NOAA Technical Memorandum NMFS F/NWC-193

Characterization and Frozen Storage Stability of Cod Mince Subjected to Mechanical Separation of "Sealworms" or "Codworms"

by
Kermit D. Reppond
and Jerry K. Babbitt

February 1991

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

CHARACTERIZATION AND FROZEN STORAGE STABILITY

OF COD MINCE SUBJECTED TO MECHANICAL SEPARATION

OF “SEALWORMS11 OR “CODWORMS”

by

Kermit D. Reppond and Jerry K. Babbitt

Kodiak Investigations--Utilization Research Division
Northwest Fisheries Science Center
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
P.O. Box 1638
Kodiak, AK 99615

February 1991

ABSTRACT

A Baader Model 694 Meat Separator and a Brown International Model 4000 Finisher were equally effective in producing minced flesh from fillet trimmings of Pacific cod (*Gadus macrocephalus*) but only the mince from the Finisher was essentially free of “sealworms” or “codworms.” Analysis for thaw drip, color, protein, ash, moisture, and amines indicated that mince from both machines had similar composition. Tests of sensory properties of blocks of mince stored for up to 6 months at -18*C indicated no differences with the exception of texture. Mechanical analysis of texture confirmed that mince refined with the Finisher tended to be firmer.

CONTENTS

INTRODUCTION

In 1987, almost 40 million pounds (18,200 metric tons) of minced fish blocks worth over $27 million were imported into the United States (O'Bannon 1988). These blocks are usually made from the flesh of the codfishes (Gadidae) family and are mostly processed into fish sticks. A significant part, if not all, of these blocks could be produced domestically using Pacific cod (Gadus macrocephalus) and walleye pollock (Theragra chalcogramma), also known as Alaska pollock. Over 170 million pounds (77,000 metric tons) of Pacific cod and 550 million pounds of Alaska pollock (250,000 metric tons) were landed by U.S. fisherman in 1987 (O'Bannon 1988). Domestic production of blocks of minced flesh as the primary product from a fishery is limited due to the low price of the blocks as compared to fillets and fillet blocks.

Use of filleting machines is widespread in the processing of cod and pollock in Alaska, but even the best machine can not produce a boneless fillet that does not need further candling and trimming to remove defects such as skin, bones, and parasites. As much as 10% of the round weight of cod may be discarded as trimmings during the production of fillets (Babbitt and Reppond 1987). Labor costs, however, will limit the amount of candling and trimming that is economically feasible. Mechanical meat separators are available that produce a boneless, skinless mince from trimmings (Erichsen et al. 1972). A problem facing production of mince from cod or pollock trimmings is the presence of parasites commonly called "sealworms" or "codworms."

Sealworms reach adult form in marine mammals, but man encounters them in an intermediate form in certain fish (Hafsteinsson and Rizvi 1987). Although sealworms do not present a significant health hazard because they are killed during freezing (-20°C for 60 hours) or cooking (60°C for 10 minutes), their presence is understandably unacceptable (Margolis 1977, Wootten and Cann 1978). The purpose of this experiment was to determine if mechanical meat separators could produce a boneless, sealwormfree mince that could be used in products such as fish sticks or portions.

MATERIALS AND METHODS

Sample Preparation

The experiment was conducted in Kodiak, Alaska, by personnel from the Utilization Research Division. The Brown International Model 4000 Finisher* operates in a manner similar to the refining apparatus in the production of surimi. Rotating paddles propel material through a cylindrical two-piece screen. A clam-shell frame holds the screen and allows for easy cleaning and switching of screens. Mince is collected in a hopper after it passes through the screen, while waste material is discharged out the far end. The Brown Finisher was equipped with paddles having a pitch of 0.375 in (9.5 mm) and the clearance between the screen and the paddles was 0.090 in (2.3 mm). Three screens were used in this work: one with 0.094 in (2.4 mm) diameter holes on

* Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

0.188 in (4.8 mm) centers; one with 0.125 in (3.2 mm) holes on 0.25 in (6.4 mm) centers; and one with 0.188 in (4.8 mm) holes on 0.25 in (6.4 mm) centers. These screens shall be referred to as the 0.094, 0.125, and 0.188 screens hereafter. A heavier backup screen with 0.625 in (15.9 mm) holes on 0.813 in (20.7 mm) centers provided support and rigidity for the finer screens. All screens had an area of 732 in^2 (4722 CM^2). The speed of paddle rotation was set at 650 rpm.

To determine the efficiency of parasite removal, trimmings from a cod filleting line in a local cannery were examined on a candling table and pieces with worms were saved. About 100 lb (45.4 kg) of trim with a load of at least 400 worms was first ground through a meat grinder equipped with a 0.188 in extrusion plate. The ground flesh was divided into three portions, one for each of the finisher screens, and then fed through the Brown Finisher. A sample of 16.75 lb (7.6 kg) from each of the screenings was examined on a candling table for bones and worms.

To produce enough material to obtain yield data and to conduct a frozen storage experiment, two lots of cod trimmings were obtained from the filleting operations of two Kodiak processors. The trimmings from Lot 1 appeared to have more pin bone trimmings and fewer belly flaps than the trimmings from Lot 2. Both lots appeared to be of good quality based on color and odor. Trimmings from Lot 1 were briefly drained on a large mesh screen then minced using a Baader Model 694 flesh separator machine equipped with a drum with 5 mm openings. Two 16.75 lb blocks of this unrefined mince were frozen in cardboard liners at -40°C for 4 hours and stored at -18°C for sensory analysis. Samples for chemical analysis were frozen in plastic bags at -40°C and stored 1 month at -18°C. The remaining mince was refined with the Brown Finisher with the 0.094 screen. Samples of refined mince for sensory and chemical analysis were prepared as before.

Trimmings from Lot 2 were prepared in a similar manner except they were fed through a meat grinder equipped with a 0.188 in plate rather than being deboned with the Baader 694. Unrefined mince was sampled for chemical analysis in the same manner as in Lot 1. The remaining mince was fed into the Brown Finisher equipped with either the 0.125 screen or the 0.188 screen. Samples for sensory and chemical analysis were prepared as before. With the 0.094 and 0.125 screens, waste material from the first pass through the Finisher was refined a second time to increase yield.

Chemical Analysis

Analyses for protein, moisture, fat, ash (Association of Official Analytical Chemists 1980), trimethylamine (TMA), dimethylamine (DMA), and trimethylamine oxide (TMAO) (Babbitt et al. 1987) were conducted within 1 month of frozen storage. At 3 and 6 months of storage, analyses for DMA and TMAO were performed using unbreaded portions cut for sensory analysis.

Sensory Analysis

Portions (3 by 1.75 by 0.5 in, 76 by 44 by 13 mm) for sensory analysis were sawed from the frozen blocks, battered, and breaded using commercial products (Newlywed Foods), and fried in vegetable oil at 350°F (177°C) in a Wells Model F-67 deep fat fryer. Coded samples were served warm to a panel consisting of 8 to 10 experienced judges. Flavor was rated on a seven point scale: 7, excellent; 4, neutral or bland; 1, extremely bad. Chewiness and moistness were rated on seven point scales, respectively: 7, very tough or dry; 4, firm or moist; 1, very soft or juicy. Desirability was also a seven point scale: 7, very desirable; 4, neutral; 1, very undesirable. Texture was rated on a 7 point categorical scale: 7, fibrous; 6, grainy; 5, flakey; 4, spongy; 3, mushy; 2, crumbly; and 1, rubbery. The panel was also asked to rank the samples with respect to lightness or darkness of the cooked flesh. Panel scores were analyzed using analysis of variance (ANOVA) techniques (Sokal and Rohlf 1969, Bowman and Cahill 1975). A sample ballot is enclosed as Figure 1.

Thaw Drip, Color, and Mechanical Texture Analysis

Determination of thaw drip by a double-bag immersion method used the same size portions as those used for sensory analysis. Each portion was weighed and placed in a perforated polyester bag. Each bag was then placed in a larger bag equipped with a weight to insure immersion. The samples were suspended in a circulating water bath at 15°C for 40 minutes. After thawing, the sample was reweighed to determine weight loss. At 3 months of storage, it became evident that the immersion method gave values that were too low; therefore, the centrifugal thaw drip method of Miyauchi (1962) was used at 6 months.

The color of the raw, thawed portions was measured with a Minolta Reflectance II meter to determine the Hunter L^*, a^*, and b^* values. Mechanical textural analyses used portions prepared in the same manner as those used for sensory analysis, except that the samples were cooled and their breading removed before testing. A Model 1000 Instron texture testing machine equipped with a 1 cm cylindrical probe at a crosshead speed of 50 mm/min was used. Stress and strain at failure were recorded and used to calculate Young's modulus (Bourne 1982).

RESULTS AND DISCUSSION

Worms, Bones, and Yield

Using the Brown Finisher, not a single intact worm was detected in any of the 16.75 lb samples of minced flesh. This is remarkable considering that the original material had four parasites per pound (Table 1). As might be expected, more worm fragments were found when larger screens were used but the 0.125 screen was still highly effective in separating parasites. An additional block of mince prepared with the 0.188 screen had three bones (0.3, 0.5, and 1.5 cm) and two worm fragments between 1.0 and 1.5 cm in length. Inspection of a block of minced flesh from the Baader 694 yielded one 3.2 cm bone, four intact worms

2 cm or greater in length, and two worm fragments 1-2 cm in length.

Total yields were 54, 81, and 89%, respectively, for the 0.094, 0.125, and 0.188 screens. It should be noted again that in using the 0.094 and 0.125 screens, waste material from the first pass was run through the Finisher a second time to increase yield. Because some material remained in the Finisher at the end of each of the the yield experiments, yields in this experiment may be lower than in a commercial operation.

Chemical Analysis

Moisture content appeared somewhat higher and protein content somewhat lower for the Lot 2 mince than for the Lot 1 mince (Table 2) but, for the purposes of the experiment, these differences were not meaningful. The values for protein, ash, lipid, and TMA appeared to be similar for all samples. Because the chemical composition of the material from the two lots were similar, it was assumed that subsequent changes during frozen storage would be similar; therefore, further reference to Lot 1 and Lot 2 in the text or tables was discontinued. The TMAO content dramatically decreased between 1 and 3 months while the DMA content showed a similar increase (Table 3). The high levels of DMA were somewhat surprising at 3 months as the samples were largely of good quality according to sensory results. Smaller changes occurred between 3 and 6 months.

Thaw Drip and Color

At 1 month, mince refined with the Brown Finisher had less thaw drip than unrefined mince (Table 4). At 3 and 6 months, essentially no thaw drip was detected using the double bag method. When the 6-month samples were subjected to the centrifugal thaw drip procedure, the extremely high values indicated that most of the protein had lost its water holding ability. Evidently, the immersion method of determining drip is not suitable for minced products.

Hunter L^* values of thawed, raw portions of unrefined and refined mince were similar at 1 or 3 months, but at 6 months, the unrefined mince had lower values (Table 5) . Lower L^* values indicate darker color. The Hunter a^* values were not affected by increasing the time of frozen storage. Although a^* values were affected by using the Brown Finisher, the trend was inconsistent. Higher a^* values indicate more red hue. The Hunter b^* values tended to be highest for material that passed through the smaller screens and tended to increase during frozen storage for the material passed through the 0.125 and 0.188 screens. A positive b^* value is associated with a yellow hue.

Sensory Analysis

Use of the Brown Finisher did not affect flavor, moistness, or desirability scores, but did affect chewiness scores as unrefined Baader mince was less chewy than mince from the Brown Finisher (Table 6). Overall quality was acceptable at 3 months of frozen storage for all samples, but at 6 months, blocks of mince from the Brown Finisher had mean desirability scores of less than 4.0 indicating lower and perhaps unacceptable quality. Throughout the study, most panelists rated the unrefined minced portions from the Baader as darker than the rest. Frozen storage resulted in more off flavor, more chewiness, less moistness, and decreased desirability, especially between 3 and 6 months for samples from the Brown Finisher.

According to a Chi-square analysis, neither screen size (G = 25.07; degrees of freedom, df = 18) nor storage time (G = 20.31, df = 12) had a significant ($P < 0.05$) effect on texture ratings. At 1 month of frozen storage, the mince from the Baader elicited a variety of texture ratings, while the mince from the Brown Finisher were predominately spongy (Table 7). At 3 months, the results were similar except that some rubbery texture was noted for the Brown Finisher mince. At 6 months, all samples were predominately spongy, but some rubbery ratings were noted again.

Mechanical Texture Analysis

Mechanical testing of cooked samples showed results similar to the sensory analyses. Portions made from mince refined with the Brown Finisher tended to have a higher stress at failure and a higher Young’s Modulus than portions made from the unrefined Baader mince (Table 8). Both stress and Young’s modulus increased during frozen storage with the amount of increase being smallest for the mince from the Baader. A higher Young’s Modulus meant that more stress is needed for the same amount of strain.

Strain at failure tended to be higher for minced samples from the Brown Finisher, especially at 3 and 6 months of frozen storage. The strain was higher at 3 months than at 1 or 6 months. A possible explanation for this result is that samples became tougher and more deformable between 1 and 3 months, but more brittle thereafter.

CONCLUSION

Use of the Brown Finisher was effective in producing a mince essentially free from parasites and with compositional and chemical characteristics similar to that of mince made with the Baader 694. However, just as minced fish flesh typically deteriorates more quickly during frozen storage than intact fillets (Babbitt et al. 1984), mince refined with the Finisher may have deteriorated more quickly than unrefined mince. Perhaps the refining process enhanced the effect of cellular disruption that is associated with minced products. Mince from the Brown Finisher was acceptable to at least 3 months of frozen storage at -18°C, but at 6 months, the texture was tough, resulting in lowered desirability. Denaturation of protein, as indicated by high levels of DMA, was probably responsible for textural changes during frozen storage in all samples. Changes in rheological properties of cooked portions paralleled those seen in the sensory work. The size of the holes in the screens did not affect results to a great degree, but use of the 0.188 screen may not prove as effective in removing bones and worm fragments as the smaller screens. The 0.125 screen may prove more feasible to use than the 0.094 screen in a commercial operation due to its greater yield. The frozen shelf life of a commercially produced product could be influenced by several factors such as the initial quality of the trim, storage temperature, length of time before and after cooking, and perhaps the size of serving portion. Additional experiments should be performed to determine how these factors affect quality, as well as the feasibility of using pollock fillet trimmings.

CITATIONS

Association of Official Analytical Chemists. 1980. Official methods of analysis, 13th ed., Association of official Analytical Chemists, Washington, D.C.

Babbitt, J. K., B. Koury, H. Groninger, and J. Spinelli. 1984. Observations on reprocessing frozen Alaska pollock (Theracrra chalcogramma). J. Food Sci. 49(2):323-326.

Babbitt, J. K., and K. D. Reppond. 1987. Minced flesh from cod and pollock trimmings. October-December Utilization Division Quarterly Progress Report. Northwest Fisheries Science Center, 2725 Montlake Blvd. East, Seattle, WA 98112.

Babbitt, J. K., K. D. Reppond, and A. Hardy. 1987. Frozen storage stability of modified pollock (Theragra chalcogramma) blocks containing 15% or 30% minced pollock. J. Food Sci. 52(2):1191-1193 and 1211.

Bourne, M. 1982. Food texture and viscosity: Concept and measurement. Academic Press, New York, 325 p.

Bowman, K. S., and M. Cahill. 1975. Statistical package for the social sciences, 2nd ed. McGraw-Hill, New York, 381 p.

Erichsen, L. B., 0. R. Taylor, G. Vedie, and F. J. Miller. 1972. Commercially available equipment. In Roy E. Martin (editor), Second Technical Seminar on Mechanical Recovery and Utilization of Fish Flesh, p. 127-156. National Fisheries Institute, Washington, D.C.

Hafsteinsson, H., and S. S. H. Rizvi. 1987. A review of the sealworm. problem: Biology, implications and solutions. J. Food Protect. 50(l):70-84.

Margolis, L. 1977. Public health aspects of "codworm" infection: A review. J. Fish. Res. Board. Can. 34:887-898.

Miyauchi, D. 1962. Application of the centrifugal method for measuring shrinkage during the thawing and heating of frozen cod fillets. Food Technol. 16(l):70-72.

O’Bannon, B. K. 1988. Fisheries of the United States, 1987. Current Fishery Statistics No. 8700, U.S. Government Printing Office, Washington, D.C. 20402.

Sokal R. F., and F. J. Rohlf. 1969. Biometry. W. H. Freemand and Co., San Francisco, CA, 776 p.

Wootten R., and D. C. Cann. 1978. Round worms in fish. Torry Advisory Note No. 80. Torry Research Station, Aberdeen, Scotland.

Table 1.--Number of worm fragments found in a 16.75 lb (7.6 kg) block of mince from a Brown Finisher.

Length of fragment inches (mm)	Screen* (inches)		
	0.094	0.125	0.188
0.125 (3.2)	4	2	2
0.188 (4.8)	1	3	2
0.250 (3.2)	0	1	5
0.313 (7.9)	0	0	1
0.500 (12.7)	0	0	2
> 0.500 (12.7)	0	0	0

* The 0.094, 0.125, and 0.188 in screens had 2.4, 3.2, and 4.8 mm diameter holes, respectively.

Table 2.--Results of chemical analyses including trimethylamine (TMA) of refined and unrefined cod mince after 1 month storage at -18°C. Values are means ± standard deviations.

	Screen[a]				
	Lot 1[b]		Lot 2[c]		
	None[d]	0.094	None	0.125	0.188
Moisture (%)	83.85 ±0.07	83.51 ±0.08	83.03 ±0.06	83.47 ±0.12	83.28 ±0.12
Protein (%)	15.42 ±0.38	13.99 ±0.52	16.30 ±0.24	16.16 ±0.12	16.20 ±0.14
Ash (%)	0.95	0.94	-[e]	0.92	0.94
Lipid (%)	0.54	0.46	-	0.52	0.54
TMA (mg N/100 g)	1.90	1.80	1.42	0.79	1.25

[a]The 0.094, 0.125, and 0.188 in screens had 2.4, 3.2, and 4.8 mm diameter holes, respectively.
[b]Minced with Baader 694 with 5 mm drum.
[c]Ground through a plate with 0.188-in (4.8 m) holes.
[d]Unrefined mince.
[e]Hyphen means that no analysis was performed on this sample.

Table 3.--Change in dimethylamine (DMA) and trimetylamine (TMAO) content (mg N/100 g) of refined and unrefined cod mince during storage at -18°C. Values are means ± standard deviations.

	Storage time months	Screen[a]			
		None[b]	0.094	0.125	0.188
DMA	1	3.66	3.24 ±0.20	1.88 ±0.02	2.92 ±0.07
	3	43.4 ±0.7	35.7 ±0.9	32.8 ±0.2	36.9 ±0.1
	6	50.3 ±1.1	48.4 ±0.7	43.5 ±0.2	45.2
TMAO	1	50.0 ±0.1	53.4 ±1.2	56.7 ±0.1	54.4 ±0.8
	3	29.3 ±1.3	38.0 ±2.7	41.2 ±3.4	36.4 ±0.1
	6	28.2 ±1.3	32.9 ±0.2	35.2 ±0.2	26.9 ±2.2

[a]The 0.094, 0.125, and 0.188 in screens had 2.4, 3.2, and 4.8 mm diameter holes, respectively.
[b]Unrefined mince from Lot 1.

Table 4.--Change in thaw drip of portions from blocks of refined mince and unrefined cod mince during storage at -18°C. Values are means ± standard deviations.

Storage time months	Screen[a]			
	None[b]	0.094	0.125	0.188
1[c]	8.67 ±0.24	4.80 ±0.95	2.64 ±0.40	5.63 ±0.16
3[c]	1.26 ±0.73	0.49 ±0.50	0.07 ±0.00	0.10 ±0.04
6[d]	49.8 ±0.1	50.5 ±0.7	52.7 ±0.2	49.4 ±1.4

[a]The 0.094, 0.125, and 0.188 in screens had 2.4, 3.2, and 4.8 mm diameter holes, respectively.
[b]Unrefined mince from Lot 1.
[c]Immersion method.
[d]Centrifugal method.

Table 5.--Change in Hunter L*, a*, and b* values of refined and unrefined cod mince during storage at -18°C. Values are means ± standard deviations.

	Storage time months	Screen[a]			
		None[b]	0.094	0.125	0.188
L*	1	55.9 ±2.5	57.0 ±1.4	56.8 ±1.3	55.9 ±0.5
	3	53.6 ±3.2	56.1 ±0.9	55.0 ±0.6	53.8 ±1.3
	6	52.5 ±1.0	59.4 ±1.1	58.9 ±0.5	57.0 ±2.3
a*	1	0.5 ±0.9	0.3 ±0.3	-0.1 ±0.1	0.5 ±0.4
	3	0.5 ±0.5	0.1 ±0.1	0.9 ±0.1	0.8 ±0.3
	6	0.1 ±0.4	0.2 ±0.4	0.6 ±0.2	1.1 ±0.2
b*	1	5.2 ±2.4	6.8 ±0.6	4.6 ±0.7	4.5 ±1.2
	3	4.5 ±1.7	5.9 ±0.7	4.6 ±0.1	3.7 ±0.0
	6	5.1 ±1.1	7.3 ±0.7	7.0 ±0.3	6.3 ±0.5

[a]The 0.094, 0.125, and 0.188 in screens had 2.4, 3.2, and 4.8 mm diameter holes, respectively.
[b]Unrefined mince from Lot 1.

Table 6.--Change in sensory scores of refined and unrefined cod mince during storage at -18°C. The F statistic and its associated probability (P) are included for a series of one-way analysis of variance (ANOVA) tests. Values are means ± standard deviations.

	Storage time months	Screen[1]				ANOVA F P
		None[2]	0.094	0.125	0.188	
Flavor	1	5.20	5.30	5.50^{A}	5.40^{A}	0.085
		±1.69	±1.42	±1.18	±1.26	0.968
	3	5.10	4.80	4.00^{B}	4.80^{A}	1.738
		±0.88	±1.48	±1.15	±0.92	0.177
	6	4.25	4.00	3.63^{B}	3.75^{B}	0.493
		±1.39	±0.76	±1.06	±0.74	0.690
ANOVA	F	1.27	2.26	7.14	4.85	
	P	0.298	0.125	0.004	0.017	
Chewiness	1	3.10^{aA}	4.10^{bA}	4.20^{bA}	4.10^{bA}	6.783
		0.57	±0.74	±0.63	±0.56	0.001
	3	3.90^{aB}	4.50^{abA}	5.30^{cB}	4.70^{bcA}	5.556
		±0.57	±0.98	±0.82	±0.67	0.003
	6	4.63^{aC}	5.75^{bB}	6.38^{bC}	6.13^{bB}	6.652
		±0.92	±0.71	±0.74	±0.99	0.002
ANOVA	F	11.17	9.48	19.47	16.94	
	P	0.000	0.001	0.000	0.000	
Moistness	1	3.90^{A}	4.50	3.50^{A}	3.50^{A}	2.65
		±0.57	±0.97	±1.27	±0.71	0.064
	3	4.70^{B}	4.00	4.30^{A}	4.50^{B}	0.830
		±1.16	±0.94	±0.95	±1.08	0.486
	6	5.00^{B}	5.00	5.63^{B}	5.38^{B}	0.66
		±0.93	±1.31	±1.07	±0.92	0.583
ANOVA	F	3.57	1.96	8.29	9.46	
	P	0.043	0.162	0.002	0.001	

Table 6.--Continued.

	Storage time months	Screen[1] None[2]	0.094	0.125	0.188	ANOVA F P
Desir-ability	1	5.00 ±1.88	5.10[A] ±1.66	5.50[A] ±1.27	5.50[A] ±1.43	0.283 0.842
	3	5.40 ±1.07	5.40[A] ±1.58	4.30[A] ±1.25	4.90[A] ±1.20	1.651 0.196
	6	4.00 ±1.60	3.25[B] ±1.16	2.75[B] ±1.49	3.13[B] ±1.64	0.995 0.410
ANOVA	F	1.87	5.13	9.53	6.56	
	P	0.175	0.014	0.001	0.005	

[1] The 0.094, 0.125, and 0.188 in screens had 2.4, 3.2, and 4.8 mm diameter holes, respectively.
[2] Unrefined mince from Lot 1.
[ABC]Means in the same column sharing the same capital letter were not significantly different ($P < 0.05$).
[abc]Means in the same row sharing the same lower case letter were not significantly different ($P < 0.05$).

Table 7.--Distribution of texture scores of refined and unrefined cod mince during storage at -18°C.

Storage time months	Screen[a]	Fibrous	Grainy	Flakey	Spongy	Mushy	Crumbly	Rubbery
1	None[b]	1	2	2	1	3	1	
	0.094		4	2	4			
	0.125		2	2	4	2		
	0.188		1	3	5	1		
3	None	2	2	3	2	1		
	0.094		1	1	7			1
	0.125		1	1	2			5
	0.188		3	1	5			1
6	None	1	1	1	5			
	0.094		2	2	4			3
	0.125	1		1	3		1	2
	0.188	1	2		4			1

[a]The 0.094, 0.125, and 0.188 in screens had 2.4, 3.2, and 4.8 mm diameter holes, respectively.
[b]Unrefined mince from Lot 1.

Table 8.--Changes in stress, and strain at failure, and Young's modulus of cooked portion of cod mince and refined mince during storage at -18°C. Values are means ± standard deviations.

	Storage time months	Screen[1] None[2]	0.094	0.125	0.188	ANOVA F P
	1	0.69[a] ±1.88	1.12[abA] ±1.66	1.55[cA] ±1.27	1.32[bcA] ±1.43	5.18 0.842
Stress Kg	3	1.19[a] ±0.25	2.85[bB] ±0.54	3.55[cB] ±0.46	1.73[aA] ±0.45	26.50 0.000
	6	1.80[a] ±0.82	3.85[bB] ±1.46	5.27[cC] ±0.89	3.69[bB] ±1.04	7.83 0.001
ANOVA	F	2.63	18.81	70.77	14.07	
	P	0.165	0.000	0.000	0.000	
	1	0.696[A] ±0.055	0.748[A] ±0.071	0.761[A] ±0.046	0.700[A] ±0.099	0.98 0.427
Strain	3	0.806[B] ±0.067	0.913[bB] ±0.016	0.888[bcB] ±0.023	0.851[abB] ±0.082	5.12 0.009
	6	0.529[aA] ±0.128	0.703[bA] ±0.066	0.769[bA] ±0.015	0.764[bA] ±0.061	12.51 0.000
ANOVA	F	6.50	25.54	48.82	3.93	
	P	0.041	0.000	0.000	0.005	

Table 8.--Continued.

	Storage time months	Screen[1] None[2]	0.094	0.125	0.188	ANOVA F P
	1	0.97^{aA} ±0.29	1.49^{aA} ±0.08	2.05^{bA} ±0.15	1.87^{bA} ±0.21	6.98 0.003
Young's Modulus	3	1.48^{aA} ±0.35	3.11^{bB} ±0.58	3.99^{cB} ±0.45	2.02^{aA} ±0.38	29.04 0.000
	6	3.34^{aB} ±0.75	5.38^{bC} ±1.67	6.85^{cC} ±1.08	4.82^{abB} ±1.27	6.53 0.000
ANOVA	F	2.63	18.81	70.77	17.68	
	P	0.165	0.000	0.000	0.000	

[1] The 0.094, 0.125, and 0.188 in screens had 2.4, 3.2, and 4.8 mm diameter holes, respectively.

[2] Unrefined mince from Lot 1.

[ABC]Means in the same column sharing the same capital letter were not significantly different ($P < 0.05$).

[abc]Means in the same column sharing the same lower case letter were not significantly different ($P < 0.05$).

NAME ____________ DATE ____________ CODE ____________

FLAVOR	CHEWINESS
7-Excellent	7-Very tough
6	6-Tough
5	5-Slightly tough
4-Bland	4-Firm
3	3-Slightly soft
2	2-Soft
1-Extremely bad	1-Very Soft

TEXTURE	MOISTNESS	DESIRABILITY
7-Fibrous	7-Very dry	7-Very desirable
6-Grainy	6-Dry	6-Desirable
5-Flaky	5-Slightly dry	5-Slightly desirable
4-Spongy	4-Moist	4-Neutral
3-Mushy	3-Slightly juicy	3-Dislike slightly
2-Crumbly	2-Juicy	2-Undesirable
1-Rubbery	1-Very juicy	1-Very undesirable

SAMPLE NO.

FLAVOR				
CHEWINESS				
TEXTURE				
MOISTNESS				
DESIRABILITY				
COMMENTS				

LIGHTER COLOR RANK DARKER

Figure 1.--Sample ballot.