CODE OF PRACTICE FOR FROZEN SURIMI

Joint FAO/WHO Food Standards Program

CODEX ALIMENTARIUS COMMISSION

This Code of Practice has been written for the use of those engaged in the frozen surimi production industry.

Frozen surimi, which is raw material and not intended for direct human consumption, in brief terms, is myofibrillar protein isolated from fish meat protein by washing that is further heat treated and consumed in the form of surimi-based products. It should be kept in mind that frozen surimi was originally developed as raw material for surimi-gel that is produced by taking advantage of the gel forming ability possessed by myofibrillar proteins. Therefore, certain properties specifically required for surimi-based products should be taken into consideration, and it should be fully understood that it is in this point that code of practice for frozen surimi is different from the codes of practice for all the other fish products.

This Code of Practice provides for technological, essential hygienic and quality inspection requirements for the production of frozen surimi that can be used for manufacturing high quality surimi-based products, and is based on established and recognized good commercial practices.

In addition, this Code is intended for guidelines for the elaboration of quality standards and quality control inspection programmes in countries where these have not yet been established.

However, since most of the practical information pertaining to the technology and hygiene of the production of frozen surimi has been based upon experiences gained in Japan and the United States of America, this Code is not intended to be strictly applied in all countries producing frozen surimi. The establishment of a code of any country, in accordance with this Code, will probably require the consideration of various conditions and consumers' tastes in the country concerned. In order words, a national code of practice of any country could be developed from the information contained in this Code supplemented by taking into consideration the species of fish and the various conditions of the country in question.

Moreover, this Code has been prepared based on **Alaska pollock** (*Theragra chalcogramma*), which constitutes the great majority of frozen surimi production in the world.

This Code, though, will require periodic revision, since the increase of surimi made from other fish species, as well as further technological development, can be foreseen.

1. ESSENTIAL FINAL PRODUCT REQUIREMENTS

These end product specifications describe the essential requirements for frozen surimi. These essential requirements are factors describing the minimal health and hygiene provisions, which must be met in order to comply with the requirements contained in Codex standards.

Frozen surimi is myofibrillar protein concentrate prepared from fish meat without retaining the original shape of fish, so that it is difficult to determine its quality from its appearance. Moreover, it is generally not consumed directly, but further processed. This means, therefore, that the quality of frozen surimi is measured by the compositional properties and the functional properties of surimi-based products. Therefore, it is strongly recommended to inspect functional properties, such as those outlined in Appendix II, which are different from those for other fishery products.

1.1 Essential Health and Hygiene Requirements

When tested by appropriate methods of sampling and examination prescribed by Codex Alimentarius Commission (CAC), the product:

1. shall be free from microorganisms or substances originating from microorganisms in amounts that may represent a hazard to health in accordance with standards established by the CAC; and
2. shall not contain any other substance in amounts that may represent a hazard to health in accordance with standards established by the CAC.

The final product shall be free from any foreign material that poses a threat to human health.

1.2 Essential Final Product Quality Requirements

When tested by appropriate sampling and acceptance procedures prescribed by the CAC, the presence of the following defects in sample units of final product will render the sample unit to be in non-compliance.

1.2.1 Foreign matter

The presence in a sample unit of any matter that has not been derived from fish (excluding packaging material), does not pose a threat to human health, and is readily recognized without magnification or is present at a level determined by any method, including magnification, that indicates non-compliance with good manufacturing and sanitation practices.

1.2.2 Odor and flavor

Surimi affected by persistent and distinct objectionable odors or flavors indicative of decomposition or rancidity.

2. OPTIONAL FINAL PRODUCT REQUIREMENTS

These end product specifications describe the optional defects for frozen surimi. The descriptions of optional defects will assist buyers and sellers in describing the defect provisions, which are often used in commercial transactions or in designing specifications for final products.

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It is most important to evaluate the following primary test attributes: moisture content, pH, and objectionable matter of raw surimi and gel strength, deformability, and color of cooked surimi gel. Other secondary attributes may be measured as desired.

2.1 Primary Quality Attribute

2.1.1 Raw Surimi Tests

Preparation of test sample:

Put 2-10 kg of frozen surimi in a polyethylene bag, seal the bag, and temper the surimi at room temperature (20^{o}C) or below so that the temperature of the surimi rises to approximately -5^{o}C. Do not soften the surface of the test sample.

2.1.1.1 Moisture

Sample for moisture content should be taken from the interior of a surimi block to insure no freezer burn (surface dehydration) of the sample has occurred. Put the test sample in a polyethylene bag or polyethylene bottle, seal the bag or bottle and let the test sample thaw so the temperature of the sealed article rises to room temperature. Then measure the moisture using any of the following methods:

- In case of using a drying oven method, see AOAC Method.
- In case of using an infrared lamp moisture tester, take out 5 g of the test sample precisely weighed with a sample tray, and dry it immediately.
- In case of using a microwave drying moisture tester, see AOAC Method.

Calculate the moisture according to the following formula to the first decimal place. In any measurement methods, test two or more test samples and indicate the average value obtained thereby. When measuring a fatty test sample with a microwave drying moisture tester, cover the top of the sample tray with glass fiber paper to prevent fat from splashing, while drying.

$$\text{Moisture (\%)} = \frac{\text{Pre-dry weight (g) - After-dry weight (g)}}{\text{Pre-dry weight}} \times 100$$

2.1.1.2 pH

Add 90 or 190 ml of distilled water to 10 g of the test sample as need to disperse. Homogenize the mixture and then measure pH of the suspension with a glass electrode pH meter to second decimal place. Indicate the value obtained thereby.

2.1.1.3 Objectionable matter

The term "objectionable matter" as used in this item shall mean skin, small bone, and any objectionable matter other than fish meat.

Spread 10 g of the test sample to the thickness of 1 mm or less and count the number of visible objectionable matter in it. Indicate the value obtained thereby, provided an objectionable matter of 2 mm or larger shall be counted as one and an objectionable matter smaller than 2 mm shall be counted as one half and any unnoticeable matter smaller than 1 mm shall be disregarded.

The inspection method for distinguishing scales visibly unnoticeable is specified in Appendix 2.2.1.1.

2.1.2 Cooked Surimi Gel Tests

2.1.2.1 Gel strength and deformability

Two methods are presented here. The test to use should be decided upon between buyer and seller.

2.1.2.1.1 Puncture test

Preparation of test sample:

Put 2-10 kg of frozen surimi in a polyethylene bag, seal the bag, and temper the surimi at room temperature (20^{o}C) or below so the temperature of the surimi rises to approximately -5^{o}C. Do not soften the surface of the test sample.

Preparation of surimi gel for testing: Surimi gel not containing added starch

A. Comminution

Sample volume necessary for surimi paste preparation depends on the capacity of mixing instrument used. Use of 1.5 kg or more is necessary to represent the property of a 10 kg block. Regarding that enough amount of surimi is necessary for consistency of testing, equipment of large capacity, which can mix surimi of 1.5 kg or more, must be installed in laboratory. When you use larger size of the equipment, you also need to put in adequate amount of surimi in accordance with equipment to secure enough texture of surimi paste. Crush 1.5 kg or more of

the test sample with a silent cutter, then add 3% of salt. Further grind and mash the sample for 10 minutes or more into homogenized meat paste. Remember to keep the temperature of the material to be tested, at 10°C or less.

Desirable timing for adding salt is at -1.5°C.

Desirable temperature of the test material is 5-8°C.

B. Stuffing

Stuff approximately 150 g of the meat paste into a polyvinylidene chloride tube of 48 mm width (30 mm in diameter) and then flatten (resulting in approximately 20 cm in length). Stuffing can be done with a 18 mm diameter stuffing tube. After stuffing, tie the both ends of the tube.

C. Heating

Heat the test material in hot water of 87 ± 3°C for 30 minutes. At the time the test material is put in, the temperature drop should not exceed 3°C.

D. Cooling

Immediately after finishing the heating treatment, put the test material in cold water and fully cool it. Then leave it at the room temperature for 3 hours or longer.

Test Method

Perform between 24 and 48 hours after cooking the following measurements of the prepared inspection sample of surimi gel. The temperature of gel should equilibrate to the room temperature and record the temperature of the sample at the time of measurement.

Measure gel strength and deformability of the inspection sample of surimi gel with a squeeze stress tester (rheometer). Use a spherical plunger, of which diameter shall be 5 mm and speed shall be 60 mm/minute.

Remove film off the inspection sample of surimi gel, cut into 25 mm long test specimen, and place test specimen on the sample deck of the tester so the center of the test specimen will

come just under the plunger. Apply load to the plunger and measure the penetration force in g and the deformation in mm at breakage.

Record the obtained value of the penetration and deformation in g by integral number. Record the obtained value of the deformation in mm to the first decimal place.

Prepare six or more test specimens from the same inspection sample of Surimi gel and test each of them. Record the average values obtained thereby.

2.1.2.1.2 Torsion test

Preparation of the surimi gel test specimen

A. Comminution

Temper frozen surimi at room temperature (near 25°C) for 1 hour or in a refrigerated tempering room to approximately -5°C. Cut the tempered surimi blocks into slices or chunks and load into the bowl of a silent cutter or cutter/mixer equipped for vacuum use. First, reduce the frozen surimi to a powder by comminution at low speed without vacuum. Add sodium chloride (2% on total batch weight basis) and ice/water (sufficient to obtain 78% final moisture content on total batch weight basis). Secure the lid and begin chopping again at low speed with no vacuum, gradually (if possible) increasing to high speed (about 2000 rpm). At the point that the mixture becomes a single mass, turn on the vacuum pump and allow approximately 70-80% of a full vacuum (approximately 20- 25 inch Hg or 500-650 mm Hg) to be obtained. During comminution, insure that paste is scraped from the walls and balls of paste are forced down into the blades of a cutter/mixer. Discontinue chopping when a temperature of 5-8°C is obtained. A minimum 6 min chopping time is recommended.

B. Stuffing

Transfer the paste to the sausage stuffer with a minimum of air incorporation. Maintain paste temperature below 10°C at all times. Stuff into polycarbonate or stainless steel tubes 1.9 cm (i.d.) of an appropriate length, typically about 20 cm. Tubes should be sprayed with lecithin

release agent before filling. Stuff the paste uniformly and without air pockets into tubes. Cap or seal both ends and place in ice bath until ready to heat process (within one hour).

C. Heating

Heat process by immersing filled tubes in a water bath previously equilibrated to the proper temperature. Time-temperature relationships for thermal processing are: low temperature setting ability: 0°-4°C for 12-18 hours, followed by 90°C for 15 min; median temperature setting ability: 25°C for 3 hours, followed immediately by 90°C for 15 min; high temperature setting ability: 40°C for 30 minutes, followed immediately by 90°C for 15 min; evaluation of protease activity: 60°C for 30 minutes, followed immediately by 90°C for 15 min; rapid cooking effect: 90°C for 15 minutes. It is recommended that water baths be heated to about 5°C higher than the intended treatment temperature, to account for the heat loss experienced upon loading, and the temperature be adjusted approximately within 2 minutes, possibly requiring ice addition.

Only cold water species will demonstrate good setting ability at lower temperatures. The heat process used to prepare the sample should be specified; if not, it is assumed that only the rapid cooking effect is being assessed. Relative proteolytic activity is assessed by comparing tests conducted on gels prepared at 60°/90°C with those processed only at 90°C.

Ohmic heating can be used as a means of heating method. Heat is uniformly generated through electrical resistance. Paste placed in a chlorinated PVC tube is heated between two electrodes. Internal temperature of 90°C can be reached within 1 min. Heating rate (fast and slow) can be controlled linearly. This method provides another advantage: Pacific whiting surimi or others with proteolytic enzymes can be successfully gelled (without enzyme inhibitors) under ohmic heating because fast heating can inactivate the enzyme.

D. Cooling

After heat processing, quickly transfer tubes to an ice water bath and equilibrate to 0°C. Remove gels from tubes with a plunger and seal in plastic bags. Keep samples refrigerated until tested (within 48 hours).

Test Method

Perform within 24 hours the following measurements of the prepared inspection sample of surimi gel, whose temperature should be equilibrated to the room temperature (20-25°C).

Measurement of Stress and Strain:

The gel-forming ability of surimi is evidenced by the fundamental rheological properties of the test product when strained to failure (breakage). Allow refrigerated samples to reach room temperature (near 25°C) before testing. Cut test specimens to length of about 30 mm. Attach specimens to mounting discs at each flat end with cyanoacrylate glue, being careful to place samples in center of mounting discs. Mill the center of test specimens to a capstan shape, the milled portion being 1 cm. in diameter. Mount the milled test specimen in the torsion rheometer. Rotate top of sample to the point of sample failure (breakage), record torque, and rotational distance at this point. Calculate and report stress and strain, respectively, at sample failure as: Stress = τ = 1581 x (torque units); Strain = ln $[1 + (\gamma^2/2) + \gamma(1+\gamma^2/4)^{0.5}]$, where γ = 0.150 x (rotational distance, mm) - 0.00847 x (torque units). In practice these equations are normally programmed onto a computer linked to the torsion rheometer for data acquisition and analysis, thus yielding directly the stress and strain measurements.

2.1.2.2 Color

Cut the inspection sample of Surimi gel into flat and smooth slices 15 mm or more thickness, and immediately measure, with a color-difference meter, the cross section of the slice pieces for the values L*(lightness), a* (red-green), and b* (yellow-blue) to the first decimal place. Test three or more slice pieces and indicate the averages of the values obtained thereby.

2.2 Secondary Quality Attributes

2.2.1 Raw Surimi Tests

Preparation of test sample:

Put 2-10 kg of frozen surimi in a polyethylene bag, seal the bag, and defrost the surimi at room temperature (20°C) or below so the temperature of the surimi rises to approximately -5°C. Do not soften the surface of the test sample.

2.2.1.1 Objectionable matter (scales)

After measurement, according to Appendix 2.1.1.3, add 100 ml of water to the same test sample, homogenize, add 100 ml of 0.2M-NaOH solution to it and dissolve with a stirrer. Filter the dissolved solution with filter paper (No.2), wash the residue with water, and then dry it at 105°C for 2 hours. Count the number of scales obtained thereby and indicate that number in brackets appearing subsequent to the number of the objectionable matter according to Appendix 2.1.1.3.

After having dissolved, leave the dissolved solution still to insure precipitation, and scoop up as much skim as possible before filtration.

2.2.1.2 Crude protein content

AOAC Kjeldahl Method

2.2.1.3 Sugar content

Precisely weigh 10 g of the test sample, put it in a 50 ml beaker, add 10 ml of 2% trichloroacetic acid (TCA) solution, and fully stir the material. Leave it still for approximately 10 minutes, stir again, and leave still for 10 minutes. Filter with filter paper (No.2), drop some part of the filtered liquid on a refractometer (for Brix 0-10% use), and read the graduation on the refractometer. Apply the reading to the following formula and calculate a value to the first decimal place. Indicate the value obtained thereby.

Calibrate in advance the refractometer at a specified temperature with distilled water.

Sugar (%) = 2.04 x Brix (%) - 2.98

2.2.1.4 Crude fat content

Put in a mortar, a precisely weighed 5-10 g of test sample with approximately the same quantity of anhydrous sodium sulfate and a small amount of refined sea sand. Mash the material uniformly into dry powder and put it in a cylindrical filter paper. Do not fail to take out and put in the cylindrical filter paper the powder remaining in the mortar by the use of a small amount of ethyl ether and absorbent cotton. Extract and determine the fat according to Soxhlet method and calculate a value according to the following formula to the first decimal place. Indicate the value obtained thereby.

Fill the ends of the cylindrical filter paper with a slight amount of absorbent cotton so the material to be tested will not fall out.

Dry the extraction receptacle in advance at 100 - 106°C, and weigh it. Extraction speed shall be 20 times per hour.

$$\text{Crude Fat (\%)} = \frac{(W_1 - W_0)}{S} \times 100$$

S : Quantity of test sample taken (g)

W_0 : Weight of receptacle (g)

W_1 : Weight of receptacle after fat has been extracted (g)

2.2.1.5 Color and whiteness

Color: Temper frozen surimi completely to room temperature (near 25°C). Fill into a 50 ml glass beaker (4 cm diameter, 5.5 cm height) and measure color values of L*, a*, and b* (CIE Lab system) to the first decimal point. Complete contact between the test specimen and the colorimeter measurement port, as well as filling of the beaker with no voids, is recommended for consistent results. Measure three or more samples and record the average value.

Whiteness: Whiteness can be calculated as: whiteness = L* - 3b* or whiteness = 100 - $[(100 - L^*)^2 + a^{*2} + b^{*2}]^{0.5}$.

2.2.1.6 Pressure induced drip

Defrost 50 g of the test sample and put it in a circular cylinder of 35 mm inner diameter and 120-150 mm long made of stainless steel or synthetic resin, which has 21 holes of 1.5 mm

diameter, 3 mm from each other, opened in the bottom. Immediately apply 1 kg of load with a pressurizing cylindrical rod of 34 mm diameter, of which weight shall be included in the load. Leave as it is for 20 minutes and then measure the weight of the dripped liquid. Calculate its percentage to the weight of the test sample to the first decimal place. Indicate the value obtained thereby.

2.2.2 Cooked Surimi Tests

2.2.2.1 Preparation of test sample

2.2.2.1.1 Water-added surimi gel:

A. Comminution

Sample volume necessary for surimi paste preparation depends on the capacity of mixing instrument used. Use of 1.5 kg or more is necessary to represent the property of 10 kg of block. Regarding that enough amount of surimi is necessary for consistency of testing, equipment of large capacity, which can mix surimi of 1.5 kg or more must be installed in laboratory. When you use larger size of the equipment, you also need to put in adequate amount of surimi in accordance with equipment to secure enough texture of surimi paste. Crush 1.5 kg or more of the test sample with a silent cutter, then add 3% of salt and 20% of 3% cooled salt water, and further grind and mash, for 10 minutes or more, into a homogenized meat paste. However, if using the remaining water-unadded, starch-unadded test material under Appendix 2.2.2.1.2.A, add 20% of 3% cooled salt water only and further grind and mash it for 5 minutes into homogenized meat paste, while keeping the temperature at 10°C or less for cold water species, such as Alaska pollock (*Theragra chalcogramma*). Warm water species may be processed at a slightly higher temperature (not to exceed 15°C). However, better quality will be achieved at a lower temperature.

B. Casing

Same as Appendix 2.1.2.1.1.B

C. Heating

Same as Appendix 2.1.2.1.1.C

D. Cooling

Same as Appendix 2.1.2.1.1.D

2.2.2.1.2 Starch-added surimi gel

A. Comminution

Add 5% of potato starch to the meat paste prepared according to the method under Appendix 2.1.2.1.1.A and mix (homogenize) within 5 minutes. Remember to keep the temperature of the test material at 10^{o}C or below all the while. Desirable temperature of the test material is 7-8^{o}C.

B. Stuffing

Same as Appendix 2.1.2.1.1.B

C. Heating

Same as Appendix 2.1.2.1.1.C. However, if performing treatment to secure Suwari (setting), same as Appendix 2.2.2.1.3.C Suwari- treated surimi gel c.

D. Cooling

Same as Appendix 2.1.2.1.1.D.

2.2.2.1.3 Suwari (setting)-treated surimi gel

A. Grinding and mashing

Same as Appendix 2.1.2.1.1.A.

B. Casing

Same as Appendix 2.1.2.1.1.B.

C. Heating

After treatment to secure Suwari (setting) in warm water of 30 ± 2°C for 60 minutes and perform the same heating as Appendix 2.1.2.1.1.C.

D. Cooling

Same as Appendix 2.1.2.1.1.D.

2.2.2.2 Test method

Perform between 24 and 48 hours after cooking the following measurements of the prepared inspection sample of surimi gel whose temperature should equilibrate to the room temperature and record the temperature of the sample at the time of measurement.

2.2.2.2.1 Whiteness

Whiteness, as an index for the general appearance of a surimi gel, can be calculated as: Whiteness = $L^* - 3b^*$ or Whiteness = $100 - [(100 - L^*)^2 + a^{*2} + b^{*2}]^{0.5}$.

2.2.2.2.2 Expressible moisture

Place a slice of surimi gel (2 cm diameter, 0.3 cm thick, and about 1 g in weight) between two filter papers and press them by an oil pressure equipment under a fixed pressure (10 kg/cm^2) for 20 sec.

Calculate the expressible water according to the following formula to the first decimal place. Test three or more pieces of the test sample, and indicate the average value obtained thereby.

$$\text{Expressible water (\%)} = \frac{\text{Pre-pressed weight (g)-after-pressed weight (g)}}{\text{Pre-pressed weight (g)}}$$

Water holding capacity is also used as an index of surimi gel as well as the expressible water. Water holding capacity (%) is calculated as follows.

$$\text{Water holding capacity (\%)} = \frac{\text{Expressible water content (g)}}{} \times 100$$

Total moisture content of pre-pressed sample (g)

2.2.2.2.3 Folding test:

The folding test is conducted by folding a 5-millimeter thick slice of gel slowly in half and in half again while examining it for signs of structural failure (cracks). Make sure the sample is folded completely in half. Keep the folded state for five seconds, then evaluate the change in the shape by 5 - stage merit marks. The minimum amount of folding required to produce a crack in the gel determines the score for this test. Test three or more slice pieces of the same inspection sample and indicate the average mark obtained. In case of folding by hand, apply constant power throughout the folding surface.

Merit Mark	Property
5	No crack occurs even if folded in four.
4	No crack occurs if folded in two, but a crack(s) occur(s) if folded in four.
3	No crack occurs if folded in two, but splits if folded in four.
2	Cracks if folded in two.
1	Splits into two if folded in two.

2.2.2.2.4 Sensory (Biting) test

Bite a 5 mm thick slice piece of the gel sample and evaluate its resilience upon touch to teeth and cohesiveness upon bite by 10-stage merit marks. Test three or more slice pieces of the same inspection sample by a panel consisting of three or more experts and indicate the average mark obtained thereby. Merit marks 2, 3, 4, 5 and 6 corresponds to the folding merit marks 1, 2, 3, 4 and 5 (above), respectively.

Merit Mark	"Ashi" (footing) Strength	Merit Mark	"Ashi" (footing) Strength
10	Extremely strong	5	Slightly weak

9	Very strong	4	Weak
8	Strong	3	Very weak
7	Slightly strong	2	Extremely weak
6	Fair	1	Incapable to form gel