The Commercial Development and Processing of a Caviar Product from Canadian Lake Whitefish (*Coregonus clupeaformis*)

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La page couverture porte le nom de l'établissement auteur où l'on peut se procurer les rapports sous couverture cartonnée.

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In 1977 a market test of an experimental salt-cured whitefish roe product was initiated under the Fisheries Development Program of the Department of Fisheries and Oceans, Industry Services Branch, Western Region. The response to this market test led to industry interest in this opportunity, and participation in roe production in 1978. A brand image has now been established for "Canadian Lake Whitefish Golden Caviar" in the North American market as well as increasing product acceptance in other export markets. The development of this product is discussed as well as the now-established processing procedure.

Key words: fishery products, canned products.

RESUME

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En 1977, un essai de commercialisation d'un produit expérimental à base d'oeufs de corégone salés fut entrepris dans le cadre du programme de développement des pêches du ministère des Pêches et Océans, direction générale des services à l'industrie, région de l'Ouest. Vu le succès de cet essai de commercialisation, l'industrie s'y est intéressée et a pris part à la production d'oeufs de poisson en 1978. Une image de marque du "caviar doré de grand corégone canadien" est bien établie maintenant sur le marché nord-américain, et le produit est de mieux en mieux accepté sur d'autres marchés d'exportation. La mise au point de ce produit est examinée ainsi que le mode de traitement actuel.

Mots-clés: produits des pêches, produits en boîte de fer blanc.

INTRODUCTION

An objective of the Department of Fisheries and Oceans Fisheries Development program is to increase the value of the primary fishing industry to the fisherman/producer. An element of this objective is the requirement to identify and encourage the development of opportunities where both conventional and new techniques can be applied to traditional production and processing practices to promote economic growth. This report discusses such an opportunity in the Western Region of Canada's inland fishery, describing the development of a whitefish roe product, its process requirements, specialized equipment design and the process methodology now in place.

On a value per unit weight basis, fish roe is potentially one of the more important of the miscellaneous food by-products accessible to the fishing industry. In spite of this potential, it has received little commercial attention in Canada's western inland fishery. Whitefish, Coregonus clupeaformis, a freshwater species of major commercial significance can also be an important source of roe for processing as a granular caviar type product. The commercial utilization of this roe has occurred in some instances in some parts of the eastern inland fishery, but apart from some production along with sturgeon roe during the late 1930's and early 1940's, when traditional European sources of caviar to North America were restricted, there has been little evidence of its commercial exploitation in the western fishery.

The factors of economic, social and environmental significance that support the commercial development of a whitefish roe product include:

- enhanced resource value to participating fishermen as roe utilization generates an approximate 30 percent added value to that portion of the whitefish catch.
- creation of seasonal employment for the processing of roe at or near whitefish production locations amounting to approximately 36 person-days per tonne of product.
- consistency with resource management objectives in that roe ripeness appropriate for processing occurs at a time coincident to already existing seasonal fisheries.
- Consistency with the environmental prerequisite of waste reduction through the more total use of the animal.

RESOURCE POTENTIAL

The western inland fishery includes the fisheries of the Northwest Territories, Alberta, Saskatchewan, Manitoba and the northwestern part of Ontario. The production of whitefish from these fisheries during the months of October (the time of appropriate roe ripeness) from 1974 to 1979 has ranged from 461 to 749 metric tonnes (1,017,256 to 1,650,472 pounds) per year. With roe recovery constituting approximately 7 percent of total production, the average production of these six years (639 metric tonnes/1,407,894 pounds) represented a potential yield of 45 metric tonnes (98,553 pounds) of roe equivalent to 38 metric tonnes (83,770 pounds) of finished product. The amount of roe available would actually be greater than indicated since roe matured to an appropriate stage of ripeness for processing can and does occur from as early as mid-September to the latter part of November. The time of roe ripeness varies within these limits depending on yearly climatic conditions, the geographic location (latitude) of the producing fishery and its physical characteristics (lake depth), as all of these influence the lowering of ambient water temperature, a major factor in triggering roe maturation and spawning.

DEVELOPMENT AND ESTABLISHMENT OF PRIMARY PROCESSING METHOD

Apart from some general information on the processing of roe from miscellaneous species of freshwater fish (Jarvis 1950) and a non-specific method for whitefish roe (Zaitsev et al. 1969) there is little published information on the process methodology for salt curing whitefish roe.

The method for processing granular caviar from sturgeon roe requires removing the intact roe sac from the fish, separating the individual eggs from the roe sac membrane by pressing through screens, washing the screened eggs rapidly and briefly in an approximate equal volume of water, draining and adding salt to commence the curing/draining process. Initial processing trials using this method with whitefish roe indicated that extensive washing of the separated eggs was needed before salting could be begun. This is because the roe sac membrane of whitefish is fragile and is thus difficult to remove without breakage and consequent contamination from visceral residues and scales. The washing removes much of these contaminants and also helps develop colour uniformity by removing the blood which is present in varying amounts in different roe sacs as part of the ovarian fluid. Observations have shown that the sensitivity of the roe of different species to water absorption may be markedly different. Although whitefish roe is able to withstand extensive washing, the roe of sucker (Catostomidae) rapidly absorbs water, even with relatively limited contact, rendering it unusable when processed similarly.

The factors influencing final product quality that became evident during experimental processing trials provided the basis for establishing the following criteria:

1. The limited time period at any given production source during which roe ripeness is suitable for processing.
   As previously discussed, the time of roe production commencement and the length of the production period are dependent on the geographic location of the producing source and the seasonal climatic conditions as they affect decreasing water temperatures.

Spawning reportedly occurs at water temperatures in the range of 3 to 6.5°C (37 to 44°F). The time of roe production commencement can be determined by test fishing to evaluate roe development and applying a measurement such as a gonadosomatic index (G.I., where the gonad weight is expressed as a percent of the weight of the whole fish). With whitefish, a G.I. of 14 has been found to be appropriate at most production sources in the western fishery. However, an absolute G.I. should not be considered the final arbiter in establishing appropriate roe ripeness at every whitefish producing source, since the climatic conditions that exist in circumpolar regions influences the cyclical incidence of spawning. Whitefish from far northern locations are believed to spawn at binannual or perhaps even greater intervals. A possible consequence of this could be the considerably higher G.I.s that have been observed in some of these fish by Gillman[1] in 1981. These higher G.I.s could be a biological compensatory factor in ensuring population maintenance. However, with a fewer number of fish producing mature roe in any given year but at the same time producing considerably more roe per fish, the recovery of roe from a total population may well be equivalent.

Further to this, test fishing allows an alternate check to be made to establish appropriate roe ripeness. This is done by measuring a composite sample of eggs from the roe of several fish, in which the eggs should be developed to a mean diameter of 2 to 2.15 mm.

2. <u>Method of separation, handling and care of fresh roe by the fishermen/producer at production sources.</u>
When removing roe sacs from the fish, care should be taken to retain the roe as much as possible within the roe sac membrane to minimize contamination from extraneous matter such as visceral residues and scales. Holding containers for packing the green roe should be constructed of a sanitary food grade material and the surface of the roe then covered with plastic film to exclude air and air-borne contaminants. Finally, the packed roe must be kept at a suitable cool temperature while awaiting transportation to a processing plant. The use of ice for cooling is not recommended because of potential physical damage to the roe. Since production takes place in the fall of the year, the lower ambient temperatures are generally conducive to cool holding of the packed roe.

3. <u>Production location and processing facilities.</u>
The production of high quality caviar from whitefish requires that the fresh roe be processed to the salted form within 24 hours of the fish being harvested. Therefore a primary processing facility must be located within close proximity to the main production locations in each fishing area.

The processing facility must meet the requirements for a registered fish processing plant as described under the Fish Inspection Regulations including proper sanitary conditions, an adequate supply of potable chlorinated water, good drainage facilities and adequate lighting. The plant should also have sufficient refrigerated storage for holding roe prior to and after processing and packing. The processing facility must be located in an area with access to a seasonal labour force.

The processing sequences that evolved from the initial processing trials constitute a "refining" procedure to prepare the roe for salting. This starts with flushing the roe sacs with water. Care must be taken with any semi-intact roe sacs to minimize further breakage and loss of eggs in the wash water. This preliminary washing allows inspection and manual removal of non-roe material from the egg mass and is a primary cleaning procedure where material such as scales, visceral matter, etc., is removed by the wash water.

The steps in processing whitefish roe into a caviar product are:

1. <u>Preliminary washing of roe sacs.</u>
Water flushing of the roe sacs can be done by either of two methods. In both, a single layer of roe sacs is placed to cover the surface of a separating screen (Fig. 1). The surfaces of the roe sacs can then either be flushed with a low pressure spray of cold water or, the separating screen with the roe sacs immersed briefly in a large container of continuously changing or filtered cold water.

2. <u>Separating or screening</u>
Following water flushing, the roe is pressed manually through the separating screen to separate the individual eggs from the roe sac membrane and other connective tissue. The separating screen shown in Fig. 1, consists of an aluminum or stainless steel frame fitted with a plastic screen material, either molded or of a monofilament weave, having openings of approximately 7 mm. The frame, Fig. 2, is constructed to facilitate easy disassembly for cleaning and screen replacement and designed so that it will nest on the surface rim of a standard plastic tote box into which the separated roe falls. After the roe is pressed through the screen, the screen surface is tapped lightly to release adhering eggs, and one edge of the screen frame is raised so that more of the adhering eggs are released by gentle scraping with a rubber spatula. Before reuse, the screen is back-flushed with a high pressure water spray to remove the roe sac membrane remaining on the surface.

3. <u>Washing</u>
The separated roe is placed in a large polyethelene barrel and clean, cold chlorinated

[1] Gillman, V. 1981. Personal communication. Arctic Operations Directorate, Western Region, DFO.

water added in a ratio of approximately 8 parts of water to 1 part of roe. The water and roe are stirred, then the roe is allowed to settle and the supernatant containing blood, fat and some membrane particles, is decanted off. This procedure is repeated until the decant water is clear. The number of times washing and decanting is repeated will depend on the initial condition of the roe, including factors such as the care with which the roe sacs were removed from the fish and the resulting amount of scales and visceral matter present, the care taken in pressing the roe through the separating screens so as to exclude as much roe sac membrane as possible, and in the decanting technique, maximizing the amount of unwanted matter such as broken eggs, and fatty tissue attached to small particles of roe sac membrane, being floated off at each washing. This may also be done nonmanually as in the continuous water flow system illustrated in Fig. 3.

4. Secondary screening
Once the decant water is clear, the roe is passed through an intermediate separating screen to remove scales and any remaining particles of roe sac membrane or connective tissue. The intermediate screen frame shown in Fig. 4 is constructed of stainless steel and designed to be suspended in the upper part of a washing and decanting barrel and moved freely up and down. The plastic screen material used can be either molded or a monofilament weave with mesh openings of approximately 2.5 mm. As indicated in Fig. 5, the screen is attached to the circular metal frame to form a "bag" configuration which contains the washed roe and is suspended in the surface water of a partially filled washing and decanting barrel. With movement of the screen the individual eggs pass into the water while scales and other extraneous material is retained on the surface.

5. Dewatering
The dewatering screen frame shown in figure 6, is constructed of stainless steel, can be easily disassembled for cleaning and/or screen replacement and is designed to contain approximately 10 kg (22 lb) of roe. The weight of the frame plus roe can be readily handled by one operator. The screen material is a nylon monofilament bolting cloth having mesh openings of 950 microns.

Following intermediate screening the roe is transferred to the dewatering screens and allowed to drain. A dewatering period of approximately one hour is required during which the draining roe should be covered with plastic-film which is in contact with the surface of the roe to limit air-borne contamination and dehydration. Also, a refrigerated area having a floor drain should be assigned to hold the dewatering screens during the draining period. Since the amount of refrigerated storage space is generally limited in smaller remote processing plants, its efficient utilization is important. Figure 7 illustrates an example of a stainless steel shelving unit having six storage levels to hold two dewatering screens per level. The shelf angle of slope runs to the centre and front of the unit to direct water run-off away from lower dewatering screens.

At the conclusion of dewatering and in preparation for salting, the roe is visually examined to ensure the removal of any remaining non-roe particles. This requires carefully moving the cleaned and dewatered roe from one side of a screen to the other with a spatula, and removing any particles that have not floated off during washing and decanting or that have passed through the intermediate screen. Non-roe particles are usually readily identifiable by colour difference, i.e. blood specks, fragments of weed and, occasionally miniscule benthic organisms such as gastropods, which will readily pass through the intermediate screen and, having a higher density than the roe will not float off during decanting. The presence of weed fragments and benthic organisms should be minimal if sufficient care has been taken during the initial water flushing of the roe sacs.

6. Salting
Salt curing the cleaned and dewatered roe, although a straightforward procedure, relies on several factors that are critical to end product quality. These include batch to batch accuracy of salt measurement, the use of salt of a high grade of purity, thorough blending of salt with roe, temperature control, and sufficient curing and draining time.

Blending the salt and roe can be undertaken manually or mechanically. In either case care must be taken to ensure complete and uniform blending. If mechanical blending is used it should be at low speeds to avoid breakage of individual eggs.

Once blended, the salted roe is transferred again to dewatering screens, the surface covered with plastic-film in direct contact with the surface of the roe and refrigerated to cure and continue draining as the salt extracts water from the egg mass.

7. Packing
The salt-cured and drained roe is bulk packaged for shipment to a centralized processing plant for further repackaging/processing or direct distribution. Appropriate bulk packaging containers are of a food-grade plastic with lids to provide an air-tight seal. On packaging the salted roe, the containers should be filled so as to exclude air from the container, i.e. the container lid should be in direct contact with the surface of the salted roe.

FACTORS INFLUENCING THE STORAGE LIFE OF SALT CURED WHITEFISH ROE

In the unfrozen, bulk packaged form, salt-cured whitefish roe has a relatively limited storage life. Factors influencing its stability include the temperature of storage, the care exercised during bulk packaging to exclude air, the initial freshness of the "green" roe and the subsequent care in processing and finally, the salt level in the product.

Given high initial quality of the salt-cured bulk packaged roe, its storage life without chemical stabilizers or pasteurization when salted to a 10 percent concentration will be up to approximately 4 1/2 months when stored at -4°C. This decreases to only 2 1/2 months at 4°C. If salted to a 5 percent concentration this storage life is reduced to approximately 3 months at -4°C or, less than 2 months at 4°C. However, a further extension of the fresh storage life can be obtained by lowering the storage temperature. For example, roe salted to a 10 percent concentration can be stored at as low as -8°C without freezing. The first indication of quality deterioration is the development of off-flavours and odours associated with yeast growth. Once these off-flavours and odours develop, the roe becomes unacceptable. Unless the roe is intended for immediate distribution and consumption during its limited period of optimum quality, it is important to utilize an alternate means of protecting its storage life, either by repackaging and freezing, or by pasteurization.

SECONDARY PROCESSING AND PACKAGING

To prepare the roe for either method of packaging an initial draining treatment was found necessary, due to the fact that refrigerated storage of the salt-cured, bulk packaged whitefish roe, even for relatively short periods of time, results in some moisture separation accumulating in the base of the containers. Although this separated moisture could be recombined with the roe and roe suspension maintained with an appropriate hydrocolloid, this option was not considered, since greater roe density and the absence of any additive other than salt, was considered important to the market image of the product.

The method used to separate this free moisture from the roe was vacuum draining. This method, versus conventional gravity draining, which required the use of refrigerated storage space for an extended period, effectively removed the free moisture rapidly. The method required placing the salt-cured roe from the bulk packaging container, approximately 12 kg, into a dewatering screen shown in Fig. 6, placing the roe filled dewatering screen over a stainless steel drum fitted with a polyethelene surface rim gasket to ensure an efficient seal, and drawing a vacuum on the drum for 2 to 3 minutes. The moisture separation speed of the batch system was sufficient that an operator could maintain drained roe to the fill level of the intake hopper of an automatic filling machine.

The simplest and fastest method of protecting the storage life of the salt-cured whitefish roe was repackaging and freezing. The selected packaging container was limited to a size that would facilitate rapid freezing so as to protect textural quality (slow freezing was found to cause varying degrees of cellular rupture, resulting in textural impairment and further moisture separation on thawing). For this, a one kilogram polyethelene container was used having a tight-fitting snap-on lid. Once filled, the lid was sealed on the container and the container blast frozen. Although easily applied, this packaging format was limited to certain specific markets that would use the product in this form.

Controlled refrigeration is another method of preserving product shelf-life. Initial marketing trials of a retail product were attempted using unfrozen roe which had to be held under specific and rigidly controlled refrigeration conditions. Because of the difficulties associated with this in the North American distribution system and the limited storage life of the product, which was further shortened by temperature abuse, the final method of protecting the storage life of the roe, by pasteurization was developed. This processing treatment was appropriate because of its minimal effect on the organoleptic qualities of the roe and its effectiveness in stabilizing and prolonging both the refrigerated and unrefrigerated storage life.

For pasteurization the selection of the container size and shape was based on ensuring rapid heat transfer. Other container considerations included the resistance of the product contact surfaces to the action of the salt in the roe, the ability to produce a head-space vacuum in the container on sealing, the requirement for a tamper-evident lid seal and finally, the container should be fabricated of a material that could be embossed to provide a process code. Conventionally, glass jars of varying sizes fitted with metal caps are used for packaging caviar or caviar type products. Because of difficulties in obtaining a suitable glass packaging container, a decision was taken to utilize a three piece metal can. This was a 68.3 x 38.9 mm (211 x 108.5) round can with a suitable product contact surface enamel and having a 113.4 g nominal fill capacity.

A series of experimental packs were prepared for temperature trials in establishing a pasteurization process for the roe. It was found that the maximum temperature that could be applied without significantly affecting the colour, flavour or textural characteristics was 57°C. Increasing the pasteurization temperature beyond this point caused the onset of protein coagulation accompanied by undesirable changes in colour, flavour and texture. Time trials were also evaluated through microbiological testing.

The salt-cured roe, once packaged and pasteurized is relatively shelf stable but still requires refrigerated storage to maximize storage life. Although refrigeration is a stated label requirement for the packaged and pasteurized roe, all roe must be salted during primary processing to provide ≥5.56 percent salt in the water phase. This is the level necessary in pasteurized caviar with a pH ≥5.0 to effectively inhibit Clostridium botulinum even should abusive temperatures occur during storage (Hauschild and Hilsheimer 1979).

MARKET DEVELOPMENT

Japan was initially identified as a test market for whitefish roe on the basis of that country's traditional interest in fish roe and in particular their increasing importation of Pacific herring roe. The interest expressed in response to a series of test samples of salt cured whitefish roe submitted to potential Japanese buyers by the Department's Western Region, Industry Services Branch, was sufficient to warrant an experimental pilot scale commercial production during the 1977 fall fishery. This pilot scale production of whitefish roe was undertaken in Manitoba and Saskatchewan in cooperation with the Freshwater Fish Marketing Corporation, the agency responsible for marketing and trading in fish, fish products and byproducts produced from the western inland fishery. Its relative market success spurred an increased production in 1978 of which the major proportion was again exported into the Japanese market. However, higher herring roe prices paid to B.C. fishermen in 1978 and 1979 and Japanese consumer resistance to higher roe prices resulted in significant inventories of roe remaining unsold by B.C. processors. The net effect of this was a general dampening of the Japanese market for all roe products, impacting upon the whitefish roe market development effort. Thus part of the 1978 whitefish roe production was set aside to explore not only its North American market potential but also to evaluate its acceptance in the European market.

The introduction of salt-cured whitefish roe into the North American market was as "Canadian Lake Whitefish Golden Caviar" under the Freshwater Fish Marketing Corporation's Freshwater brand. As previously discussed this was as an unpasteurized product requiring controlled refrigeration throughout its distribution and final handling and having a relatively limited storage life. Two packaging formats were tested, one a 250 g vacuum seamed three piece can for the institutional market and the other a 30 g screw cap sealed glass jar for the retail consumer. The difficulties experienced during this test period due to the controlled refrigeration requirement and its limited shelf life led to a packaging format change in 1979 to a canned and pasteurized product containing 106 g of caviar. However, notwithstanding the marketing difficulties experienced with the unpasteurized product during 1978, product acceptance was sufficiently encouraging to cause the Freshwater Fish Marketing Corporation to discontinue marketing efforts in Japan and concentrate on developing a North American market for the product.

Factors contributing to the market acceptance of Canadian Lake Whitefish Golden Caviar include its price advantage in relation to sturgeon caviar, its mild, lightly salted flavour and its natural colour (Note: Conventionally, caviars such as those processed from lumpfish roe are dyed black to simulate sturgeon or red to simulate salmon caviar. With Canadian Lake Whitefish Golden Caviar, consumers have expressed approval over the absence of dye in the product and have recognized an advantage in that when used to compliment other foods it obviates the concern related to colour leaching). Also a significant feature for a caviar product is the use of container coding which has given the Freshwater Fish Marketing Corporation a means of controlling what product inventory is in the market and in turn the consumer greater assurance of product quality.

THE FUTURE

Difficulties related to stock management and recent political influences in the region of the Caspian Sea fishery, the principal source of sturgeon for the production of traditional caviar, have been major factors contributing to the increasing cost and decreasing availability of that product. These conditions, coupled with the limited access to Canada's coastal fishery, favours the continued expansion of a domestic industry to serve traditional and new markets for caviar.

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The authors wish to express their appreciation to Fisheries and Oceans, Western Region district field personnel for their support in monitoring quality, the Freshwater Fish Marketing Corporation and their agencies for their enthusiasm and S.K. Law for his continuing support and confidence in the project. Finally, special thanks are due to L.E. Gambrel for his untiring assistance in field and headquarters supervision of processing since the inception of the project.

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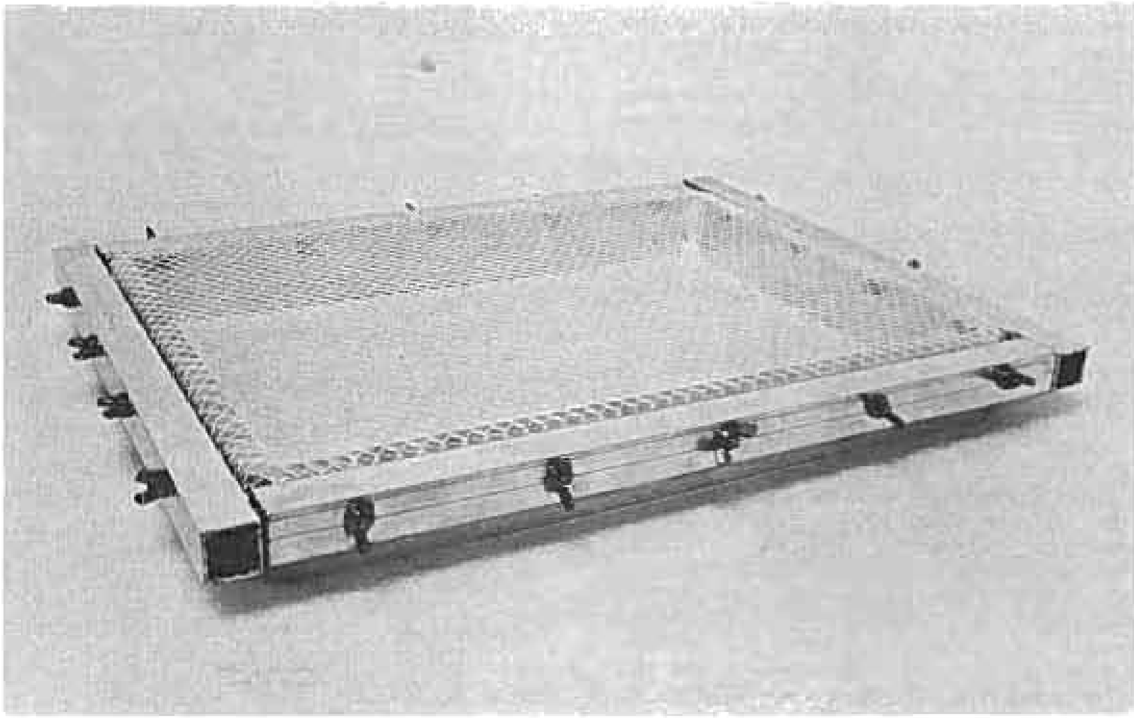

Fig. 1. Aluminum separating screen - for separating eggs from roe-sac membrane.

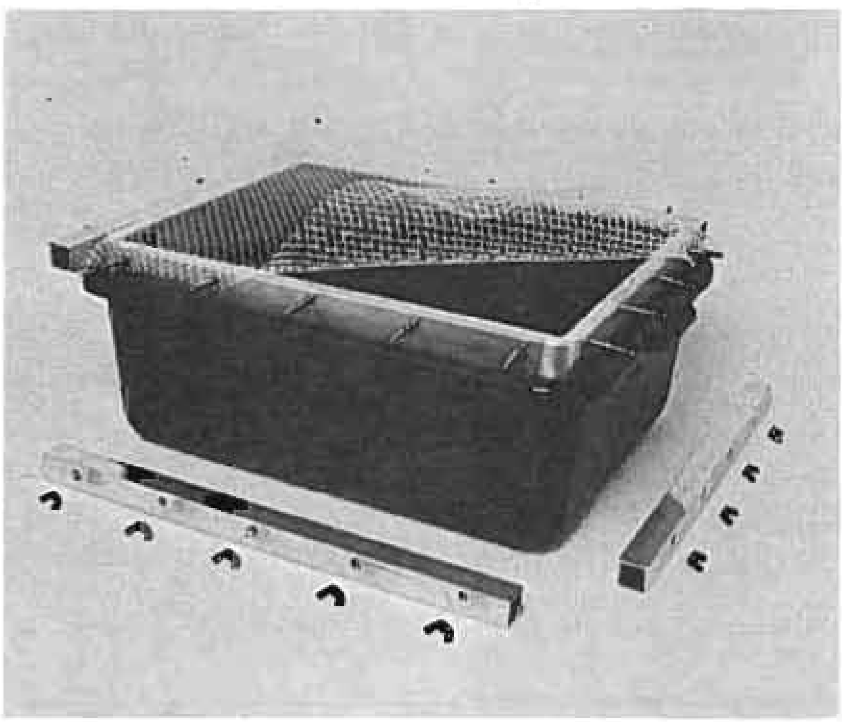

Fig. 2. Partially assembled separating screen nesting on surface rim of standard plastic tote box.

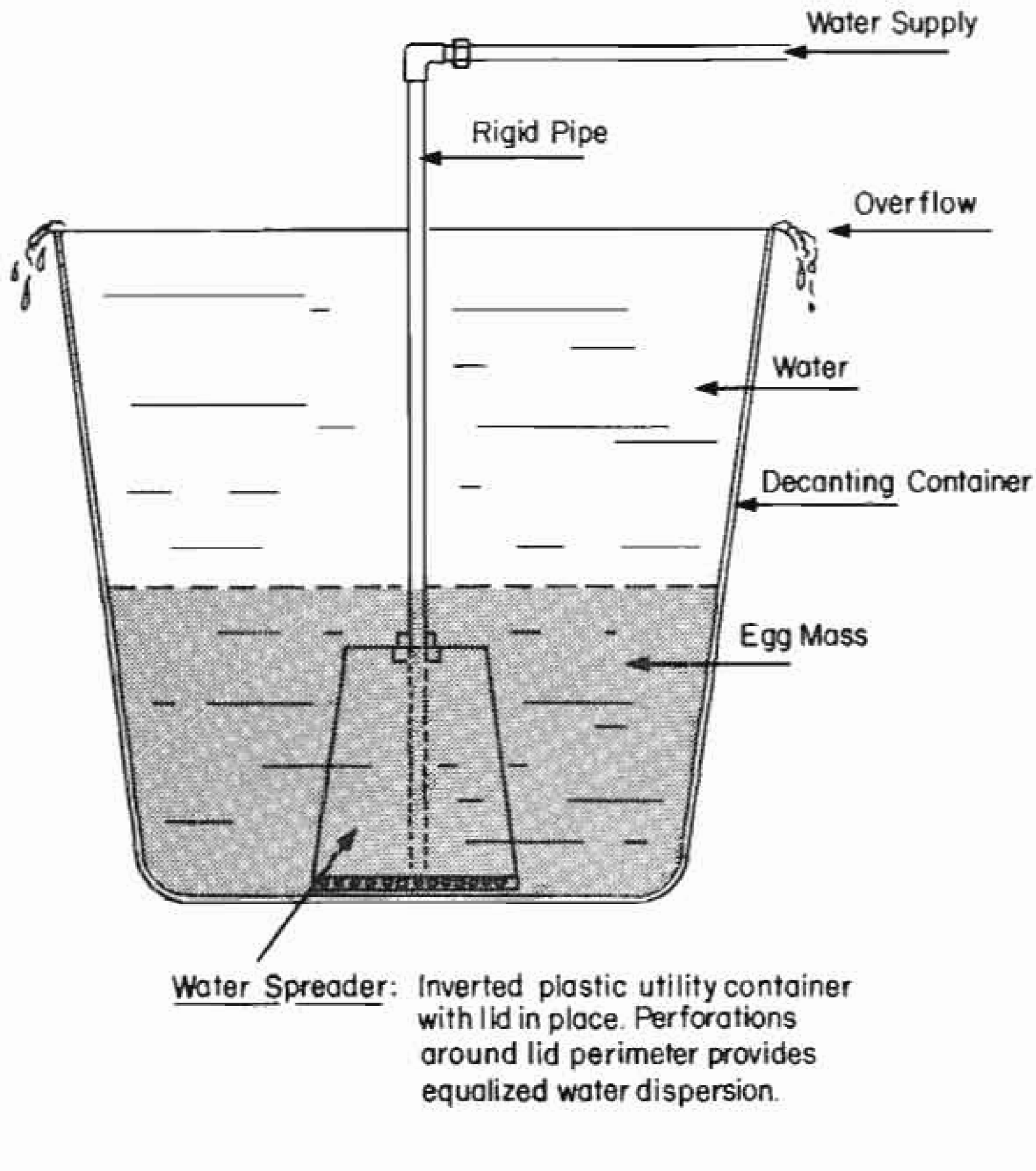

Fig. 3. Continuous-flow water system for washing roe.

Fig. 4. Stainless steel secondary screen - for removing any larger particles of extraneous material remaining after washing roe.

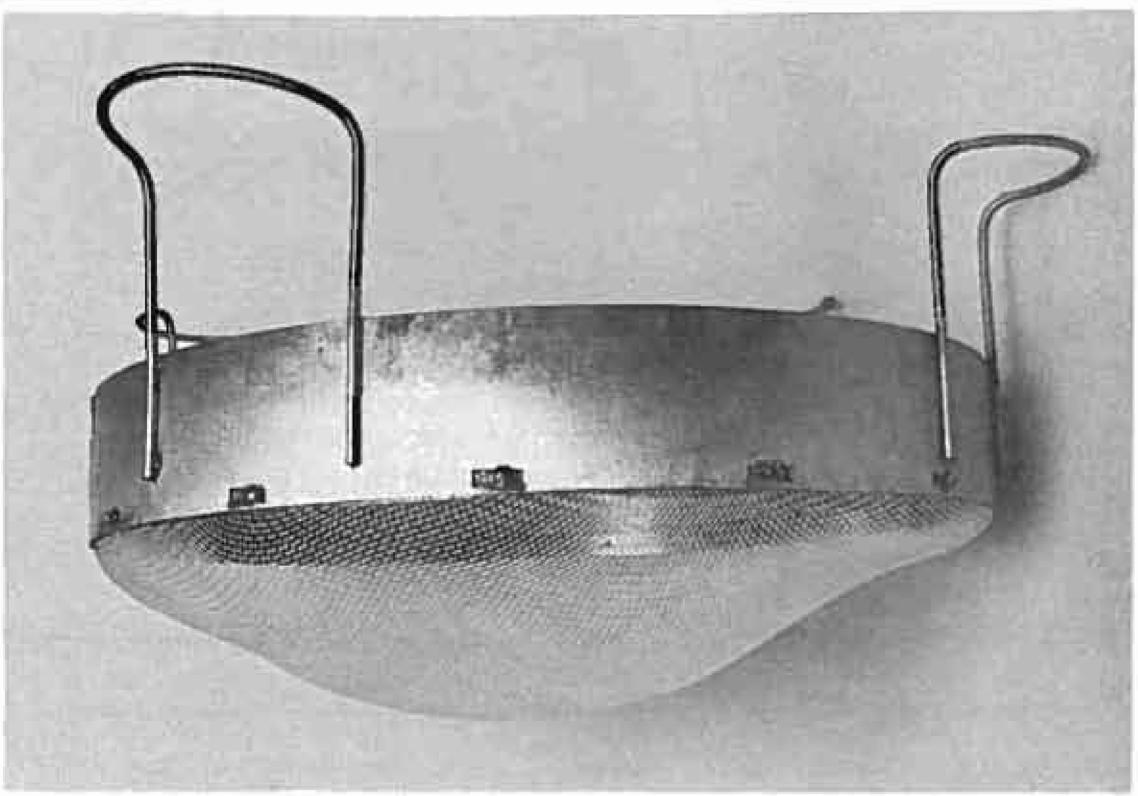

Fig. 5. Stainless steel secondary screen showing configuration of nylon mesh attached to form "bag".

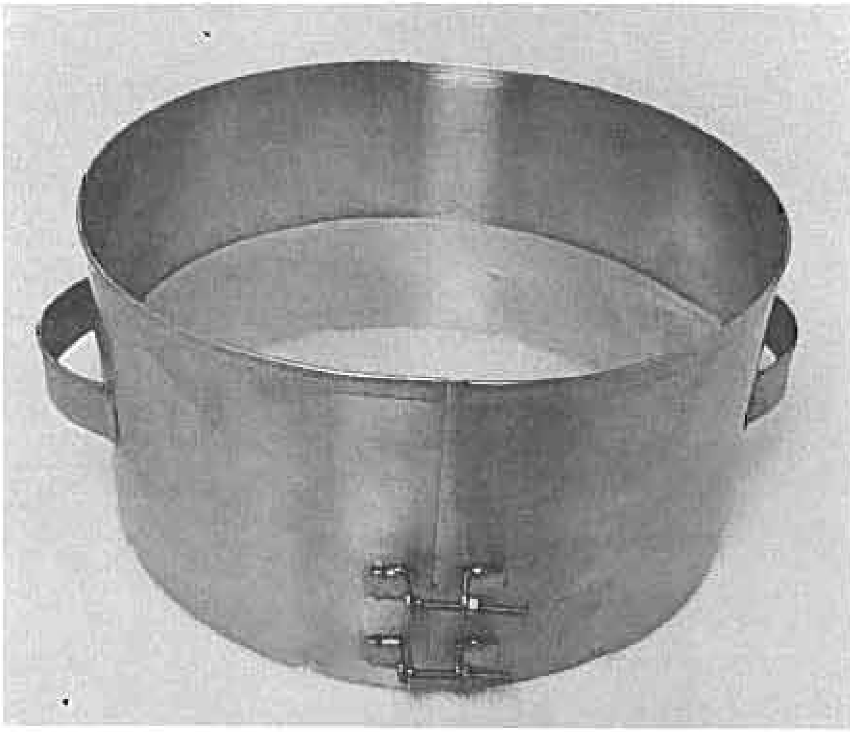

Fig. 6. Stainless steel draining screen for dewatering and curing roe.

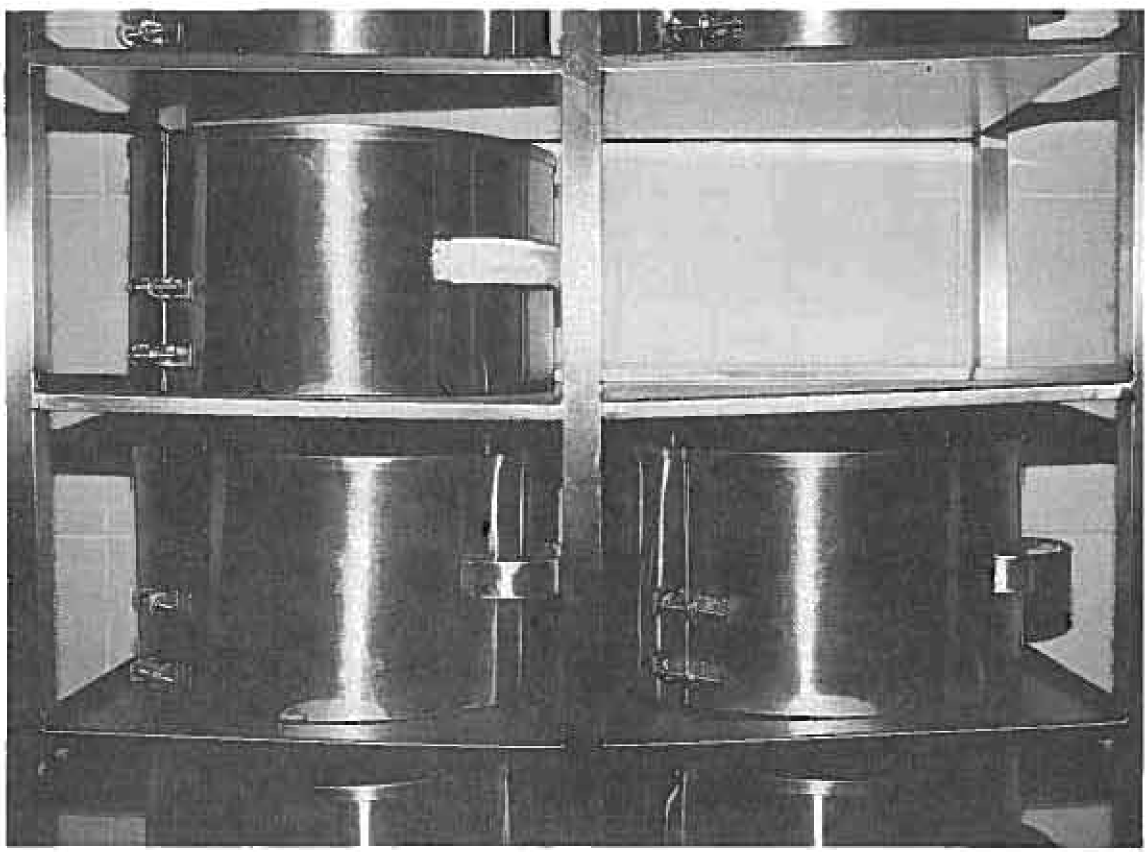

Fig. 7. Stainless steel draining rack - designed to hold 12 draining screens during dewatering and curing.