NOAA Technical Memorandum NMFS-NWFSC-21

Frozen Storage Stability of Fillets, Mince, and Mixed Blocks Prepared from Unfrozen and Previously Frozen Pink Salmon *(Oncorhynchus gorbuscha)*

March 1995

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

NOAA Technical Memorandum NMFS

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This document should be cited as follows:

Reppond, K. D., and J. K. Babbitt. 1995. Frozen storage stability of fillets, mince, and mixed blocks prepared from unfrozen and previously frozen pink salmon *(Oncorhynchus gorbuscha).* U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-21, 57 p.

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March 1995

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ABSTRACT

Pink salmon (*Oncorhynchus gorbuscha*) is the most abundant species of salmon in Alaska and is mostly processed by canning. Processing of pink salmon into other forms will be necessary to maintain profitability. The objectives of this experiment were to investigate the processing of pink salmon into boneless fillets and mince and to determine changes in quality during frozen storage.

Blocks containing fillets, mechanically deboned mince, or mixtures of fillets and mince were made from unfrozen fish and stored at -18°C. Blocks were also made from salmon that had been stored as headed and gutted (H&G) fish for 3, 6, or 12 months. The blocks were subjected to chemical and sensory analysis as well as thaw drip and mechanical textural testing.

Minced pink salmon alone or in combination with boneless fillets made acceptable product forms. Use of minced salmon increased the yield of edible product by one-third. These product forms were also produced from previously frozen fish, although thaw drip increased as the total time in frozen storage approached 12 months. Desirability scores tended to be higher for blocks made from unfrozen fish than for blocks made from previously frozen fish and higher for blocks with 0% or 25% mince than for blocks with 50% or 100% mince. Loss of quality during frozen storage as determined by sensory analysis was generally lower for blocks of fillets and for blocks made from unfrozen fish than for blocks made from frozen fish. One exception was

chewiness, which tended to increase more for blocks made from unfrozen fish than for blocks made from frozen fish. Changes in color and rancidity values were small. Mechanical textural analysis agreed with the trends seen in the sensory results.

Recovery of edible flesh from pink salmon by use of mechanical flesh separators is technically feasible and could boost yields from landed product. Acceptable product forms using minced pink salmon by itself or in combination with boneless fillets is possible. Products made from previously frozen H&G fish were somewhat less desirable than products made from unfrozen fish but were still acceptable.

CONTENTS

INTRODUCTION

Pink salmon (*Oncorhynchus gorbuscha*) are the most abundant species of salmon in Alaskan waters with commercial catches ranging 84,000 to 158,000 tons from 1988 to 1991 (Pacific Associates 1994). Although pink salmon are the least expensive species of salmon to purchase, their cost is higher than fish such as Alaska pollock, so recovery of edible flesh must be maximized to maintain profitability. Most of the pink salmon catch is canned (Pacific Associates 1994) whereas other species of salmon are mostly sold fresh or in the form of frozen portions, fillets, or steaks at premium prices.

Pink salmon are usually too small to market as steaks and the texture of the flesh is softer than that of other species of salmon, which makes them more difficult to fillet. Use of mechanical deboning may provide pink salmon flesh that could be processed into marketable, convenient forms on an economical basis. Accordingly, the objectives of this experiment were to determine the yield at various steps in the processing of pink salmon into boneless fillets or mince, to determine changes in quality during frozen storage of product forms made from fillets and/or mince, and to determine if frozen, headed and gutted, pink salmon can be reprocessed into these forms.

MATERIALS AND METHODS

Materials

Pink salmon were caught by a commercial seiner in the vicinity of Kodiak Island on 28 July 1986 and transported in slush ice to a processor in the city of Kodiak, Alaska. The average weight of the fish was 1.6 kg. The next day, about 1,000 kg of iced salmon were transferred to the National Marine Fisheries Service (NMFS) Utilization Research (UR) Division pilot plant facilities in Kodiak where heads and internal organs were removed by hand. Collars were left on the fish. Most of the headed and gutted (H&G) fish were frozen either in a plate freezer for 6-12 hours at -40°C or in an air blast freezer for 16 hours at 0°C, glazed in fresh water, packaged in 2.0-mm polyethylene sleeves, and placed in a master carton lined with a polyethylene bag. The remaining unfrozen H&G fish were re-iced.

The next day, the unfrozen H&G fish were trimmed to remove the backbone, and then fins, collars, and rib bones were removed. The fish were mechanically skinned using a Baader[1] Model 50 skinner. Pin bones were removed by making parallel cuts the length of each fillet (Fig. 1). Boneless, skinless fillets were placed in polyethylene bags and iced overnight. Trimmings from removal of pin and rib bones were similarly treated. The next day, trimmings and some of the fillets were minced using a Baader

[1] Use of trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Model 694 deboner equipped with a 5-mm drum. Blocks containing 0 (fillets), 25, 50, or 100% mince were prepared using the method of Babbitt et al. (1987) and frozen at -40°C in the plate freezer. The frozen blocks were placed in master cartons and stored at -18°C as were the H&G fish. Several of the fillet blocks were stored at -34°C to serve as a control sample for the sensory evaluations. Yield data were collected at each stage of the sample preparation. Yields at various steps in commercial processing of salmon were obtained at the processor's plant on one lot of 10 fish. In the commercial operation, the viscera were removed manually, heads and collars were removed by a Baader Model 421, filleting was done with a Baader Model 184, skins were removed with a Baader Model 50, and trimming was done by hand. These blocks, made from unfrozen H&G fish, are referred to as once-frozen blocks in the discussion of results.

At 3, 6, and 12 months of frozen storage, H&G fish were thawed overnight at room temperature (60-65°C) prior to being manually filleted, skinned, and trimmed. The fillets and minced flesh were immediately processed into the various block forms previously described and refrozen. These twice-frozen blocks are referred to as reprocessed blocks in the discussion of results.

Thus, our samples consisted of H&G pink salmon that were made into fillet blocks (0% mince) and blocks containing 25, 50, and 100% mince. The mince was made from pink salmon fillets and trimmings of pin and rib bones. These blocks were then frozen. One test group used fresh H&G fish known as once-frozen blocks.

The second test group used frozen H&G fish that had been in storage for 3, 6, or 12 months. These twice-frozen blocks are the reprocessed blocks.

Chemical, Color Analysis, and Thaw Drip

Material for analysis was sawed from blocks, tempered overnight at 4°C, and passed through a 6-mm plate on an Oster grinder. The samples were analyzed for protein, total solids (Reppond et al. 1985), lipid (Horowitz 1980), and malonahldehyde (MAH) content (Lemon 1975). Color was analyzed by measuring Hunter L*, a*, and b* using a Minolta Chroma II reflectance colorimeter. Hunter L* denotes lightness with 0 being black and 100 being white, while a* denotes a red hue when positive or a green hue when negative, and b* denotes a yellow hue when positive and a blue hue when negative.

To determine thaw drip, an unthawed portion of the same size as that used for sensory analysis was weighed and placed in a perforated plastic bag which was placed inside an outer bag weighted to insure submersion. The samples were immersed in a 15°C bath for 40 min, and the thawed portion weighed. Thaw drip was carried out in duplicate and calculated as the percent original weight lost by thawing. Mineral composition was determined in duplicate using the method of Teeny et al. (1984) by personnel from the UR Division in Seattle, Washington.

Sensory Evaluation

We used the sample preparation procedure of Reppond et al. (1985). Portions (3" x 1.75" x 0.5") were sawed from the blocks, vacuumed bagged, and placed in frozen storage for no more than 1 week prior to being cooked by steam for 15 min. The sensory panel consisted of 10 judges selected from NMFS staff experienced in sensory analysis of seafood. Panelist were trained to determine the quality characteristics of salmon and changes that occur during frozen storage and were asked to compare various properties of experimental samples to that of a control sample of 100% fillet which had been held at -34°C. Because little or no change in quality should occur at that temperature, a control sample was used to enhance the judge's ability to detect changes due to frozen storage.

We used 7-point scales to evaluate color, flavor, chewiness, moistness, and desirability. The control sample was defined as having a score of 4 for color, chewiness, and moistness. A score greater than 4 indicated the experimental sample was rated as lighter in color, more tender, or more moist than the control. Scores lower than 4 indicated that the sample was darker, tougher, or drier than the control.

The control sample was defined as having a flavor score of 7, which was excellent fresh salmon flavor. A sample ballot is included as an appendix. Flavor ratings of 6 to 1 were defined as good but not intense fresh flavor, only mildly pleasant, trace of bad (rancid), mildly bad, strongly bad, and intensely bad, respectively. Thus, the flavor scale was partly hedonic rather than purely intensity in nature.

On the desirability scale, 7 was defined as like extremely; 6, like moderately; 5, like slightly; 4, neutral; 3, dislike slightly; 2, dislike moderately; 1, dislike extremely. A 5-point categorical scale was used to rate texture: 5, fibrous; 4, grainy or mealy; 3, flaky and firm; 2, soft; 1, mushy. Panelists were allowed to rate the texture and desirability of control samples along with the experimental samples.

No more than 4 samples were served at a seating of the panel so it was necessary to determine if grouping of samples affected the sensory scores. At 3 months of frozen storage, each block was tested twice. At the first seating of the panel, the judges were served fillet (0% mince) and 100% mince portions from once-frozen and reprocessed blocks. The next day, portions with 25% or 50% mince were served. These two seatings formed a grouping of the samples that emphasized the effect of reprocessing.

One week later, the panel was served portions from the once-frozen blocks containing 0 (fillet), 25, 50, or 100% mince one day and the analogous samples from the reprocessed blocks the next day. The second grouping therefore contrasted block form or the effect of mince.

An analysis of variance (ANOVA) treatment of the data indicated no significant interaction between the grouping effect and other experimental treatments. A lack of interaction meant that there was no significant effect with respect to which samples were served together. Furthermore, the mean panel scores were the same except for moistness scores. The scores for the 3-month samples were pooled. At most seatings, the panel was served portions with identical frozen storage histories but with different amounts of mince, thus contrasting block form.

Mechanical Testing of Texture

Mechanical evaluation of the texture of cooked portions was conducted by Dr. John French and Eileen Brown of the University of Alaska Fishery and Industrial Technology Center. Portions used for mechanical texture analysis were the same size and were cooked in the same manner as portions used in the sensory analysis. Portions were cooled to room temperature prior to testing with an Instron Universal testing machine, model 1000, equipped with a 1 cm diameter cylindrical probe and a 5-kg load transducer. The crosshead speed was 20 mm/min and each of the three portions was tested three or four times. The shape of the curve in most cases did not allow the determination of stress or strain at failure. An elasticity modulus, E, was calculated using the equation

$$E = (M*L)/A$$

where M is the slope of the linear portion of the stress/strain curve, L is the thickness of the portion, and A is the cross sectional area of the probe (Bourne 1982).

Statistical Treatment of Data

Thaw drip, Hunter color, Instron, and sensory evaluation data other than texture scores were subjected to ANOVA at each period of frozen storage. If a treatment variable affected results, a series of one-way ANOVAs were performed to determine which means were different according to the least significant difference test (Sokal and Rohlf 1969). Because the texture rating was categorical rather than an intensity scale, Chi-square analysis was more appropriate (Sokal and Rohlf 1969). All calculations were performed using the Statistical Package for Social Sciences computer programs (Nie 1975).

RESULTS AND DISCUSSION

Yield

The recoveries at each step of processing were similar whether mechanical or manual methods were used (Table 1). For manually filleted fish, the yield of boneless fillet and mince based on whole fish was 33.3% and 11.0%, respectively. Recovery of a boneless mince thus contributed significantly to total yield. Roughly 90% of the trimmings were recovered as minced flesh. A larger sample of fish in an accompanying experiment had a fillet to mince yield ratio of 2.2:1. Yield is likely to vary considerably depending upon the quality of the fish and the efficiency of mechanical and manual processing. Manually removing pin bones from fillets was more difficult with pink salmon than with walleye pollock.

Chemical Analysis

Minced pink salmon trimmings were slightly lower in protein and higher in lipid content than the boneless fillet (Table 2). Moisture and ash contents were about the same. Mince was higher in calcium and sodium but lower in iron, potassium, and phosphorus than fillets. The higher calcium content may have been caused by addition of bone. The nutritional significance of these differences may be meaningful only in the case of calcium and iron, however.

After 1 month of frozen storage, malonaldehyde content ranged from 1.30 to 1.60 mg/100 g, indicating little rancidity (Table 3). After 3 months, the results were similar with the reprocessed blocks having lower values than the once-frozen blocks. This may have been caused by unintentional deep skinning of previously frozen fish. The tissue just under the skin of pink salmon has a high fat (lipid) content and should be more susceptible to oxidative rancidity. Leaving this fatty layer on the fillet was much easier with fish that had not been previously frozen. However, lipid content was not affected by reprocessing (data not shown). After 6 months, the malonaldehyde content of the samples was unchanged and after 12 months appeared to have decreased in some cases. These apparent decreases may be the result of variability within the blocks or the reaction of malonaldehyde with other components in the flesh. More importantly, although the chemical test for rancidity indicated little problem, these samples were ground before analysis so any rancidity that occurred on the surface of a block would have been diluted.

Thaw Drip

Addition of mince did not significantly affect thaw drip according to a series of ANOVAs of the data at each period of frozen storage (Tables 4 and 5). Frozen storage as H&G fish prior to reprocessing into blocks significantly increased thaw drip at 6 and 12 months and but not at 3 months. Thawing the fish and refreezing as blocks of fillets or mince evidently damaged the tissue. The thaw drip of reprocessed samples at 12 months may prove too high for processors unless some additive to retard drip is used. The thaw drip of blocks prepared from unfrozen fish was less than 6% throughout the experiment. At 12 months, the interaction between time as H&G fish and block form was significant. A series of one-way ANOVAs for each block form revealed that time as frozen H&G fish affected drip for the fillet and 100% mince blocks but not for either of the mixed blocks. While this accounted for the statistical significance of the interaction term, no explanation for the cause of this observation was evident.

Hunter Color

The Hunter L* value was not affected by addition of mince at 1 month of frozen storage but increased at 3, 6, and 12 months (Tables 5 and 6). A higher L* value indicates that the hue was lighter. Frozen storage as H&G fish prior to being made into blocks did not significantly affect L* values at 3 or 6 months but did at 12 months. At 12 months of frozen storage, the blocks made at 3 and 6 months tended to have lower L* values than the blocks from unfrozen fish or fish frozen for 12 months. The only significant interaction between reprocessing and block form occurred among the 6 month samples (Table 5). For those samples, the 25% mince once-frozen block had a lower L* than corresponding blocks made from fish reprocessed at 3 or 6 months. In contrast, among the 100% mince blocks, the once-frozen blocks had the highest L* value. Other than natural variability in the samples, no reason was evident to explain this difference.

The Hunter a* value is a measure of how much red hue is in the color of a sample (the higher the a* value, the redder the sample). Addition of mince did not significantly affect the a* values at any given period of frozen storage (Tables 5 and 6). At 3 months frozen storage, reprocessing did not affect a* values, but it did at 6 months. The blocks from fish reprocessed at 6 months tended to have higher a* values (were more red) than once-frozen blocks or fish reprocessed at 3 months. At 12 months, reprocessing affected a* values but in a manner that varied to some degree with block form. Some of the differences between samples may have been caused by the natural variation in color of the samples.

The Hunter b* values were not affected by addition of mince at 1 month but tended to increase at 3, 6, and 12 months indicating a more yellow hue. This may reflect the greater susceptibility of minced flesh to changes during frozen storage. Reprocessing did not affect b* values at 3 or 12 months but, at 6 months frozen storage, the blocks made at 3 months tended to have lower b* values than the other blocks. As with the Hunter a* values, at least some of the differences between samples may be due to the inherent variability of the flesh of the fish.

Sensory Analysis

One Month

Sensory scores (Table 7) at 1 month of frozen storage indicated that addition of mince did not significantly affect color, chewiness, or moistness scores but did affect flavor and desirability scores (Table 8). Addition of mince decreased the intensity of fresh salmon flavor but no off flavor was detected. Addition of mince significantly (Chi square G = 19.455, P = 0.004, df = 6) affected the distribution of texture scores causing an increase in grainy texture (Table 9). The samples with 50% or 100% mince had significantly lower desirability scores but all samples were of acceptable quality.

Three Months

Color scores were not significantly affected by addition of mince but were affected by reprocessing as portions from once-frozen blocks fish tended to have lighter color than portions from reprocessed H&G fish (Tables 8 and 10). Flavor scores were not significantly affected by addition of mince but were affected by reprocessing as portions from once-frozen blocks tended to have more fresh salmon flavor.

Addition of mince did not significantly affect chewiness scores (Tables 8 and 10) but reprocessing did. Portions from reprocessed H&G fish were rated more chewy than portions from once-frozen blocks. The interaction for chewiness scores was significant because addition of mince made portions from once-frozen blocks chewier but did not affect portions made from reprocessed blocks since reprocessing itself had already toughened the flesh to some degree.

Moistness scores were significantly affected by addition of mince as increased mince was associated with increased dryness (Tables 8 and 10). The effect of reprocessing on moistness was not significant. Texture (Table 9) became more grainy with addition of mince ($G = 59.381$, $P < 0.001$, $df = 9$) but was not affected by reprocessing ($G = 6.723$, $P = 0.081$, $df = 3$). Desirability scores were lower for samples with added mince and those made from reprocessed H&G fish rather than unfrozen fish (Tables 8 and 10). However, all samples were of acceptable quality.

Six Months

Color scores of portions from once-frozen blocks were usually higher indicating lighter color than portions from reprocessed blocks (Tables 11 and 12). Addition of mince did not affect color scores (Table 12). Flavor scores were generally lowered by addition of mince but were not affected by reprocessing (Tables 11 and 12). No sample had a mean flavor score lower than 4.2 which indicated little problem with rancidity.

Addition of mince increased chewiness of portions from the once-frozen blocks but not from reprocessed blocks (Tables 11 and 12). Reprocessing did not increase chewiness of portions except for blocks of fillets ($F = 6.18$, $P = 0.006$). Therefore, the overall effects of addition of mince and reprocessing were not significant, but the interaction between block form and reprocessing was significant (Table 12).

Moistness scores were not affected either by addition of mince or reprocessing (Tables 11 and 12). Addition of mince increased graininess ($G = 53.549$, $P < 0.001$, $df = 9$) but reprocessing did not affect the distribution of texture scores ($G = 6.474$, $P = 0.372$, $df = 6$).

Mean desirability scores for the samples prepared from unfrozen fish decreased by more than 2 points with the addition of mince (Tables 11 and 12). For the samples prepared at 3 months and held an additional 3 months as blocks, a smaller decrease was seen. For the samples from blocks reprocessed at

6 months, the block with 25% mince scored higher than the other samples. Separate ANOVAs performed on data from each block form revealed that reprocessing affected desirability for the blocks with 0% mince (fillets) but not for the blocks with 25, 50, or 100% mince (Table 11). This difference explains the significant interaction between block form and reprocessing. Only two samples had mean scores less than 4.0, so the overall quality was still acceptable for all samples.

Twelve Months

At 12 months of frozen storage, minor surface discoloration due to oxidation was seen in some of the blocks made at 0, 3, or 6 months. Usually, discoloration was seen in blocks from which samples had been taken earlier in the experiment and was probably the result of loss of packaging integrity. The samples were not trimmed to remove discolored material in order to realistically simulate possible commercial conditions where loss of packaging integrity could happen.

Mean color scores were lower (darker) for the 100% mince blocks than for the blocks containing fillets (Tables 13 and 14). The effect of mince on color scores was most obvious for the samples reprocessed at 6 or 12 months. Increased frozen storage as H&G fish prior to reprocessing into blocks also tended to decrease color scores, especially for the 100% mince blocks. Flavor scores at 12 months were affected by the amount of mince but not by storage time as H&G fish (Tables 13 and 14). The effect of mince on flavor was most evident for the blocks reprocessed at 6 and 12 months. In general, the flavor scores indicated little or no problem with oxidative rancidity.

Storage as H&G fish prior to being made into blocks did not affect chewiness scores but addition of mince made portions somewhat tougher, especially for once-frozen blocks (Tables 13 and 14). Although chewiness scores for reprocessed blocks did not appear to be as sensitive to addition of mince (Table 13), the interaction term was not significant (Table 14). Moistness scores followed the pattern of the chewiness scores with the fillet block from unfrozen fish rated as most moist and the minced samples being a little drier (Tables 13 and 14).

Chi-square analysis of texture scores (Table 9) at 12 months indicated that addition of mince continued to significantly affect results ($G = 72.119$, $P < 0.001$, $df = 6$) as blocks with 0% (fillets) or 25% mince generally had a flaky texture but some fibrousness was detected. Blocks with 50% or 100% mince usually had a grainy texture. Frozen storage as H&G fish prior to reprocessing affected the texture of blocks with 50% mince ($G = 13.244$, $P = 0.039$, $df = 6$) but not for the other blocks. For the blocks with 50% mince, the texture was usually rated grainy except for the block reprocessed at 6 months which was rated flaky. In general, the effect of reprocessing on texture scores was not significant ($G = 3.972$, $P = 0.681$, $df = 6$). Desirability scores were not affected by reprocessing but addition of mince decreased scores (Tables 13 and 14).

Correlations

Mean desirability scores were significantly ($P < 0.01$, df = 1,38) correlated with mean flavor, chewiness, and moistness scores with correlation coefficients, r = 0.967, 0.753, and 0.876, respectively. Coefficients with mean color and texture scores (r = 0.460 and -0.587) were lower but still significant ($P < 0.01$, df = 1,38). Evidently, higher desirability was associated with lighter color, more fresh flavor, more tender and flaky texture, and increased moistness. Correlation coefficients between mean thaw drip values and mean chewiness, moistness, and desirability scores were -0.487, -0.449 and -0.638, respectively, and all were significant ($P < 0.01$, df = 1,38). Increased thaw drip was therefore associated with a tougher, drier, and less desirable sample. The only significant correlation between mean color score of cooked portions and objective measurement of the color of raw portions was with the L^* value, r = -0.393, ($P < 0.05$). A negative correlation was surprising in that higher L^* values indicate whiter samples and presumably higher color score of cooked samples.

Effects of Frozen Storage

To determine the effects of frozen storage on sensory properties by ANOVA techniques, we used only the data on blocks that were either made from unfrozen fish (stored as blocks) or reprocessed blocks examined immediately after being formed (stored as H&G fish). Scores for control samples were similarly excluded. The results of the three-way ANOVA indicated that color of the reprocessed blocks was rated slightly darker than blocks made from unfrozen fish (Tables 15 and 16). Change in color with time in frozen storage was more complex in that color scores from unfrozen fish did not change but scores for reprocessed blocks did (Table 17). This difference explained the significance of the Repro x Stime interaction term (Table 16). Evidently, the color of pink salmon was better protected in the form of a block than in the form of H&G fish. The panel detected no difference in color due to addition of mince.

Flavor scores were affected by all experimental treatments, but no interaction term was significant (Tables 15 and 16). Addition of mince tended to lower flavor scores, especially at 6 and 12 months frozen storage. Once-frozen blocks tended to have higher flavor scores than reprocessed blocks. Flavor scores decreased with storage time for blocks made from either unfrozen or reprocessed fish, but only one sample had a mean value lower than 4.0 indicating that, in general, the samples were acceptable.

Chewiness scores (Table 15) were increased by addition of mince, reprocessing, and frozen storage (Table 16). The Repro x Form interaction term was significant because addition of mince resulted in tougher portions for once-frozen blocks but not for reprocessed blocks (Table 17).

Moistness scores (Table 15) were significantly affected by block form and storage time (Table 16). The portions were rated drier with increased amounts of mince and with increased storage time. The effect of reprocessing on moistness scores was not significant.

Addition of mince significantly affected texture scores (G = 130.65, P = 0.000, df = 9). The texture of blocks with 0% (fillets) or 25% mince was usually rated as flaky, while 50% and 100% mince blocks were rated as grainy (Table 18). Most judges indicated that the grainy texture was not unpleasant, just different from the fillet. The effect of reprocessing on texture scores was not significant (G = 7.532, P = 0.057, df = 3). Time of frozen storage did not affect texture scores for the blocks with 0, 50, or 100% mince but did for the 25% blocks (G = 15.516, P = 0.004, df = 4) where increased incidence of fibrous texture ratings occurred between 6 and 12 months. The reason for this difference is not apparent.

With the exception of the 100% mince block made from reprocessed H&G fish at 12 months, all samples had desirability scores of 3.5 or greater, indicating that their quality was still acceptable. Desirability scores (Table 15) indicated that portions from reprocessed blocks (H&G) were not as desirable as portions from once-frozen blocks (Table 16). Addition of more than 25% mince tended to lower desirability scores.

Determining a cause of the significant three-way interaction (Repro x Form x Form, Table 16) for desirability scores is best done by examining the Form x Stime interaction terms of samples stored as blocks or as H&G fish (Table 17). While the Form x Stime interaction was significant for reprocessed H&G samples, it was not significant for samples stored as blocks. This difference in behavior thus explains why the Repro x Form x Form interaction of Table 16 is significant. The significant interaction between storage time and block form for reprocessed blocks was probably caused by block-form affecting desirability scores at 6 and 12 months but not at 3 months. Thus, the decrease in desirability due to addition of mince was smallest for material with frozen storage of 3 months or less or for material made from unfrozen fish. The decrease in desireability was greatest for material with total frozen storage time of 6 months or more or for material made from reprocessed H&G fish.

Mechanical Texture Test

At 1 month of frozen storage, the elasticity modulus (E) for the block with no mince was lower than for the blocks with added mince indicating addition of mince made the portions tougher (Table 19). This is in agreement with the sensory results. For blocks prepared from H&G fish after 3 months of frozen storage, the results were similar, as the E values for 0% (fillet) and 25% mince samples were less than the E values of the 50% and 100% mince samples.

At 6 months of frozen storage, both addition of mince and reprocessing affected E values (Tables 19 and 20). As at 1 and

3 months, addition of mince tended to increase E values. The portions from blocks that had been made from H&G fish reprocessed after 3 months frozen storage tended to be tougher than the other comparative samples, a trend not clearly seen in the sensory data. The interaction between block form and reprocessing was significant because no change was seen with addition of mince in blocks made from unfrozen fish, whereas addition of mince tended to increase the E value for blocks made from reprocessed H&G fish (Table 19). No mechanical texture testing was performed on the 100% mince block made from unfrozen fish.

At 12 months of frozen storage, addition of mince increased E values in most but not all cases (Tables 19 and 20). No reason was evident to explain why the 50% mince blocks had a higher E value than the 100% mince blocks for samples reprocessed at 3 and 12 months of frozen storage. Storing the fish in H&G form prior to being made into blocks may have decreased E values in the case of the blocks with no mince, but the opposite trend was seen for blocks with mince. Evidently, minimizing the time minced salmon spends in frozen storage reduces toughening.

To determine the effect of frozen storage on E values, separate ANOVAs were performed on data from blocks made from unfrozen fish (H&G time = 0) and blocks examined immediately after being made from previously frozen H&G fish (H&G time = 3, 6, or 12). For samples prepared from unfrozen fish, the E values increased during frozen storage especially between 6 and

12 months and for samples containing mince (Tables 21 and 22). For samples made from reprocessed fish, the effect of storage time was significant for the 0% (fillets), 25%, and 50% blocks but not for samples from blocks containing 100% mince (Table 21).

The E values were significantly ($P < 0.001$) correlated with mean chewiness and desirability scores ($r = -0.569$ and -0.621, respectively). The negative coefficients meant that samples with high E values tended to be chewier and less desirable.

CONCLUSIONS

Maximizing recovery of edible flesh from pink salmon by use of mechanical flesh separators is technically feasible and could boost yields from landed product by approximately one-third. Acceptable product forms using minced pink salmon by itself or in combination with boneless fillets is possible. Addition of mince tended to make a product that was less flavorful, tougher, and drier, but the changes were fairly small. Mince appeared to be more susceptible to loss of quality during frozen storage than fillets but had a frozen storage shelf life of at least 6 months at -18°C.

Although the quality of blocks made from unfrozen fish was generally better than blocks made from reprocessed H&G fish, portions made from reprocessed fish were acceptable. According to the results of sensory analysis, frozen storage produced a slight but significant darker color for blocks made from reprocessed H&G fish. Decreases in flavor scores during frozen storage were minor and attributed more to the loss of fresh flavor than the occurrence of rancidity. Toughness as measured by chewiness scores increased during frozen storage for blocks made from unfrozen fish but not for blocks made from reprocessed H&G fish. Thaw drip may be a problem for reprocessed material as frozen storage time approaches 12 months. Results of mechanical textural analysis agreed with the trends observed by sensory analysis.

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Table 1. Yield at various processing steps of pink salmon using manual and mechanical methods.

	Manual		Mechanical	
	Recovery as % of		Recovery as % of	
Step	Whole fish	Dressed fish	Whole fish	Dressed fish
Dressed fish	72.2	100.0	83.4	100.0
Head & collar removed			63.8	76.0
Fillets				
Skin-on, bone-in	56.5	78.2	57.0	68.0
Skinless, bone-in	44.6	61.7	48.0	57.6
Skinless, boneless	33.3	46.1	33.6	40.0
Skin	14.1	19.6		
Pin & rib bone trimming	12.2	17.0	14.8	17.6
Mince	11.0	15.3		
Backbones, fins, collars	15.4	21.3		

Table 2. Composition of fillet and minced pink salmon.

	Fillet	Mince
Protein,%	19.9	18.8
Moisture,%	76.6	76.5
Ash,%	1.26	1.13
Lipid,%	1.98	3.47
Calcium, ppm	65.0 ± 5.4	133 ± 28
Iron, ppm	17.2 ± 6.8	7.8 ± 0.7
Potassium, ppm	3962 ± 51	3435 ± 1
Sodium, ppm	680 ± 6	824 ± 10
Phosphorus, ppm	2625 ± 8	2416 ± 28

Table 3. Malonaldehyde (micromoles/100 g) content of mixed blocks of pink salmon stored at -18°C.

Months as		% Mince				
H&G	Block	0	25	50	100	Control[a]
0	1	1.60 ±0.11	1.40 ±0.09	1.30 ±0.00	1.33 ±0.01	1.49 ±0.01
0	3	1.61 ±0.06	1.34 ±0.15	1.50 ±0.04	1.48 ±0.01	
3	0	0.71 ±0.05	0.78[b]	0.85[b]	0.98 ±0.06	
0	6	1.33 ±0.02	1.32 ±0.03	1.12 ±0.01	1.38 ±0.01	0.80 ±0.01
3	3	1.68 ±0.07	1.54 ±0.03	1.44 ±0.01	1.75 ±0.04	
6	0	1.26 ±0.07	1.02 ±0.03	1.21 ±0.04	0.87 ±0.10	
0	12	0.80 ±0.02	0.68 ±0.01	1.23 ±0.02	1.05 ±0.01	1.05 ±0.01
3	9	0.99 ±0.10	1.22 ±0.01	1.15 ±0.01	1.16	
6	6	0.90 ±0.02	1.23 ±0.02	1.03 ±0.05	1.26 ±0.04	
12	0	0.67 ±0.01	0.81 ±0.03	0.91 ±0.01	1.01 ±0.02	

[a] Blocks of fillets held at -34°C.

[b] Estimated from values for fillet and 100% mince blocks.

H&G = headed and gutted.

Table 4. Thaw drip of portions from mixed blocks of pink salmon stored at -18°C and the control block stored at -34°C.

Months as		% Mince				
H&G	Block	0	25	50	100	Control[a]
0	1	3.10 ±0.99	4.09 ±0.08	5.13 ±1.53	4.00 ±0.25	
0	3	3.46 ±0.06	4.46 ±0.55	2.62 ±0.51	3.07 ±0.29	
3	0	3.80 ±1.91	3.60 ±0.00	3.64 ±1.76	5.39	
0	6	2.70 ±0.47	3.55 ±0.44	3.56 ±0.52	4.45 ±0.62	2.06 ±0.39
3	3	8.04 ±0.07	5.58 ±0.71	5.77 ±1.30	7.34 ±1.07	
6	0	5.60 ±0.70	5.77 ±1.56	6.31 ±0.80	6.29 ±1.75	
0	12	3.43 ±0.15	5.85 ±0.70	5.26 ±1.28	4.61 ±0.30	3.43 ±0.07
3	9	9.40 ±1.10	9.49 ±1.82	6.91 ±0.55	8.28 ±0.83	
6	6	11.74 ±0.17	8.29 ±1.66	9.46 ±1.92	10.85 ±1.06	
12	0	7.78 ±1.82	10.21 ±0.60	11.80	11.07 ±2.17	

[a] Blocks of fillets held at -34°C.

H&G = headed and gutted.

Table 5. F statistics and their probabilities (P) from a series of ANOVAs of thaw drip and L* (Lightness), a* (red hue), and b* (yellow hue) data at 6 and 12 months of frozen storage at -18°C.

	Time of storage (months)	Block form		Reprocessing		Interaction	
		F	P	F	P	F	P
Thaw drip	1	1.61	0.320				
	3	1.69	0.283	5.19	0.072	2.09	0.251
	6	1.29	0.323	22.35	0.000	1.52	0.251
	12	0.43	0.732	29.96	0.000	2.95	0.031
L*	1	1.92	0.205				
	3	27.59	0.000	2.95	0.112	0.01	0.915
	6	32.91	0.000	0.80	0.471	4.82	0.010
	12	25.12	0.000	5.40	0.010	2.25	0.079
a*	1	3.36	0.076				
	3	2.62	0.099	3.45	0.88	3.85	0.073
	6	1.3	0.316	6.98	0.010	2.60	0.075
	12	1.00	0.419	6.39	0.005	1.49	0.243
b*	1	0.65	0.605				
	3	12.54	0.001	4.63	0.052	1.43	0.255
	6	4.50	0.035	0.46	0.715	1.78	0.185
	12	3.11	0.058	1.21	0.340	1.24	0.344

Table 6. Hunter L* (Lightness), a* (red hue), and b* (yellow hue) values for uncooked pink salmon samples.

Months as		% Mince			
H&G	Block	0	25	50	100
		L*			
0	1	59.7 ±3.1	57.0 ±0.9	60.4 ±1.2	58.6 ±1.3
0	3	54.1 ±2.2	58.2 ±1.6	59.4 ±0.5	59.7 ±1.0
3	0	55.5 ±1.3	56.5[a]	57.5[a]	59.4 ±0.6
0	6	57.5 ±1.3	57.5 ±0.5	61.4 ±0.9	64.3 ±0.7
3	3	59.0 ±0.3	60.3 ±1.3	61.3 ±0.6	62.6 ±0.8
6	0	59.8 ±1.7	60.1 ±0.8	60.8 ±0.7	62.6 ±0.4
0	12	56.7 ±0.5	57.5 ±2.0	61.4 ±1.5	61.4 ±0.9
3	9	56.2 ±1.7	57.8 ±1.0	59.7 ±1.8	60.9 ±1.3
6	6	56.0 ±0.6	58.4 ±0.6	58.4 ±0.2	59.6 ±0.5
12	0	58.9 ±0.5	58.7 ±0.5	61.1 ±1.1	62.4 ±0.7

Table 6. Continued.

Months as H&G	Months as Block	% Mince 0	% Mince 25	% Mince 50	% Mince 100
		a*			
0	1	15.1 ±1.4	13.1 ±1.4	13.4 ±0.3	12.3 ±1.0
0	3	13.5 ±0.9	13.6 ±0.6	13.5 ±0.7	14.1 ±0.6
3	0	13.4 ±0.3	13.8[a]	14.1[a]	14.8 ±1.0
0	6	14.6 ±0.9	14.1 ±0.7	13.9 ±0.1	14.1 ±1.1
3	3	12.1 ±0.5	13.3 ±0.4	14.8 ±0.1	13.8 ±0.6
6	0	15.0 ±1.3	14.8 ±1.1	15.1 ±0.5	15.2 ±0.2
0	12	13.0 ±0.9	12.7 ±0.6	13.1 ±0.2	13.6 ±0.7
3	9	12.7 ±0.4	13.7 ±1.0	14.2 ±0.7	13.4 ±1.0
6	6	16.3 ±2.5	13.7 ±1.3	13.8 ±0.6	15.3 ±0.1
12	0	13.7 ±0.6	12.2 ±0.6	11.4 ±0.1	10.8 ±0.3

Table 6. Continued.

Months as H&G	Months as Block	% Mince 0	% Mince 25	% Mince 50	% Mince 100
		b*			
0	1	19.0 ±3.7	16.9 ±1.9	18.3 ±0.8	16.9 ±1.4
0	3	18.9 ±1.4	20.6 ±0.7	21.5 ±0.5	22.6 ±0.5
3	0	19.4 ±1.5	20.2[a]	20.9[a]	22.4 ±0.7
0	6	23.1 ±2.7	22.5 ±0.9	23.0 ±0.5	23.6 ±1.1
3	3	19.7 ±1.3	21.3 ±0.8	22.7 ±0.5	22.0 ±1.4
6	0	22.6 ±1.1	22.0 ±0.4	22.4 ±0.7	22.5 ±0.3
0	12	19.4 ±0.7	19.3 ±1.9	21.9 ±0.8	21.2 ±0.8
3	9	19.5 ±0.5	20.0 ±1.8	21.5 ±1.6	21.3 ±0.7
6	6	20.9 ±0.6	20.8 ±1.6	21.0 ±0.1	22.5 ±0.4
12	0	20.5 ±1.0	20.1 ±0.5	19.8 ±0.6	19.6 ±0.6

[a] Estimated from values for fillet and 100% mince blocks.

H&G = headed and gutted.

Table 7. Sensory analyses of pink salmon blocks prepared from unfrozen fish and with different levels of mince and stored one month at -18°C. The control sample was a block of fillets held at -34°C.

Sensory property	% Mince 0	25	50	100	Control	ANOVA F P
Color	4.00 ±0.47	3.90 ±0.57	3.60 ±0.70	3.60 ±0.84		0.975 0.416
Flavor	6.70[a] ±0.67	6.50[a] ±0.53	6.30[a] ±0.67	5.60[b] ±0.52		6.30 0.002
Chewiness	3.50 ±0.53	3.90 ±0.74	3.40 ±0.70	3.40 ±0.70		1.26 0.303
Moistness	3.90 ±0.57	3.90 ±0.74	3.70 ±0.82	3.40 ±0.97		0.90 0.450
Desirability	6.50[ab] ±0.71	6.10[ab] ±1.10	5.80[ab] ±0.63	5.00[c] ±0.94	6.60[a] ±0.52	6.32 0.000

[abc] Means sharing a common letter were not significantly different($P < 0.05$).

Table 8. F statistics and their probabilities (P) from ANOVA of the effect of block form (Form) and reprocessing (Repro) on sensory analysis of salmon blocks containing different levels of mince and prepared from unfrozen or previously frozen headed and gutted fish and stored at -18°C for 1 or 3 months.

Sensory property		1 Month	3 Month		
		Form	Form	Repro	Interaction
Color	F	0.97	0.27	9.70	0.280
	P	0.416	0.849	0.002	0.840
Flavor	F	6.30	2.49	7.26	0.135
	P	0.002	0.062	0.008	0.939
Chewiness	F	1.26	0.87	6.82	2.89
	P	0.303	0.457	0.010	0.037
Moistness	F	0.901	4.07	3.43	2.48
	P	0.450	0.008	0.066	0.063
Desirability	F	6.35	20.96	12.45	0.822
	P	0.000	0.000	0.001	0.512

Table 9. Distribution of texture scores of portions from blocks of pink salmon containing 0 (fillets), 25, 50, or 100% mince. Blocks were made from unfrozen fish or from thawed headed and gutted (H&G) fish. Storage temperature was -18°C.

Time of storage (months)	Time as H&G fish (months)	Mince (%)	Texture score: Flaky	Grainy	Fibrous	Soft
		0	8	2		
		25	6	3	1	
1	0	50	2	7	1	
		100		10		
		0	16	4		1
		25	14	7		
	0	50	14	6		1
		100		20	1	
3						
		0	17	1	2	
		25	11	7	2	
	3	50	6	11	3	
		100	1	17		1
		0	10			
		25	9	1		
	0	50	4	6		
		100		9	1	
		0	6	2	1	1
		25	6	4		
6	3	50	3	5	2	
		100		9	1	
		0	8	1	1	
		25	8	2		
	6	50	5	4	1	
		100	1	8	1	

Table 9. Continued.

Time of storage (months)	Time as H&G fish (months)	Mince (%)	Texture score: Flaky	Grainy	Fibrous	Soft
	0	0	9		1	
		25	6	2	2	
		50	3	7		
		100	1	8	1	
	3	0	8	1	1	
		25	7	2	1	
		50	4	5	1	
		100	1	8	1	
12	6	0	7	1	2	
		25	6	1	3	
		50	9	1		
		100		9	1	
	12	0	9		1	
		25	4	2	4	
		50	2	7	1	
		100		9	1	

Table 10. Sensory analyses of pink salmon blocks with different levels of mince and prepared from unfrozen or reprocessed frozen headed and gutted (H&G) fish and stored 3 months at -18°C. Control was fillet block stored at -34°C.

Sensory property	H&G time (months)	% Mince 0	25	50	100	Control
Color	0	3.90 ±0.77	3.90 ±0.83	4.14 ±0.65	4.10 ±0.89	
	3	3.65 ±0.81	3.60 ±0.75	3.60 ±0.75	3.65 ±0.88	
Flavor	0	6.05 ±1.02	5.62 ±0.86	5.71 ±0.85	5.57 ±0.68	
	3	5.75 ±1.20	5.15 ±1.27	5.15 ±1.04a	5.20 ±1.06	
Chewiness	0	3.71 ±0.64	3.48 ±0.60	3.52 ±0.75	3.24 ±0.83	
	3	3.25 ±0.55	3.05 ±0.51	3.05 ±0.75	3.50 ±0.69	
Moistness	0	3.47 ±0.75	3.43 ±0.81	3.62 ±0.74	2.86 ±0.73	
	3	3.45 ±0.68	3.15 ±0.59	2.95 ±0.69	3.00 ±0.73	
Desirability	0	5.76 ±1.04	5.43 ±1.08	5.52 ±0.93	4.80 ±1.08	6.62 ±0.05
	3	5.35 ±1.31	4.75 ±1.37	4.65 ±1.37	4.15 ±1.39	6.55 ±0.52

Table 11. Results of sensory analysis of pink salmon blocks containing different levels of mince and prepared from unfrozen or reprocessed headed and gutted (H&G) fish frozen and stored at -18°C for 6 months. Control was block of fillets stored at -34°C.

Sensory property	H&G time (months)	% Mince 0	25	50	100	ANOVA F P
Color	0	3.90 ±0.57	3.80 ±0.92	4.00 ±0.81	3.60 ±1.35	0.32 0.811
	3	3.60 ±0.52	3.30 ±0.82	3.10 ±0.74	3.20 ±0.79	0.88 0.459
	6	3.50 ±0.71	3.40 ±0.70	3.40 ±0.84	2.90 ±0.99	1.09 0.365
Flavor	0	5.70[a] ±0.95	5.50[a] ±0.92	5.40[a] ±1.18	4.20[b] ±0.79	4.53 0.009
	3	5.30 ±1.16	4.70 ±1.06	4.90 ±1.37	4.40 ±0.70	1.18 0.331
	6	4.50 ±1.27	5.50 ±0.85	5.00 ±1.05	4.80 ±0.42	1.95 0.139
Chewiness	0	4.10[a] ±1.29	3.40[ab] ±0.72	2.90[b] ±0.74	2.80[b] ±0.79	4.27 0.011
	3	3.20 ±0.79	3.40 ±0.70	3.10 ±0.74	3.10 ±0.88	0.33 0.804
	6	2.60 ±0.70	3.10 ±0.88	3.30 ±0.82	3.20 ±0.63	1.66 0.194
Moistness	0	3.70 ±0.82	3.30 ±0.95	3.00 ±0.94	2.60 ±0.84	2.73 0.058
	3	3.20 ±0.92	3.10 ±0.88	3.00 ±0.82	2.70 ±0.67	0.68 0.568
	6	2.70 ±1.16	3.20 ±0.79	3.00 ±0.67	2.60 ±1.17	0.80 0.502

Table 11. Continued.

Sensory property	H&G time (months)	Control	% Mince 0	25	50	100	ANOVA F P
Desirability	0	6.60[a] ±0.52	5.80[b] ±0.79	5.30[b] ±0.67	4.70[c] ±1.34	3.50[d] ±0.85	17.73 0.000
	3	6.40[a] ±0.52	4.90[b] ±1.37	4.60[bc] ±1.43	4.60[bc] ±1.08	3.80[c] ±0.63	7.90 0.000
	6	6.60[a] ±0.52	3.90[c] ±1.52	5.50[b] ±0.71	4.30[c] ±1.49	4.10[c] ±0.74	11.18 0.000

[abc] Means within a row sharing a common lowercase letter were not significantly different ($P < 0.05$).

Table 12. The effect on sensory properties of adding mince (Block form) and reprocessing at 6 months frozen storage at -18°C as measured by analysis of variance F statistics, their probabilities (P), and degrees of freedom (df).

Sensory Property	Block Form			Reprocessing			Interaction		
	df	F	P	df	F	P	df	F	P
Color	3	1.368	0.257	2	5.216	0.007	6	0.375	0.894
Flavor	3	3.607	0.016	2	1.398	0.252	6	1.930	0.082
Chewiness	3	0.843	0.473	2	0.942	0.393	6	3.074	0.008
Texture	4	25.51	0.000	2	1.444	0.239	8	0.576	0.796
Moistness	3	2.649	0.053	2	0.938	0.395	6	0.733	0.593
Desira-bility	4	30.31	0.000	2	1.558	0.214	8	2.698	0.009

Table 13. Means and standard deviations of sensory properties at 12 months storage at -18°C of pink salmon blocks containing different levels of mince and prepared from unfrozen fish or previously frozen headed and gutted (H&G) fish. F statistics and their probabilities (P) from one-way ANOVAs of means within a row or a column are also included. Control was fillet block stored at -34°C.

Sensory property	H&G time (months)		% Mince 0	% Mince 25	% Mince 50	% Mince 100	ANOVA F / P
Color	0		3.90	4.00	4.20	4.20[A]	0.224
			±0.74	±1.16	±1.03	±1.03	0.879
	3		3.80	3.90	3.70	3.10[B]	1.24
			±1.14	±1.10	±0.95	±0.88	0.310
	6		4.00[a]	3.40[a]	3.50[a]	2.40[bBC]	7.59
			±0.81	±0.70	±0.71	±0.84	0.001
	12		3.70[a]	3.10[a]	3.50[a]	2.20[bC]	7.55
			±0.67	±0.88	±0.71	±0.79	0.001
	ANOVA	F	0.27	1.90	1.47	10.31	
		P	0.878	0.148	0.239	0.000	
Flavor	0		5.40[A]	4.60	4.50	4.50	0.779
			±1.43	±1.58	±1.58	±1.65	0.513
	3		4.00[B]	4.40	4.10	3.60	0.64
			±1.15	±1.26	±1.10	±1.65	0.596
	6		4.50[AB]	4.20	4.80	3.50	1.50
			±1.43	±1.48	±1.14	±1.65	0.230
	12		5.40[A]	4.70	4.50	3.50	4.14
			±0.84	±1.42	±1.08	±1.43	0.013
	ANOVA	F	3.14	0.24	0.54	0.92	
		P	0.037	0.876	0.661	0.439	

Table 13. Continued.

Sensory property	H&G time (months)	% Mince 0	25	50	100	ANOVA F P
Chewiness	0	3.70[a] ±0.67	3.10[b] ±0.57	2.50[c] ±0.71	2.50[c] ±0.53	8.49 0.000
	3	3.00 ±0.94	3.10 ±0.57	3.10 ±0.57	2.70 ±1.06	0.54 0.658
	6	3.00 ±0.67	2.80 ±0.63	3.10 ±0.57	2.80 ±0.63	1.52 0.226
	12	3.30 ±0.82	2.90 ±0.88	2.80 ±0.92	3.00 ±0.82	0.63 0.599
ANOVA	F	1.33	0.50	1.66	0.70	
	P	0.279	0.687	0.193	0.557	
Moistness	0	3.50[a] ±0.85	3.00[ab] ±0.94	2.90[ab] ±0.74	2.50[b] ±0.53	2.78 0.055
	3	2.90 ±0.99	3.10 ±0.74	2.90 ±0.32	2.60 ±0.84	0.725 0.584
	6	2.90 ±0.57	2.60 ±0.70	3.20 ±0.63	2.60 ±0.52	2.23 0.101
	12	3.10 ±0.57	3.10 ±0.88	3.20 ±0.63	2.70 ±0.67	1.01 0.399
ANOVA	F	1.36	0.84	0.83	0.16	
	P	0.271	0.479	0.486	0.925	

Table 13. Continued.

Sensory property	H&G time (months)	% Mince 0	25	50	100	Control	ANOVA F P
Desirability	0	5.00[b] ±1.80	4.00[bc] ±1.57	3.50[bc] ±1.71	3.50[c] ±1.08	6.40[a] ±0.52	7.52 0.000
	3	3.60[bc] ±1.43	3.90[b] ±1.29	3.30[bc] ±0.82	2.70[bc] ±1.42	6.50[a] ±0.53	16.13 0.000
	6	4.20[bc] ±1.75	3.70[bc] ±1.77	4.10[bc] ±1.29	2.90[c] ±1.37	6.50[a] ±0.53	9.01 0.000
	12	5.10[a] ±0.63	4.10[bc] ±0.94	3.80[cd] ±0.57	2.90[d] ±0.32	6.50[a] ±0.57	14.99 0.000
ANOVA	F P	2.04 0.126	0.13 0.945	0.77 0.517	0.74 0.535	0.09 0.965	

[abc] Means within a row sharing a common lower case letter were not significantly different ($P < 0.05$).

[ABC] Means within a column sharing a common upper case letter were not significantly different ($P < 0.05$).

Table 14. F statistics and probabilities (P) from ANOVA of the effects of addition of mince (Block form) and reprocessing on sensory properties of blocks of pink salmon stored 12 months at -18°C.

Sensory property		Block form	Reprocessing	Interaction
Color	F	7.50	8.47	1.82
	P	0.00	0.000	0.070
Flavor	F	4.03	2.08	0.78
	P	0.009	0.105	0.637
Chewiness	F	4.46	0.04	1.39
	P	0.005	0.989	0.196
Moistness	F	3.97	0.65	0.91
	P	0.009	0.584	0.518
Desirability	F	42.15	1.56	0.783
	P	0.000	0.201	0.668

Table 15. Sensory analysis of pink salmon blocks with different levels of mince and prepared from unfrozen fish (Block) or reprocessed frozen fish (H&G). Storage temperature was -18°C.

Sensory property	Time of storage (months)	Storage form	% Mince 0	25	50	100
Color	3	Block	3.90 ±0.77	3.90 ±0.83	4.14 ±0.65	4.10 ±0.89
		H&G	3.65 ±0.81	3.60 ±0.75	3.60 ±0.75	3.65 ±0.88
	6	Block	3.90 ±0.57	3.80 ±0.92	4.00 ±0.81	3.60 ±1.35
		H&G	3.50 ±0.71	3.40 ±0.70	3.40 ±0.84	2.90 ±0.99
	12	Block	3.90 ±0.74	4.00 ±1.16	4.20 ±1.03	4.20 ±1.03
		H&G	3.70 ±0.67	3.10 ±0.88	3.50 ±0.71	2.20 ±0.79
Flavor	3	Block	6.05 ±1.02	5.62 ±0.86	5.71 ±0.85	5.57 ±0.68
		H&G	5.75 ±1.20	5.15 ±1.27	5.15 ±1.04	5.20 ±1.06
	6	Block	5.70 ±0.95	5.50 ±0.92	5.40 ±1.18	4.20 ±0.79
		H&G	4.50 ±1.27	5.50 ±0.85	5.00 ±1.05	4.80 ±0.42
	12	Block	5.40 ±1.43	4.60 ±1.58	4.50 ±1.58	4.50 ±1.65
		H&G	5.40 ±0.84	4.70 ±1.42	4.50 ±1.08	3.50 ±1.43

Table 15. Continued.

Sensory property	Time of storage (months)	Storage form	% Mince 0	25	50	100
Chewiness	3	Block	3.71 ±0.64	3.48 ±0.60	3.52 ±0.75	3.24 ±0.83
		H&G	3.25 ±0.55	3.05 ±0.51	3.05 ±0.75	3.50 ±0.69
	6	Block	4.10 ±1.29	3.40 ±0.72	2.90 ±0.74	2.80 ±0.79
		H&G	2.60 ±0.70	3.10 ±0.88	3.30 ±0.82	3.20 ±0.63
	12	Block	3.70 ±0.67	3.10 ±0.57	2.50 ±0.71	2.50 ±0.53
		H&G	3.30 ±0.82	2.90 ±0.88	2.80 ±0.92	3.00 ±0.82
Moistness	3	Block	3.47 ±0.75	3.43 ±0.81	3.62 ±0.74	2.86 ±0.73
		H&G	3.45 ±0.68	3.15 ±0.59	2.95 ±0.69	3.00 ±0.73
	6	Block	3.70 ±0.82	3.30 ±0.95	3.00 ±0.94	2.60 ±0.84
		H&G	2.70 ±1.16	3.20 ±0.79	3.00 ±0.67	2.60 ±1.17
	12	Block	3.50 ±0.85	3.00 ±0.94	2.90 ±0.74	2.50 ±0.53
		H&G	3.10 ±0.57	3.10 ±0.88	3.20 ±0.63	2.70 ±0.67

Table 15. Continued.

Sensory property	Time of storage (months)	Storage form	% Mince 0	25	50	100
Desirability	3	Block	5.76 ±1.04	5.43 ±1.08	5.52 ±0.93	4.80 ±1.08
		H&G	5.35 ±1.31	4.75 ±1.37	4.65 ±1.37	4.15 ±1.39
	6	Block	4.80 ±0.79	5.30 ±0.67	4.70 ±1.34	3.50 ±0.85
		H&G	3.90 ±1.52	5.50 ±0.71	4.30 ±1.49	4.10 ±0.74
	12	Block	5.00 ±1.80	4.00 ±1.57	3.50 ±1.71	3.50 ±1.08
		H&G	5.10 ±0.63	4.10 ±0.94	3.80 ±0.57	2.90 ±0.32

Table 16. F statistics and their probabilities (P) from an ANOVA on the effect of reprocessing (Repro), storage time (Stime), and block form (Form) on sensory properties of blocks of pink salmon. Degrees of freedom (df) are included.

Source of variation		Color	Flavor	Chewiness	Moistness	Desirability
Repro	F	35.78	7.27	5.33	3.44	10.04
df=1	P	0.000	0.007	0.022	0.065	0.002
Stime	F	3.19	17.85	7.18	3.70	20.60
df=2	P	0.043	0.000	0.001	0.026	0.000
Form	F	1.62	6.30	4.17	8.63	15.51
df=3	P	0.187	0.000	0.007	0.000	0.000
Repro x Stime	F	3.02	0.29	1.41	1.02	1.82
df=2	P	0.050	0.746	0.247	0.362	0.165
Repro x Form	F	1.89	0.18	7.45	1.45	0.39
df=3	P	0.131	0.912	0.000	0.230	0.761
Stime x Form	F	1.18	2.03	1.43	0.25	2.06
df=6	P	0.318	0.061	0.203	0.960	0.058
Repro x Stime x	F	1.29	1.67	2.01	1.69	2.28
Form	P	0.262	0.128	0.064	0.122	0.043
df=6						

Table 17. F statistics and their probabilities (P) from a series of two-way ANOVAs on the effect of block form (Form) and storage time (Stime) on sensory properties of blocks of pink salmon. Degrees of freedom (df) are included.

Sensory property	Storage form		Form df=3,152	Stime df=2,152	Interaction df=6,152
Color	Block	F	NS	NS	NS
		P			
	H&G	F	3.26	5.84	2.44
		P	0.023	0.004	0.028
Chewiness	Block	F	10.15	7.07	NS
		P	0.000	0.001	
	H&G	F	1.18	1.38	NS
		P	0.320	2.56	
Desira-bility	Block	F	10.33	19.13	1.56
		P	0.000	0.000	0.164
	H&G	F	5.95	4.59	2.60
		P	0.001	0.012	0.020

H&G = Headed and gutted.

NS = Not significant.

Table 18. Texture scores of samples stored either as blocks or as headed and gutted (H&G) fish. Storage temperature was -18°C.

Mince (%)	Frozen storage form	Time of storage (months)	Texture score: Flaky	Grainy	Fibrous	Soft
0	Block	3	16	4		1
		6	10			
		12	9		1	
	H&G	3	17	1	2	
		6	8	1	1	
		12	9		1	
25	Block	3	14	7		
		6	9	1		
		12	6	2	2	
	H&G	3	11	7	2	
		6	8	2		
		12	4	2	4	
50	Block	3	14	6		1
		6	4	6		
		12	3	7		
	H&G	3	6	11	3	
		6	5	4	1	
		12	2	7	1	
100	Block	3		20	1	
		6		9	1	
		12	1	8	1	
	H&G	3	1	17		1
		6	1	8	1	
		12		9	1	

Table 19. Elasticity modulus from Instron test of portions from pink salmon blocks prepared from unfrozen fish or reprocessed headed and gutted (H&G) fish. Storage temperature was -18°C.

Time of storage (months)	Time as H&G fish (months)	% Mince 0	25	50	100	ANOVA F P
1	0	2.29^{a} ±0.50	3.31^{b} ±0.36	3.57^{bc} ±0.66	3.87^{c} ±0.52	16.02 0.000
3	3	3.28^{ab} ±0.73	2.98^{a} ±0.70	3.69^{bc} ±0.28	3.92^{c} ±0.49	6.22 0.001
0	6	3.51 ±0.90	3.52 ±0.59	4.14 ±0.87		2.42 0.104
3	3	4.05^{a} ±1.15	4.05^{a} ±0.96	4.94^{b} ±0.52	4.60^{ab} ±0.71	3.08 0.037
6	0	3.08^{a} ±0.38	3.57^{b} ±0.72	3.12^{a} ±0.49	3.87^{b} ±0.54	5.80 0.002
0	12	4.86^{a} ±1.27	6.82^{b} ±0.86	7.50^{bc} ±0.54	7.63^{c} ±0.73	24.99 0.000
3	9	4.56^{a} ±1.24	4.92^{ab} ±0.83	6.70^{b} ±1.07	5.35^{a} ±0.62	11.26 0.000
6	6	4.64^{a} ±1.08	4.37^{ab} ±0.74	3.73^{b} ±0.83	4.81^{a} ±0.71	3.70 0.018
12	0	3.92^{a} ±0.80	4.30^{a} ±1.14	5.32^{b} ±0.76	3.81^{a} ±0.66	8.00 0.002

^{abc} Means in a row sharing the same letter were not significantly different ($P < 0.05$).

Table 20. Effect of addition of mince (Block Form) and reprocessing on elasticity modulus.

Months at -18°C	Source of variation	Degrees of freedom	ANOVA F	P
6	Block form	3	5.10	0.002
	Reprocessing	2	21.60	0.000
	Interaction	5	2.43	0.039
12	Block form	3	18.60	0.000
	Reprocessing	3	74.83	0.000
	Interaction	9	10.05	0.000

Table 21. Elasticity modulus from Instron test of portions from pink salmon blocks prepared from unfrozen fish (storage form = block) or from reprocessed headed and gutted (H&G) fish.

Storage form	Time of storage (months)	% Mince			
		0	25	50	100
Block	1	2.29 ±0.50	3.31 ±0.36	3.57 ±0.66	3.87 ±0.52
	6	3.51 ±0.90	3.52 ±0.59	4.14 ±0.87	
	12	4.86 ±1.27	6.82 ±0.86	7.50 ±0.54	7.63 ±0.73
H&G fish	3	3.28 ±0.73	2.98 ±0.70	3.69 ±0.28	3.92 ±0.49
	6	3.08 ±0.38	3.57 ±0.72	3.12 ±0.49	3.87 ±0.54
	12	3.92 ±0.80	4.30 ±1.14	5.32 ±0.76	3.81 ±0.66

Table 22. Effect on elasticity modulus of addition of mince (Block form) and storage time (Stime) at -18°C either as blocks or headed and gutted (H&G) fish.

Storage form	Source of variation	Degrees of freedom	ANOVA F	P
Block	Block form	3	33.25	0.000
	Stime	2	254.34	0.000
	Block form x Stime	6	5.98	0.000
H&G fish	Block form	3	5.71	0.001
	Stime	2	27.93	0.000
	Block form x Stime	6	7.70	0.000

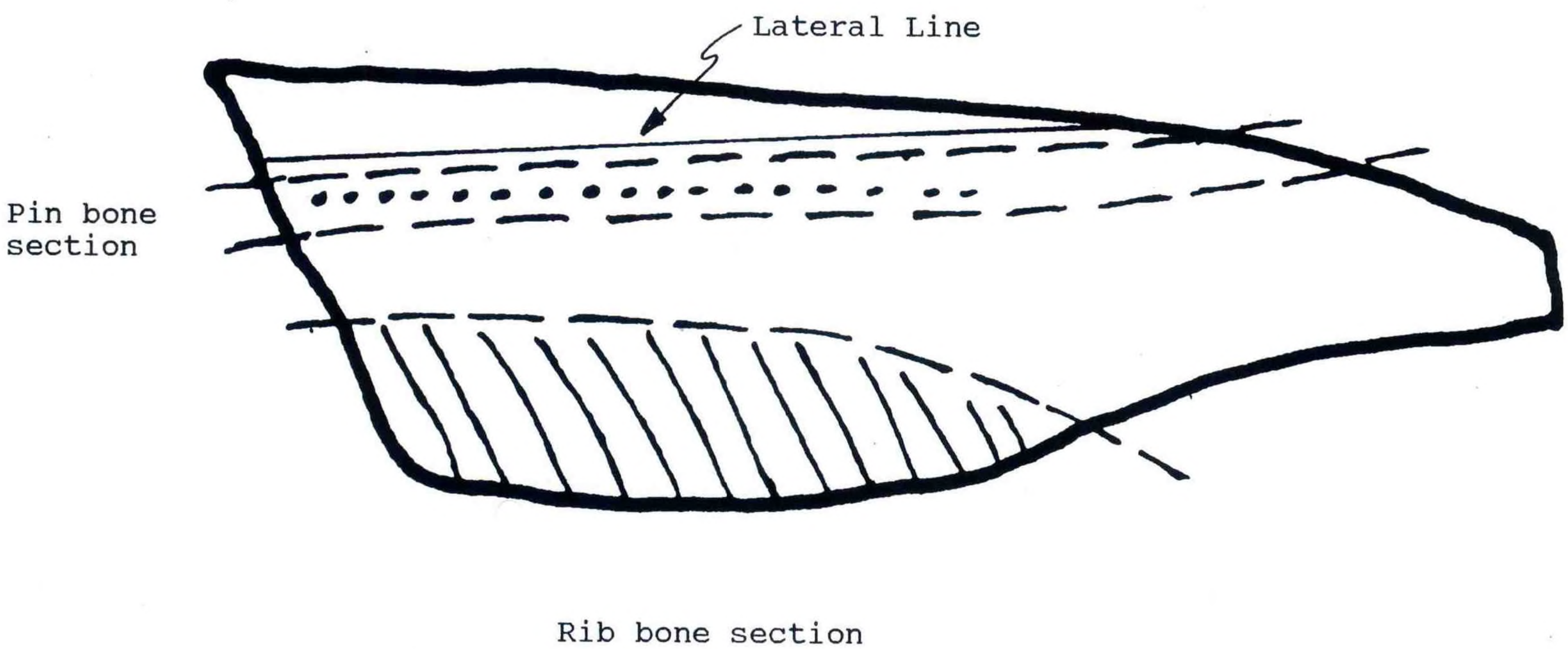

Figure 1. Cuts used to prepared pink salmon fillets (skinless, boneless) and trimmings (pin- and rib-bones).

APPENDIX

Sample Ballot

FLAVOR	CHEWINESS	MOISTNESS
7- Intense fresh flavor	7- Very tender	7- Much more moist
6- Good but not intense	6- Moderately tender	6- More moist
5- Only mildly pleasant	5- Slightly tender	5- Sl. more moist
4- Trace of bad flavor rancid, oxidized	4- Tender	4- Moist as control
3- Mild bad flavor	3- Slightly tough	3- Sl. drier
2- Strong bad flavor	2- Moderately tough	2- Drier
1- Intense bad flavor	1- Very tough	1- Much drier

COLOR	TEXTURE	DESIRABILITY
7- Much Lighter		7- Like extremely
6- Lighter	5-Fibrous	6- Like moderately
5- Sl. lighter	4-Grainy	5- Like slightly
4- Same as Control	3- Flaky	4- Neutral
3- Sl. darker	2- Soft	3- Slight dislike
2- Darker	1- Mushy	2- Moderate dislike
1- Much darker		1- Dislike extremely

Sample	Color	Flavor	Chewiness	Texture	Moistness	Desira-bility	Comment

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