Prototype Product Development

Using Alaska Surimi, Salmon, and Pollock Mince

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Prepared for:

Alaska Fisheries Development Foundation, Inc.
508 West Second Avenue, Suite 212
Anchorage, Alaska 99501
(907) 276-7315

by:

L.E. Lampila, Ph.D., R.D.
D.L. Crawford, Ph.D.
Oregon State University
Seafoods Laboratory
Department of Food Science and Technology
250 36th Street
Astoria, Oregon 97103-2499
(503) 325-4531

and

L. Eric Benson
Route 1, Box 692
Warrenton, Oregon 97146
(503) 738-7576

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FINAL REPORT

Project: Prototype Product Development Contest

Conducted by: L.E. Lampila, Ph.D., R.D.
D.L. Crawford, Ph.D.
Oregon State University
Seafoods Laboratory
Department of Food Science & Technology
Oregon State University
Astoria, Oregon 97103

L. Eric Benson
Warrenton, Oregon 97146

Funded by: Alaska Fisheries Development Foundation
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AFDF

Alaska Fisheries Development Foundation, Inc. 508 West Second Avenue, Suite 212, Anchorage, AK 99501

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L. E. Benson

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EXECUTIVE SUMMARY

Three food products were developed from chum salmon or pollock minces. Over a three month storage trial, the products maintained stability as determined by specific lipid classes. Macro-nutrients were quantitated as well as several micro-nutrients. Wholesome foods were developed in terms of high protein and Vitamin A content (Seafood Chili) and niacin and complex carbohydrate content (Klondyke potato). The sodium content of the Chili was determined to be high, however, the AOAC method used may have been skewed by interference from the spices. The thiamin and Vitamin D methods used did not result in accurate results. Again, interference from pigment and flavor compounds may have skewed instrumental detection.

These results may lead to economic benefits by the seafood industry due to enhanced utilization of low-value species. Additionally, this work has taken a concept through development into the pilot plant and a short term storage trial. This has established the framework for industry to further study and market test these products.

INTRODUCTION

As the connection between diet and health becomes more clearly defined, consumer interest in seafood and seafood products has grown creating the need for appropriate, relevant information, and making this the ideal time to initiate programs to educate industry and the public. In addition to reported health benefits of marine lipids, consumers and processors are discovering that seafoods provide tasty, low cost diversity to diets and menus. A study sponsored by the National Fisheries Institute and Better Homes and Gardens supports these observations: five hundred members of the Better Homes and Gardens Consumer Panel were surveyed and indicated that taste/flavor, health/nutrition and variety were the primary reasons that seafoods were chosen over alternatives such as beef, poultry, pork or lamb (Hasselback, 1986a).

Seafood consumption is increasing and is expected to constitute 44% of the diet by the year 2000 (Redmayne, 1986). Although accounting for a small fraction of increased seafood consumption, the surimi-based analogs have increased in popularity. This industry has grown from a domestic consumption of 6 million pounds in 1981 to a projected 119.5 million pounds for 1986 (Hasselback, 1986b). These items are marketed as imitation crab, shrimp and scallops and are common ingredients at restaurant salad bars.

Further, seafood consumption would increase with the availability of high quality and varied seafoods and convenient, prepared seafood entrees. Despite the heightened interest in seafood consumption, there is a demonstrated need for consumer education. Most consumers admit to a fear of preparing seafoods at home and express the old wives tale that cooking seafoods leaves a lingering and objectionable odor. As a consequence, it has been estimated that 70% of the seafood is consumed outside of the home. When dining out, consumers tend to order seafood entrees about half of the time (Lewis and Shoemaker, 1986). If there were greater product diversification, availability and convenience, consumers would probably eat more seafoods at home.

Seafood lipids have recently attracted the interest of the food and health science communities due to the reported benefits in relieving clinical conditions associated, primarily, with heart disease. Epidemiologic studies have established an association between a low death rate from heart disease in Eskimos of Greenland and a high level of seafood consumption (Bang and Dyerberg, 1972; Bang et al., 1980). These diets consist primarily of whale, sea birds and fish, including Greenland halibut, capelin and salmon. Such epidemiologic data has since been confirmed in Japanese (Yamori et al., 1985) and Dutch populations (Kromhout et al., 1985). Since correlation does not necessarily represent causation, controlled feeding studies relating fish oils to the reduction of risk factors associated with cardiovascular disease have been initiated with animal models and human subjects. Fatty seafoods with a high concentration of omega-3 fatty acids or fish oil concentrates have been substituted for traditional sources of dietary fat, particularly the omega-6 fatty acids which are normally found in vegetable oils. The results have indicated that plasma cholesterol, triglycerides and very low-density lipoproteins were markedly reduced (Phillipson et al., 1985; Swanson and Kinsella, 1986).

In one way or another, marine lipids have also been associated with the alleviation of the clinical symptoms of breast cancer (Karmali et al., 1984; Karmali, 1985; Rogers et al., 1986) asthma (Kinsella, 1986), multiple sclerosis (French, 1984), strokes (Lands, 1982) and arthritis (Chalmers et al., 1966; Kremer et al., 1987).

Despite this, large numbers of pink and chum salmon which are fairly high in the omega-3 fatty acids are underutilized. In the last ten years, the amount canned has decreased from 75% to 50% (Bard, 1985), and in 1986 42% was exported (NOAA, 1987). Canned salmon is not a product of high added value. Pink and chum may have a soft texture and a low flavor profile. As a consequence, value off the boat may be only 35 cents per pound, and less in years where the stocks are overly abundant. Similarly, salmon returning to the hatcheries are graded and only those of highest quality are sold as food grade; the balance is sold for fish meal manufacture. Spawned salmonids (that have returned to the hatcheries) generally have sensory defects such as poor flesh color and off flavors. Depending upon the condition of the returning fish and the demand, the prices for spring chinook may range from 23 to 93 cents per pound and for coho, 33 to 92 cents per pound (Bauer, 1987).

PURPOSE

There is a need to develop value-added products from underutilized species; fish trimmings and pieces resulting from processing; and species having sensory defects associated with color and flavor. The objective of this work was to develop both a blended product which used surimi and pink or chum salmon and a product in which pollock frame and trimmings mince were a main ingredient.

APPROACH

Product concepts were developed according to two of five categories established by the Alaska Fisheries Development Foundation. This product research and development was in response to the Prototype Product Development Contest.

> Category 2. Product that combines surimi and pink or chum salmon. A blended seafood product which owes its texture to whole salmon muscle and bind abilities to surimi.

The product concept is one directed toward a market niche, specifically, volume feeding operations, such as, the school lunch program, the military, campus commissaries, and fast food operations. The product, The Klondyke Potato, is a mixture of shredded potato and either pink or chum salmon. Surimi is used as the agent to bind the salmon and potato. This product is stored in the freezer and is readily available for either deep-fat frying or oven baking.

Advantages of this product include:

1. the versatility of the formulation by use of either off-colored salmonids or other underutilized fin fish
2. use of low grade surimi
3. adaptability to volume feeding operations, e.g., application in hospitals and in other institutions
4. nutritious due to content of high quality protein, complex carbohydrate, Vitamin C and omega-3 fatty acids
5. acceptability by virtue of traditional visual form but unusual and delightful sensory attributes.

Category 5. Product in which pollock frame and trimmings mince is the main ingredient.

Four different products, Ketchikan Bisque, Arctic Vichyssoise, Alaska Seafood Chowder and Seafood Chili were formulated. Since such comminuted fish can contain considerable quantities of heme pigment which acts as a pro-oxidant, and amines which can cause strong "fishy" flavors, these are products in which potential off-flavors can be stabilized and/or masked.

Ideally, each product would contain from 30 to 50% seafood. Three products, the Ketchikan Bisque, Arctic Vichyssoise and Alaska Seafood Chowder were dairy-based (non fat milk) and the Seafood Chili had a tomato base. Each of the dairy-based products may contain any one or a combination of the following: potatoes, onions, leeks, celery or green peppers. Spices were used to enhance the flavor. The chili is Texas-style (no beans) and uses onions and spices to enhance the flavor.

Initially, all four products were to be developed. The most favored of the three dairy-based soups (the Ketchikan Bisque, Arctic Vichyssoise and Alaska Seafood Chowder) was determined and further refined for shelf-life stability studies. Only one dairy-based soup and the Seafood Chili were studied for term product stability.

These products were stored in the freezer and readily available for microwave heating. Conceptually, each can be packaged in single serve containers for a fast, convenient meal. This would be ideal for a retail market. Similarly, for volume feeding, these could be packaged in a concentrated, bulk form and diluted as required.

Advantages of this product include:

1. versatility of production due to use of frame minces, small chunks of a variety of finfish and/or shellfish
2. convenience (microwavability) and adaptability to volume feeding operations
3. high quality protein, complex carbohydrate, Vitamin C and omega-3 fatty acids contributing to a nutritious product
4. the use of noncruciferous and nonleguminous vegetables to avoid flatulence, which is important in hospitals and nursing homes
5. as frozen rather than canned products, these offer the significant advantage of a lower sodium content without sacrificing food safety
6. a greater flavor profile since the product does not need to be subjected to the prolonged heat treatment of retorting.

Formulations

Preliminary work with formulations was conducted by Chef Benson. Surimi, at the two per cent level was added as a binder for the Klondyke potato. It did not enhance the cohesiveness of the product and, additionally, resulted in a tacky surface once the product thawed. Based on these observations, it was not added to further formulations. Other attempts were made to use added starches and gums (Crispfilm [0.88%], Pure-Flo [0.88% to 4.25%] and guar gum [0.44%], National Starch Company) to stabilize the potato during thawing; and, thus, more desirable for retail sales. In addition, Crispfilm enhances crispiness of the case hardened surface. None of the different combinations and concentrations of added starches were, however, effective. A combination of binders that was equally as effective involved the addition of potato starch (1.7% of total product composition) and fortified (50% added solids) egg white (ca. 15% of total product composition). The combination of egg white and potato starch is more desirable since it involves the addition of high quality protein (egg white) and appears more favorable from the labelling aspect (ingredients and nutritional value). At this point the Klondyke potato is considered a freezer to oven product and best suited to volume operations.

On May 19, 1988, the preference between the Ketchican Bisque, Arctic Vichyssoise and the Alaska Seafood Chowder was tested. Twenty-two panelists participated and ranked the most preferred and least preferred samples in a consumer test. The results indicated that the Alaska Seafood Chowder was preferred first by 95% of the panelists. It clearly was the favorite variety of the three tested. The Ketchikan Bisque was preferred second by 73% of the panelists while the Arctic Vichyssoise was preferred second by 18%. The Arctic Vichyssoise was liked least of all the samples. It was ranked third by 77% of the panelists. This indicated that the Alaska Seafood Chowder would be scaled up and subjected to storage trials.

In development, it was determined that about 20% pollock was desirable in the chowder. A higher level of seafood might be possible if a different species, such as shellfish, were added. Since the chili was Texas style, a level of about 60% seafood was found very desirable.

On October 3, 1988, large scale quantities (40 liter) of each product were prepared at the OSU Seafoods Laboratory. The objective was to scale up each formulation for pilot plant production and to have sufficient quantities of product for biochemical evaluation and for industry evaluation.

Formulations and Protocol

Alaska Seafood Chowder

A. Product Formulation

Source	%	kg	
Pollock	19.03	7.61	
Water	49.85	14.28	
Water		2.78	(to rehydrate bell peppers)
Water		2.88	(to rehydrate celery)
Non fat dry milk (NFDM)	6.08	2.43	
Onions (fresh)	7.60	3.04	
Flour	5.08	2.03	
Potatoes (dried)	5.05	2.02	
Crisco	5.08	2.03	
	%	(g)	
Bell pepper (dried)	0.54	217.10	
Celery (dried)	0.30	121.60	
Thyme	0.078	31.00	
Clam base	1.27	508.00	

B. Preparation

1. This product will be prepared with frozen Alaska pollock. Pollock will be tempered in the cold room (ca. 5°C) for ca. 16 h prior to being ground. The tempered pollock will be ground with the Autio grinder (Model 601) with a 5 mm die on the day that it is to be used.

2. Product will be prepared with the use of a clam base which eliminates the addition of NaCl and MSG that may be included in an alternate formulation. The lobster base lends a pink color to the final product and may be less desirable from sensory aspects.

3. Add bell pepper and celery to mixing vessel and add 5.66 kg water to rehydrate the vegetables. Allow this mixture to stand at ambient temperature for 30 mins.

4. Peel onions and chop in the Hobart Silent Cutter (Model VCM-40) for ca. 90 sec.

5. To a 77 liter capacity steam jacketed kettle, add 14.28 kg water and bring to a boil. Add the ground fish, onions, bell pepper, celery, thyme and clam base. Bring this mixture to a boil.

6. Blend the crisco and NFDM with a Kitchen Aid mixer for five mins or until a smooth paste develops. Add the paste to the heated mixture and bring to a boil.

7. Add the dehydrated potatoes, discontinue the steam source and allow the mixture to set for 10 mins. In the 10 min period, the potatoes will rehydrate.

8. Cool the mixture and package in 10.3x13x5 cm (ca. 600 g) plastic containers.

9. Cover, freeze overnight (ca. 16 h) at -30°C and vacuum package with the Cryovac vacuum chamber unit (Model 6250-B) at 29" Hg.

Seafood Chili

A. Product Formulation

Source	%	kg
Salmon	59.35	23.75
Onions	11.87	4.75
Tomato Sauce	25.96	10.39
	%	g
Nacl	0.62	247.37
Black pepper	0.19	74.21
Chili powder	1.48	593.70
Garlic powder	0.25	98.94
M.S.G.	0.25	98.94
Cayenne pepper	0.04	14.23

B. Preparation

1. Frozen chum salmon is tempered in the cold room (ca. 5°C) for 48 h and then placed in tap water to thaw. The salmon is hand filleted and skinned. The flesh is ground with an Autio grinder (Model 601) with a 5 mm die on the day that the salmon is to be used.

2. Peel the onions and chop with a Hobart Silent Cutter (Model VCM-40) for ca 90 sec.

3. To a 77 liter capacity steam jacketed kettle, add the tomato sauce, chopped onions and spices. Bring the mixture to a boil.

4. Add the ground fish and return the mixture to a boil. The mixture is boiled for one hour. The mixture is cooled and packaged in 10.3x13x5 cm (ca. 600 g) plastic containers.

4. Cover, freeze overnight (ca. 16 h) in the blast freezer at -30°C and vacuum package with a cryovac vacuum chamber unit (Model 6250-B) at 29" Hg.

Klondyke Potato

A. Product Formulation

Source	%	kg
Potato (dry)	5.17	17.24
Water	34.48	10.34
Crisco	5.17	1.55
Egg White (liquid)	13.79	4.14
Salmon	25.86	7.76
	%	g
Chives	0.054	161.00
White pepper	0.054	161.00
MSG	0.269	81.00
NaCl	0.269	81.00
Egg White (dried)	1.08	323.00
Potato starch	1.72	517.00

B. Preparation

1. Frozen chum salmon is tempered in the cold room (ca. 5°C) for 48 h and then placed in tap water to thaw. The salmon is hand filleted and skinned. The flesh is ground with an Autio grinder with a 5 mm die on the day that the salmon is to be used.

2. To a 77 liter capacity steam jacketed kettle, add the potato, chives, pepper and water. Bring the mixture to a boil and boil for 11 minutes.

3. Blend the liquid and dried egg white with the potato starch. Note: Before adding this mixture into the balance of the product, it must be whipped since settling of the potato starch has occurred.

4. Cool the mixture. Add the Crisco and mix, until blended (ca. 2 to 3 mins) with the Kitchen Aid mixer. After the potato/crisco blend has

reached a temperature of 120°F or 48.9°C, add the egg white/potato starch blend and mix for an additional 3 or 4 mins.

5. Add the salmon, salt and MSG and hand mix to fold the salmon into the base ingredients.

6. Spread the mixture into stainless steel trays (10x45.7x2.5 cm), cover and blast freeze. After frozen (ca. 16 h), saw into sections ca. 2.5x2.5x10 cm and package in 10.3x13x5 cm (ca. 600 g) plastic containers. Vacuum package with the cryovac vacuum chamber unit (Model 6250-B) at 29" Hg.

Biochemical Materials and Methods

Proximate Composition

Proximate composition (moisture, protein, fat and ash) for each product was determined according to AOAC methodology (1984). Carbohydrate was determined by difference.

Caloric Content

Total caloric content was determined by multiplying the protein and carbohydrate by four calories per gram and the fat by nine calories per gram. Total caloric content is based on an eight ounce serving for the chili and the chowder and a four ounce serving for the Klondyke potato.

Sodium Content

Sodium content was determined by Quantab Chloride titration strips [Environmental Test Systems, Inc., Elkhart, IN), (AOAC, 1984)]. The titration ranges were 60 to 480 ppm and 300 to 3,600 ppm.

Lipid Classes

Thin layer chromatography was used to separate the lipid classes. Lipids were isolated from each sample by methods described by Bligh and Dyer (1959). A five microliter aliquot was spotted onto Silica Gel G thin layer chromatograpy plates (J.T. Baker, Phillipsburg, NJ) and developed in a solvent system containing chloroform: methanol: water (65: 24: 4). After migration of the lipid classes was complete, the plates were developed in an iodine (Sigma, St. Louis, MO) tank. The sample spots corresponding with the purified standards, phosphtidylethanolamine and phosphatidylcholine (Avanti Polar Lipids, Pelham, AL) were scraped from the plates and weighed.

Fatty Acid Analysis

Fatty acid methyl esters were derivatized from the previously extracted lipid treated with boron triflouride (AOAC, 1984). The fatty acid methyl esters were separated with a Hewlett Packard gas chromatograph (Model 5890). Methyl esters were identified by retention times of standards (Supelco, Bellefonte, PA).

Water Soluble Vitamins

Methods used to extract and quantitate the water soluble vitamins were modifications of Ashoor et al. (1985) for riboflavin and Skurray (1981) for niacin and thiamin.

Seventy five grams of each sample was homogenized with 75 ml 0.5N H_2SO_4. Aliquots (15 g) were weighed into 25 ml screw top Corex centrifuge tubes then mixed thoroughly with 2.5 ml 0.5N H_2SO_4 and 7.5 ml distilled water and heated in a boiling water bath for 30 minutes. After cooling, the samples were centrifuged at 7000 rpm for 30 minutes. The samples were filtered through Whatman No. 40 filter paper. Samples were stored in screw top shell vials. The vials were flushed with nitrogen and wrapped with foil and held frozen at -20°C until analyzed.

All samples were analyzed by high pressure liquid chromatography. The column was an Alltech Lichromsorb RP-18 10 u 250 x 4.6 mm column (Alltech Associates, Deerfield, IL). The detector was an ISCO UA-4 absorbance monitor (ISCO, Lincoln, NE) with a type 9 optical unit with 254 nm filter. The integrator was an Apple IIe computer; Chromatochart software and an AnaLabs card from Interactive Microware were used.

Fat Soluble Vitamins

The fat soluble vitamins (A and D) were sent to an independent Laboratory for evaluation (Columbia Laboratories, Inc., Corbett, OR). With consideration to the time needed to develop methods for determination of the water soluble vitamins, analysis of the fat soluble vitamins would not have been possible.

Product Evaluation

Samples of the three products were sent to Innovative Foods (South San Francisco, CA) in early January, 1989. A company representative, Mr. Ed Hirschberg, indicated an interest in developing new food products involving the use of seafoods. Their interest was to market both a seafood and potato or seafood and rice entree, and either a dried or concentrated seafood entree. The Klondyke Potato would meet their first category and the Alaska Chili and Seafood Chowder could be either concentrated or dried. Mr. Hirschberg has indicated that he will share his observations of these products.

FINDINGS

The Alaska Seafood Chowder contained 73.31% moisture, 7.22% protein, 1.59% ash, 4.44% fat and 13.44% carbohydrate. Since this is a concentrate, the total energy level would be 140 calories per eight ounce serving if diluted with water (1:1) and would contain 459 mg of sodium chloride. There was no detectable level of Vitamin A (< 75 I.U. per 100 grams of sample) in this product and interference, presumably from the spices, prevented detection of Vitamin D. There were 0.048 mg riboflavin and 1.333 mg niacin per 100 g product. The minimum detectable levels of riboflavin and niacin were 4 and 2 ug per ml, respectively. Thiamin was detectable but no accurate quantitation was permissible since its peak was masked in the shoulder of interfering compounds.

The Seafood Chili contained 77.21% moisture, 15.87% protein, 2.23% ash, 1.70% fat and 2.99% carbohydrate. Since this product would be thawed and heated without any dilution, the total energy level would be 207 calories per eight ounce serving and would contain 1471 mg of sodium chloride. There is 1199 I.U. of Vitamin A activity per eight ounce serving but no detectable level of Vitamin D in this product due to interference, presumably from the spices. There were 0.042 mg of riboflavin and 0.650 mg niacin per 100 g and thiamin was masked.

The Klondyke Potato contained 68.16% moisture, 9.54% protein, 0.74% ash, 5.39% fat and 16.17% carbohydrate. This product had a total energy level of 173 calories per four ounce serving and would contain 88 mg of sodium chloride. There was no detectable level of Vitamin A (< 75 I.U. per 100 grams of sample) and Vitamin D could not be determined due to interference. There were 0.029 mg of riboflavin and 3.361 mg niacin per 100 g and thiamin was not quantifiable.

Of the products tested, the Seafood Chili would provide 20 to 25% of the Recommended Dietary Allowance of Vitamin A and the Klondyke potato would supply roughly 20% of niacin. The protein content (16%) of the Chili would contribute 30 to 45% of the RDA for the 7 to 18 year old human. The sodium content of the Chili was high (1471 mg per eight ounce serving) and the method for determination may be suspect. Since the Quantab chloride titrator was used, chloride and not sodium was determined. Although this is an AOAC method for NaCl determination, there may have been interference from the spices or there may have been a high chloride but not necessarily high sodium content.

Product stability has been determined by analysis of lipid classes by thin layer chromatography and quantitation of the degradation products of phospholipids. There was no significant loss of either phosphtidylethanolamine or phosphatidylcholine during the three month storage period. Similarly, there was no significant accumulation of either lysophosphatidylethanolamine or lysophosphatidylcholine during the storage period. The phospholipids are generally the most unstable of the lipid classes and measures of these sensitive compounds provide a reliable index of product quality.

Methyl esters of the extracted fatty acids were prepared, however, a resistor in the integrator shorted and burned the insulation of the surrounding circuit board. This prevented operation of the gas chromatograph. As soon as the integrator is repaired, the analysis will be completed and the results of the fatty acid determinations forwarded to AFDF. It would be anticipated that the level of omega-3 fatty acids would be quite low in the Alaska Seafood Chowder since pollock is a lean species (ca. one per cent fat) and the bulk of the fat in this formulation is crisco, a saturated fat. The fat content of the chili would consist largely of salmon oil and roughly 15 to 20% would be omega-3; 40 to 45%, the monounsaturated fatty acids and 20 to 25%, the polyunsaturated fatty acids. Fatty acid content of the Klondyke Potato would be predominantly saturated and attributed to the Crisco.

Special problems encountered during this project included lengthy contract negotiations and a shortage of laboratory personnel due, primarily to sick leave. The net results were the reduced term of the storage trials and delays in developing methodology for the vitamin assays. Since the gas chromatograph had been installed for less than one year, its malfunction was totally unanticipated.

Limitations in detection caused by background interference in the Vitamin D and thiamin assays also presented problems. Since the Vitamin D assay was conducted by an independent laboratory, it is plausible that few measures were taken to overcome obstacles. This assay is, however, tedious, involves numerous transfers and is prone to error. Thiamin was detectable as demonstrated with standard purified solutions, however, in a combination food product its concentration peak became a shoulder of larger interfering compounds with similar retention times.

EVALUATION

The original project goals and objectives were to develop new food products from pollock minces and chum salmon. Although these products were formulated from specific fish species, there is every reason to believe that other species could also be used. Originally, one potato product, one chili and three chowders were proposed; of the three chowders, preference for the most desirable formulation was determined.

Pilot plant (40 l) quantities of each product were prepared in order to determine product stability during frozen storage.

Goals were measurable in terms of the products that were developed and monitoring their stability. Ostensibly, vacuum packaging contributed to stability of the lipids. In terms of commercial production, all products could be packaged under vacuum to avoid addition of antioxidants and their presence on the list of ingredients.

Modifications made to project goals involved the length of the storage trial due to protracted contract negotiations and a shortage of laboratory personnel. Malfunction of relatively new laboratory equipment was totally unanticipated. Despite the obstacles, three outstanding foods were developed. The Chili was originally proposed to be made with pollock mince. Chef Benson, however, made convincing arguments for the substitution of salmon for pollock. The fatty acid profile would be more desirable, in terms of health claims. Although this Chili is Texas style, it might also be used as the filling for a hot sandwich.

The goals included the development of new food products with the formulations to include significant quantities of either pollock mince or salmonids of low value. These goals were obtained. Chef Benson has been working with a seafood processor to market a canned chili (not frozen as described herein), however, to promote the use of under-valued salmonids in a large quantity of the formulation will indirectly meet the goals. Although word of Innovative Foods´ evaluation is pending, successful introduction of new food products includes least cost formulation, desirablility and marketing. By analysis of the lipid fractions, these products were stable over a three month period. A longer, six month storage study to include sensory evaluation would have been highly desirable.

Specific information relating to the nutritive value and storage stability of these food products has been obtained. As negotiated, formulations have been delivered. It is, however, unfortunate that a longer storage trial could not have been conducted.

All three products that were developed meet the needs of the fishing industry. If commercially marketed, the Seafood Chili and the Klondyke Potato would increase the demand and provide a new outlet for chum salmon. The Seafood Chowder would provide an outlet for pollock minces. More importantly formulations of these products could involve other underutilized and/or species of low economic value. In particular, the Chili and the Seafood Chowder are fully cooked products; biochemical mechanisms, such as the trimethylamine oxidase system, are inactivated by heating. Additionally, because of the low heme content, there is no significant (and undesirable) flavor change mediated by myoglobin. The rapid heating of the comminuted fish in these systems might lead to enhanced use of species with heat stable proteases such as arrowtooth flounder and Pacific whiting. Fillets from these species may undergo rapid hydrolysis during conventional cooking methods.

The fishing industry also benefitted by this research and product development. Sharing results with the commercial sector enhances the potential for further development and market testing. Methodology developed during the course of this project will be an asset to future investigation on the nutrient content of seafoods. Industry has benefitted to a great extent by this project since the research and development cost to move a concept into market testing ranges from two to four million dollars.

The fishing industry should benefit by this research since this work has involved a different use for chum salmon and pollock mince in value-added products. Although the species studied may not be used on a continual basis, an alternative for their use has been defined. In addition, the total budget of this project and the results provide a major contribution to the ground work normally assumed by the food industry. The direct nature of the benefits, again, relates to the small investment by federal funding which would have been a major investment by the private sector. Federal assistance was required so that these results could be available to the public.

CONCLUSIONS

This research has demonstrated that stable products can be developed from salmonids of low economic value and by-products (minces) of seafood processing operations. These results are not necessarily restricted to the species tested. Since the Chili and the Chowder were fully cooked products, application of other under-valued species may be possible. New information has been provided in terms of product concept and storage stability of the developed products. Further work to be done would include sensory evaluation studies in conjunction with storage trials and investigation of formulations with other underutilized and/or species whose problematic nature (heat stable proteases) limits current use. Product development related to seafoods is frequently discouraged since species availability is seasonal and prices may fluctuate. This research presents the framework for further development and market testing by the industry.

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