	19.92	59.77	16.65	0.00
	P	W	1.50	0.00	0.00	0.00	0.00		
		W/O	0.00	779.09	0.00	0.00	66.23		
Poached	A	W	250.00	0.00	0.00	0.00	180.00	232.50	68.00
		W/O	145.00	0.00	0.00	428.75	233.30	0.00	0.00
	P	W	410.00	160.00	203.33	85.00	90.00		
		W/O	0.00	0.00	80.00	450.00	410.00		
Baked-in-Bag	A	W	38.74	33.00	30.07	0.00	321.41	0.00	17.64
		W/O	8.46	0.00	7.29	0.00	19.58	27.90	91.33
	P	W	33.09	0.00	69.75	0.00	662.75		
		W/O	23.10	0.00	606.90	0.00	174.44		

Table 21. Shear press and press fluid measurements of samples from five chinook and two coho salmon cooked by three methods.

Cooking Method	Position	Chinook 1	Chinook 2	Chinook 3	Chinook 4	Chinook 5	Coho 1	Coho 2
		SHEAR PRESS (lb. force per g.)						
Baked	A	8.42	9.52	8.72	7.87	9.05	8.11	7.23
	P	8.57	8.28	11.00	8.12	8.73	. . .	. . .
Poached	A	5.84	7.66	8.72	7.08	8.68	5.96	6.84
	P	6.90	7.59	7.95	7.70	7.81	. . .	. . .
Baked-in-Bag	A	8.46	9.50	9.44	8.63	8.29	7.77	7.65
	P	8.69	8.24	9.96	8.77	7.74	. . .	. . .
		PRESS FLUID (%)[1]						
Baked	A	44.12	40.59	44.79	43.91	45.94	50.87	49.80
	P	44.10	46.86	41.65	44.37	44.52	. . .	. . .
Poached	A	48.53	51.16	49.12	52.37	51.19	55.53	51.79
	P	52.34	51.05	48.24	50.41	53.21	. . .	. . .
Baked-in-Bag	A	46.85	51.44	49.27	47.70	50.99	50.89	50.14
	P	48.12	52.83	49.34	51.07	52.49	. . .	. . .

[1]Each value is an average of duplicate determinations.

Table 22. Cooking times and losses of samples from five chinook and two coho salmon cooked by three methods.

Cooking Method	Position	Chinook 1	Chinook 2	Chinook 3	Chinook 4	Chinook 5	Coho 1	Coho 2
		COOKING TIME (min)						
Baked	A	46.0	62.0	45.0	47.8	42.3	33.0	38.0
	P	67.8	45.8	23.5	38.3	37.5	. . .	. . .
Poached	A	8.0	7.3	6.5	9.0	5.8	7.5	4.8
	P	8.3	5.5	8.5	5.5	5.5	. . .	. . .
Baked-in-Bag	A	18.5	17.3	15.3	15.0	14.0	9.5	12.3
	P	16.5	13.0	12.0	15.3	7.5	. . .	. . .
		TOTAL COOKING LOSSES (%)						
Baked	A	25.9	41.4	27.1	31.6	30.1	25.7	23.4
	P	31.7	31.8	26.3	30.6	23.2	. . .	. . .
Poached	A	13.3	18.1	12.5	13.9	13.6	9.1	10.4
	P	14.4	14.7	14.8	13.7	15.7	. . .	. . .
Baked-in-Bag	A	18.9	19.4	15.7	18.7	18.0	11.3	16.6
	P	15.2	18.8	14.1	16.5	13.2	. . .	. . .
		VOLATILE COOKING LOSSES (%)						
Baked	A	24.9	41.0	26.2	30.7	29.6	25.3	22.8
	P	30.7	31.0	25.8	29.8	22.5	. . .	. . .
Baked-in-Bag	A	4.9	5.7	4.0	3.7	3.1	3.3	4.1
	P	4.3	6.7	5.2	3.4	3.1	. . .	. . .
		DRIP COOKING LOSSES (%)						
Baked	A	1.0	0.4	0.9	0.9	0.5	0.4	0.7
	P	0.9	0.9	0.6	0.7	0.7	. . .	. . .
Baked-in-Bag	A	14.0	13.7	11.7	15.0	14.8	8.0	12.4
	P	11.0	12.1	8.9	13.2	10.1	. . .	. . .