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Improving the Supply of Minced Blocks for the Fish Stick Trade: A Progress Report

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BACKGROUND

The scarcity of fish blocks and the increasing demand for fish sticks have prompted us to develop a process for making minced blocks using fish frames (a fish backbone after fillets have been removed). At present, these frames are utilized for meat or fertilizer even though their flesh is essentially the same as the flesh of the fillets cut from them. Besides this white flesh, the frames contain blood-rich tissues right under the backbone. Since these tissues are as soft as the white muscle, they will pass through with it in a meat-bone separator. The blood pigments will give the minced flesh a red color (similar to ground beef) or if they become oxidized, a brown or gray color. In a fish stick, any color other than white is usually considered as a defect.

A marketplace for fish sticks made from minced flesh has already been established. These sticks are made from minced flesh obtained from V-cuts (fillet trimmings) which do not contain visible blood pigments. The yield of edible meat from this source is only about 2 percent of the carcass weight. In contrast, fish frames contain about 20 percent machine-separable flesh (based on carcass weight). These considerations have stimulated R&D work to find how to utilize flesh from frames in the manufacture of fish sticks.

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ONE SUGGESTION—DILUTE OR BLEND THE COLOR

We found that the intensity of the blood color in minced blocks could be reduced by dilution. For example, if headed and gutted fish are passed through a meat-bone separator, the minced flesh will be whiter because it contains a greater proportion of white muscle. A similar method of dilution is to mix fillet trimmings or V-cuts with the frames and pass this mixture through a meat-bone separator. This method saves the fillet meat for sale as regular fillets; but it, too, does not decolorize the blood pigments specifically. We have also used selective cuts from frames (such as tail sections, belly flaps, etc.) to avoid passing the blood-rich tissues through a separator. This method does reduce the intensity of color in the minced flesh. It also reduces the yield of edible meat from the carcass and introduces the costs of making the selective cuts.

Another method of increasing the whiteness of minced fish flesh is to blend it with a suitable flour or a similar white vegetable product. This method has been used by Japanese firms for several years in making traditional products such as kamaboko (Tanikawa, 1971). It can be applied to occidental seafood products such as fish cakes. However, it is obviously not suitable for the manufacture of all-fish-flesh products.

ANOTHER SUGGESTION—WASH OUT THE COLOR

None of the above methods attempts specifically to decolorize or remove the colored blood pigments. Chemical additives such as hydrogen peroxide or sodium hypochlorite can whiten fish flesh, but their employment can introduce unacceptable deterioration in texture and flavor. The Japanese method of making minced fish blocks (surimi) involves washing minced flesh with copious amounts of water after it has been separated from bone and skin as well as using headed and gutted fish to obtain the minced flesh (Tanikawa, 1971). The advantages of this method of leaching blood pigments from minced fish flesh prompted us to study its adaptability for making minced blocks from fish frames or headed and gutted fish that would be suitable for the manufacture of fish sticks.

TEST METHODS FOR WASHING SUGGESTION

This method of preparing minced fish blocks is based on the following sequence of steps:

1. Remove heads and viscera (if present) from frames or whole fish.

2. Pass raw material through a meat-bone separator and wash the flesh while it is being separated.
3. Dewater the minced flesh.
4. Pass dewatered flesh through a strainer.
5. Prepare minced fish blocks from the strained material.

Several species have been used so far in these tests. Filleting leftovers (backbones or frames) have included: cod *(Gadus morhua)*, tom cod *(Microgadus tomcod)*, cusk *(Brosme brosme)*, flounder, mixed *(Pseudopleuronectes americanus, Limanda ferruginea, Hippoglossoides platessoides,* and *Glyptocephalus cynoglossus)*. Headed and gutted species have included: whiting *(Merluccius bilinearis)*, ocean perch *(Sebastes marinus)*, and herring *(Clupea harengus)*. Fresh water species (all headed and gutted) have included: carp *(Cyprinus carpio)*, sucker *(Catostomus commersonni)*, sheepshead *(Aplodinotus grunniens)*, and white amur *(Ctenopharyngodon idellus)*. With the exception of herring, the edible flesh of these species consists mostly of white muscle with a small amount of dark, lateral line muscle. Again, with the exception of herring, we found that species differences were less important than our processing and handling variables in influencing the quality of our minced blocks.

Heading and Gutting

Removal of heads and viscera (if the fish were not gutted at sea) is presently done by hand labor. Using a band saw to cut off the heads has increased productivity but heading and gutting equipment would be more satisfactory. Such equipment is available for certain species or sizes and shapes, but there is a need for more versatile heading and gutting equipment to match the versatility and throughput of meat-bone separators.

Flesh Separation and Washing

Flesh can be removed from skin and bone in a variety of commercially available meat-bone separators. We are using a Bibun Model 15 separator[1] (Figure 1; see also Figures 2, 3, and 4). This machine contains a wide flexible belt that moves against the outside of a rotating, perforated metal drum. The belt and drum move at different speeds in the same direction. Since these speeds are different, flesh is separated by a shearing action as well as the mechanical pressure between belt and drum. The flesh passes through the holes of the drum while bones and skin are dumped off the end of the belt. Although we have used drums with 3 mm or 5 mm holes, we settled on a drum with 7 mm holes in most of our testing to increase the yield of recovered flesh and to minimize fragmentation of bones in the separator.

[1]The mention of commercial items does not constitute an endorsement by the Department of Commerce over other items of a similar nature not mentioned.

We have found that washing the flesh as it is being separated from bones and skin offers several advantages. The most obvious one is that it leaches a significant amount of blood before the blood clots and becomes insoluble in water. Washing also hastens movement of flesh down the drum and out of the machine. Originally, we used a garden hose with an adjustable nozzle and sprayed the water by hand into the flesh-packed holes of the moving drum. More recently, we mounted adjustable nozzles on the separator itself to eliminate this requirement for hand labor. The amount of water used has been in the order of 2 to 3 times the weight of dewatered minced flesh obtained. This amount of water is considerably less than the ratios of about 7 or more

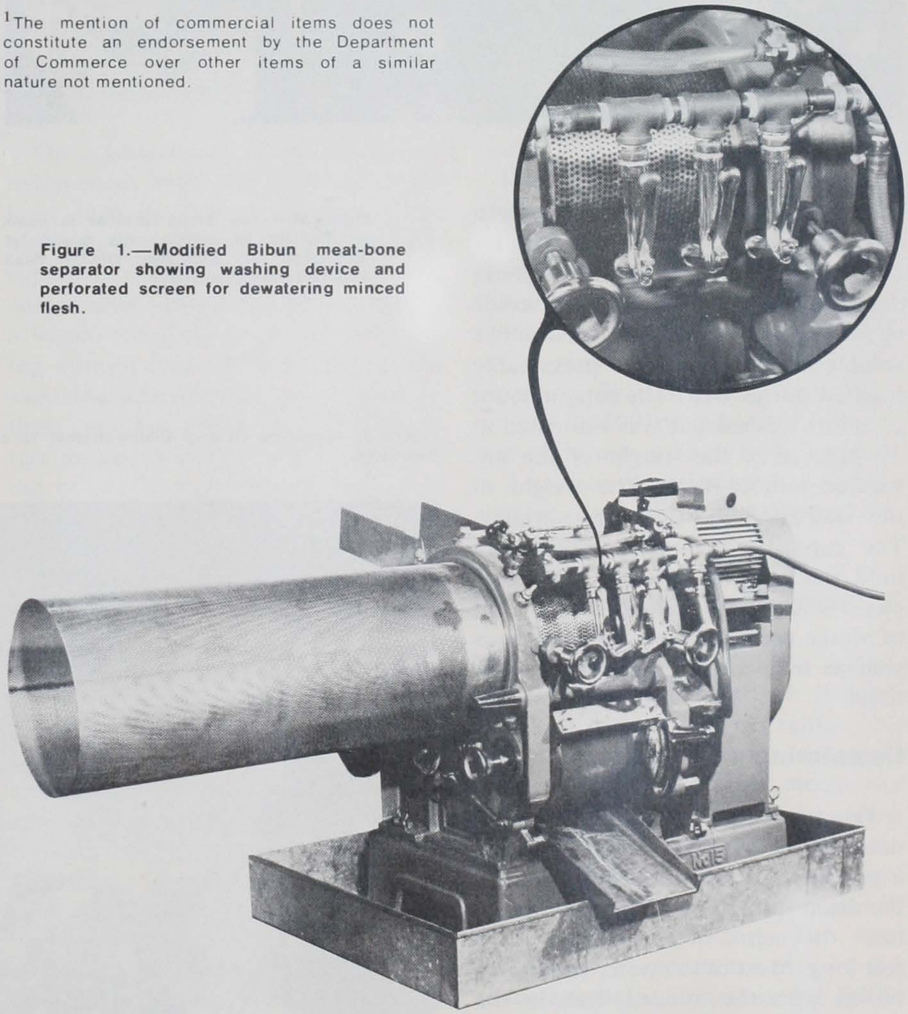


Figure 1.—Modified Bibun meat-bone separator showing washing device and perforated screen for dewatering minced flesh.

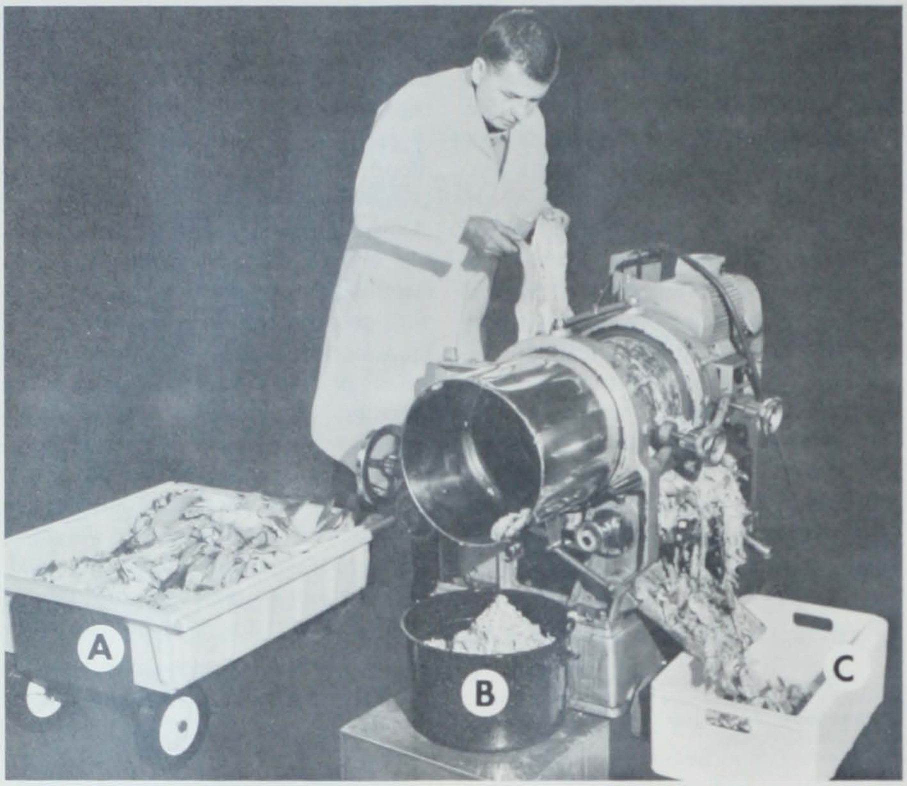


Figure 2.—This Bibun separator is being used to separate minced flesh from filleting leftovers (fish frames), shown at A. The recovered minced flesh is shown at B, the waste at C. This is the machine of Figure 1 without the washing device and the dewatering screen.

to 1 used by Japanese technologists in washing minced flesh to make surimi.

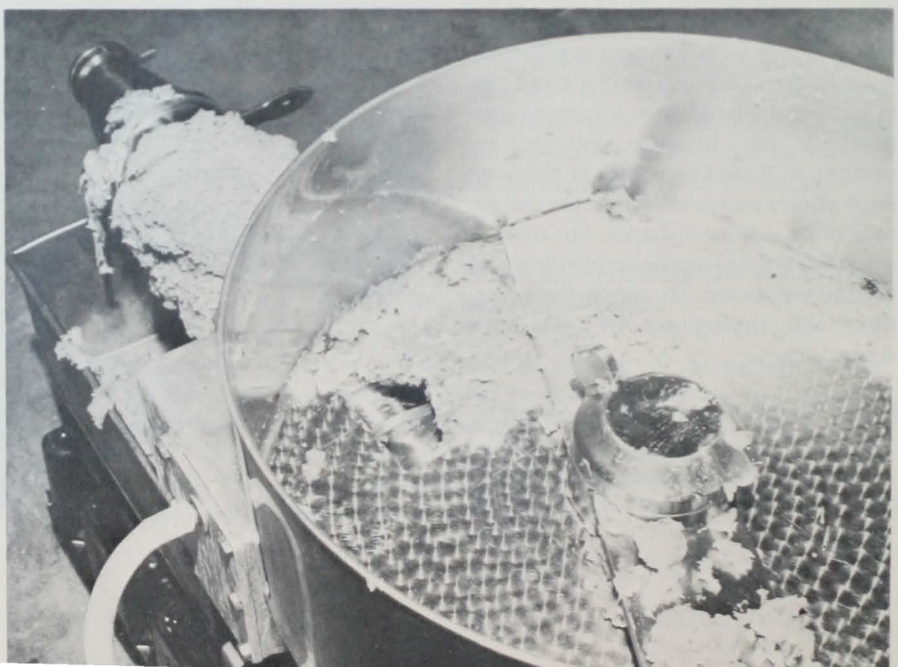
Although our purpose in washing the minced flesh was to reduce color by removing blood pigments, other soluble components were presumably leached out as well. The total amount of solids washed out was estimated at 10 percent of the weight of the unwashed minced flesh. The weight of the washed flesh itself was variable. The capacity of muscle proteins to hold water is well known. This capacity is affected by particle size, amount of water used, intimacy of mixing as well as temperature, and time conditions.

Dewatering

Dewatering the minced flesh is the next step in the process. We have put a perforated screen around the end of the drum in the separator. This screen has ⅛-inch holes and is 3 feet long. Most of the water which was mixed with the minced flesh in the

Figure 3.—The Bibun strainer is used, as desired, to improve the quality of dewatered and unwashed minced flesh obtained from a separator.

Figure 4.—Close-up view of Bibun strainer to show separation of minced flesh from skin or bone fragments.



drum drops out during the first third of the minced flesh's travel down this screen. How much water to remove from the minced flesh which drops off this screen and what equipment to use for this dewatering are two problems for which we have only partial answers at the present time.

Removal of excess water is necessary from a technological as well as a consumer viewpoint. For example, in the manufacture of fish sticks, the blocks from which these sticks are cut should have less than 5 percent "drip" (a measure of excess water). If these blocks have more than 5 percent excess water, sticks made from them tend to have too loose a coating of batter-breading and are apt to "explode" during cooking.

On the other hand, removal of too much moisture from minced flesh can accelerate deterioration of the flesh during frozen storage. The relation of moisture content or water activity to rate of lipid oxidation has been worked out in several model system studies as well as in various foods (review by Karel and Flink, 1973). The irreversible denaturation of fish muscle proteins, especially the myofibrillar protein, during frozen storage has been studied from this and other aspects (reviews by Connell, 1968; Dyer, 1968). The rate of this denaturation or loss of water holding capacity might be slowed down by holding the muscle protein under more favorable conditions (King, 1966). To reverse the loss of water-holding capacity by fish muscle proteins, chemical conditions such as the use of detergents or a highly alkaline pH have been suggested, but such conditions are generally unsuited to storing edible fish muscle.

It may be difficult to stop a dewatering operation at the proper time if one relies solely on analyses for moisture content. It is possible for one to develop a rapid, intuitive procedure with a bit of practice and follow-up analytical determinations. After several opportunities for practicing this art, I found that a sample of minced flesh should not form a puddle of water in the open palm of my hand, but this flesh should form a small puddle if I squeezed it gently. This subjective judgment had a surprisingly good correlation with the analytical data obtained from the minced blocks produced from this washed flesh.

Apart from the problem of how much to dewater the minced flesh after it leaves the separator, we are also investigating dewatering equipment which is feasible on a commercial scale. This equipment can be classified into three broad categories: screens, presses, and centrifuges.

On a pilot plant scale, we found that nylon mesh bags ("laundry bags") were a satisfactory type of screen for dewatering. After several empirical tests, we settled on placing about thirty pounds of wet minced flesh in a bag and hanging it on a support in a chill storage room (36° - 40°F). The bag was hung for one hour or less, depending on the time needed to dewater the flesh.

On a commercial scale, the use of nylon mesh bags can introduce problems such as slow throughput rate, high space requirements, and laundry expenses. With the cooperation of commercial processors, we are testing a Sweco vibrating screen for dewatering minced flesh. Several options are available with this equipment. Some of these options affect the throughput rate as well as the amount of dewatering of the washed minced flesh. For example, larger perforations in a screen increase throughput rate (partially because more "fines" escape with the liquid), and a larger diameter screen allows more time for dewatering the flesh. At present, we are using a single No. 20 screen (opening 840 microns, 0.0331 inch) five feet in diameter in a Sweco unit. This may not be the best combination for all applications, and for example, we are contemplating the use of a second Sweco unit to recover the "fines" that pass through the No. 20 screen with the water.

Presses are commercially available in a wide variety of capacities and pressures which can be applied for dewatering. We have used a simple cider press on a pilot-plant scale with essentially the same results as obtained by hanging a nylon mesh bag of minced flesh to dewater it. We are still looking for a press with a commercially feasible throughput and with quite low applied pressures.

Centrifuges are also available in a wide variety of equipment. Our initial experiments in dewatering minced flesh were based on a domestic type washing machine on a spin-dry cycle. The capacity of this batch centrifuge was obviously too small for commercial use, but we gained some useful data using it. Originally, it was capable of generating a centrifugal force of about 70 pounds per pound of flesh. This force tended to overdry the minced flesh so we geared it down to provide a centrifugal force of about 30 pounds per pound of flesh. This lower force was an improvement, but minced blocks made from this dewatered flesh had no drip at all.

On a commercial scale, centrifuges offer advantages of complete recovery of solids (including "fines") and continuous operation. We have used a DeLaval solid bowl centrifuge to dewater minced fish after it had been put through a strainer as well as the separator. By using centrifugal forces of 100 to 500 pounds per pound of flesh, drip was reduced from 8 percent to 3 percent even though the moisture content of these dewatered "fines" was 85 percent.

Flesh Separation by Straining

It is possible to prepare minced blocks from dewatered flesh that has not been put through a strainer. The texture of such blocks is at least equal to to the texture of minced blocks prepared from V-cuts. However, these blocks may not have a uniform appearance. They may have a few blood clots (not soluble in water), small pieces of skin or belly membranes. This non-uniformity in appearance may be disadvantageous in preparing fish sticks from such blocks. Occasionally, a few small bone chips may be found in these blocks; and if found in a fish stick, these chips are not desirable.

To improve uniformity of appearance and freedom from bone chips, we have been putting the dewatered flesh through a Bibun strainer before making minced blocks. This machine uses an auger or "wiper" blade to place the incoming material against a perforated cylindrical screen. A conical tube is used at the far end of the screen to create a slight back pressure which helps squeeze the flesh through the holes of the screen. Bone chips or skin pieces pass through the conical tube along with some of the flesh. This "waste" can be put into a second strainer to increase the yield of flesh if desired.

The perforated cylindrical screen can be fabricated with a variety of different sized holes. We have used screens with holes between 1 and 3 mm diameter. Choosing a size for a particular application involves three considerations: desired size of flesh particles, freedom from skin pieces, and yield of flesh. With a larger hole, the flesh is not minced as thoroughly, but there is a possibility that some small pieces of skin may be forced through the holes. These pieces would give the flesh a non-uniform appearance. This possibility can be avoided by using a very low back pressure in operating the strainer and, if desired, by using a second strainer to separate minced flesh from the "waste" mixture of flesh and skin pieces discharged by the first strainer. On the other hand, using a screen with a smaller hole enables one to use a wider range of back pressures to increase the yield of flesh from a single strainer although this flesh is more thoroughly minced.

Making Blocks

Usually, we have frozen the minced flesh to preserve it. Our techniques were similar to commercial methods for freezing fillets into blocks. The minced flesh was weighed into either a 13½ pound or a 16½ pound waxed chipboard carton, frozen in a plate freezer, then stored at 0° F. We have not used flexible films to inhibit desiccation or oxidative deterioration during storage. Such overwraps have been used successfully to preserve a variety of frozen foods, in general, and to preserve surimi, in particular, by the Japanese industry. However, such overwraps are not common in our regular block industry, and their effect on the storage life of minced blocks has not been determined.

We have not determined the effect of specific compounds on the frozen storage life of minced blocks. In the Japanese method of making surimi, the washing step is designed to remove components which, if left in the minced flesh, can accelerate deterioration in its quality during storage (Tanikawa, 1971). The Japanese method also includes adding salt, sugar, condensed phosphates, or other additives to inhibit protein denaturation (loss of water holding capacity) in the surimi during storage (Tanikawa, 1971). These additives and antioxidants have also been used for storing minced black rockfish blocks to be made into fish sticks (Teeny and Miyauchi, 1972). Unlike most of the species we have used, black rockfish itself is notorious for poor frozen storage life due to lipid oxidation. Our limited experience suggests that, without additives, the useful frozen storage life of minced blocks can be extended by improving the time, temperature, and sanitary conditions of making these blocks, as well as the frozen storage conditions.

EVALUATION OF MINCED FISH BLOCKS

The quality of our minced blocks was evaluated by two organizations, the NMFS Inspection Service and a private consulting laboratory. Both evaluations were made in Gloucester, Massachusetts, on a frozen sample that we provided. Both organizations used the criteria given in Figure 5. Descriptive analyses were based on a 4-point scale (Excellent, Good, Fair, Unacceptable), and numerical analyses were based on standard AOAC methods.

Appearance and Color

Washing the minced flesh did improve the appearance of the minced blocks. The color of these blocks was described as reasonably off-white rather than snow-white. Clotted blood was not removed by the washing treatment, but the strainer treatment broke up these clots and diffused their color into the rest of the flesh. Some variation in color results from the choice of species or form of raw material from which the minced flesh is obtained. We have found that a slight pink color (the color of very dilute normal blood) in a minced block has been synonymous with good odor, flavor, and low total plate counts. In contrast, minced blocks which have a brownish tint (the color of dilute oxidized blood) may have developed a rancid, bitter flavor and/or a higher total plate count.

Odor and Flavor

The majority of the samples received a rating of good or fair by both inspection agencies. Those samples receiving the higher ratings were described as "bland flavor" and having "less odor."

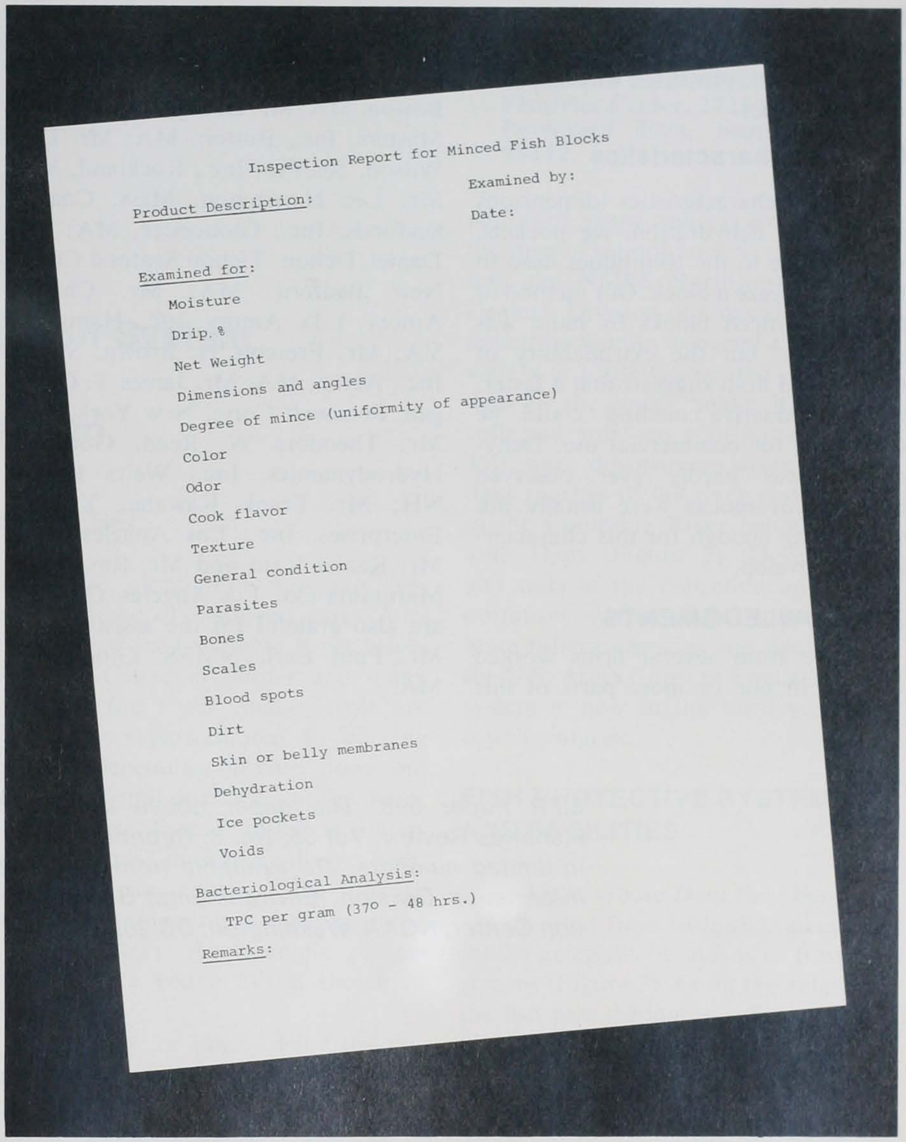
Texture

Comments were made on the texture or "mouth feel" of these minced block samples. These comments were made more frequently on the blocks which had the better ratings for color, odor, and flavor. They included adjectives such as "rubbery" or "tacky." It is not clear whether these adjectives were based on subjective comparison with a typical regular (fillet) block or with a typical minced cod block made from V-cuts. Although textural evaluations tend to be more subjective than taste evaluations, it appears that further R&D work is appropriate to make the textural qualities of minced blocks more acceptable to American consumers.

Moisture and Drip

The moisture content of minced fish blocks prepared from washed flesh has been in the order of 75-85 percent. From the results of our sensory data, we suspect that the flavor and texture of minced fish blocks might be improved if they have a moisture content in the order of 5-10 percent greater than the original fish muscle. Love (1970) has reviewed factors which affect the moisture content of fish muscle itself.

The drip content of the same blocks varied from 0 to 10 percent. Unlike moisture content, drip is a measure of protein quality or water-holding capacity. We have prepared good quality minced blocks with 80-85 percent moisture on several occasions; however, we do not have enough storage data to indicate the suitability of such moisture contents on prolonging the useful storage life of these minced blocks. Our limited experience in storing minced blocks does indicate that minced fish flesh has a greater water holding capacity than intact fish muscle initially, but the minced flesh can be dehydrated more easily by fluctuations in time-temperature storage conditions as well as moisture permeable packaging.



Inspection Report for Minced Fish Blocks

Product Description: Examined by:

Date:

Examined for:

Moisture

Drip. %

Net Weight

Dimensions and angles

Degree of mince (uniformity of appearance)

Color

Odor

Cook flavor

Texture

General condition

Parasites

Bones

Scales

Blood spots

Dirt

Skin or belly membranes

Dehydration

Ice pockets

Voids

Bacteriological Analysis:

TPC per gram (37° - 48 hrs.)

Remarks:

Figure 5.—Inspection report for minced fish blocks.

Bacteriological Analysis

The lowest total aerobic plate counts in our minced blocks were in the order of 10^3 to 10^4 per gram. These counts were highly dependent on the freshness of the raw material. They were influenced by the speed with which we processed this material. They were lowered only slightly by washing the minced flesh before freezing it. When we used freshwater species, coliform and coagulase positive staphlycoccus were also estimated. The results (MPN per gram) did not indicate excessive contamination.

Miscellaneous Materials

Under this heading are categorized such things as parasites, bones, scales, blood spots, dirt, membranes. True parasites such as codworms or Sphyrion buttons were not found, presumably because our raw materials did not contain them. Occasionally a curled piece of white belly membrane was found which superficially resembled a codworm. Bones were not found partly because we excluded bone chips less than ⅛-inch long from our definition of bone. Scales and dirt (foreign materials) were eliminated by separating handling of the raw material from handling of the minced flesh. Blood spots (clots), pieces of skin or belly membrane and bone chips were sometimes found in separated, but not strained, flesh due to the hole size of the separator's drum (3, 5, or 7 mm) and the tension of belt against drum. These pieces were removed by putting the separated flesh through a strainer (1 mm holes in its screen) and avoiding excessive back pressures while operating the strainer.

Physical Characteristics

Physical characteristics (dimensions and angles, dehydration, ice pockets, voids) relate to the techniques used to form and freeze a block. Our method of forming minced blocks by hand was satisfactory, but the extrudability of this minced flesh suggests that a faster, more productive method could be developed for commercial use. Dehydration was hardly ever observed because our blocks were usually not stored long enough for this characteristic to develop.

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