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PROGRAM

PROCESSING SQUID FOR FOOD

By

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with an introduction

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E. R. Pariser

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SEA GRANT PROGRAM

ADMINISTRATIVE STATEMENT

This publication is the result of work undertaken by members of the Department of Nutrition and Food Science at the Massachusetts Institute of Technology and should serve as a useful introduction to the properties of squid muscle and to the different ways that squid may be used to prepare a number of palatable dishes.

A United Nations sponsored World Food Conference, planned to take place in Rome, late in 1974, will assemble expert delegates from 60 or more nations to document, and attempt to counteract, the increasingly perilous world food shortage.

It is against such a background of world-wide concern that a study into the better utilization of squid--a widely distributed and largely underutilized food resource of high nutritive value--assumes national and international significance.

Funds for this research project and report came in part from the NOAA Office of Sea Grant, U. S. Department of Commerce, on grants No. 23150 and NG-43-72; from the Henry L. and Grace Doherty Charitable Foundation, Incorporated, and from the Massachusetts Institute of Technology.

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Professor Zeki Berk with Squid Eviscerating Machine

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PART I

POSSIBILITIES OF WIDER UTILIZATION OF SQUID IN AMERICAN DIETS*

by

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*Extracts of a paper presented by E. R. Pariser at the 18th Annual Atlantic Fisheries Technological Conference, October 14-17, 1973 at the King's Grant Motor Inn in Danvers, Massachusetts.

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A. Introduction

The race between the population explosion and the means to feed this growing mass of people has by no means been decided. The cost of meat is rising and will continue to rise in this and many other countries. It is, therefore, urgently necessary to continue to examine, develop, and utilize to the fullest extent possible all food resources available and potentially available on land or in the water.

In 1971, a project funded in part by the M.I.T. Sea Grant Program was launched in the Department of Nutrition and Food Science to determine the potential value of squid as food for the American consumer. The project was designed to investigate:

1. methods for processing squid;
2. the chemical characteristics of the squid muscle proteins, and
3. the acceptability of squid and squid products by the U.S. consumer.

Methods for processing squid are discussed in Part II of this paper entitled "Processing Squid for Food." The present introductory remarks are intended to give some general background information on squid, its habitat and significance.

Reports on the chemical characteristics of squid muscle proteins and on the studies to determine the acceptability of squid and squid products by the U.S. consumer are in preparation and will be released shortly.

A. Taxonomy

The squid belongs to a group of animals called cephalopods, which are the most highly developed creatures of the phylum Mollusca. The squid and cuttlefish are active, strong swimmers and close relatives of the oyster and clam. The cephalopods as a whole and the squid in particular are probably the most abundant of the underutilized species of marine food animals and deserve much more serious attention by the fishing and food industries than they have received so far.

Of the five sub-divisions of the cephalopods, the squid belongs to one, the Teuthoidea, containing the sub-orders Myopsida and and Oegopsida. Among the former we find one of the commercially most important species of squid, Loligo, which lives seldom beyond the edge of the continental shelf; to the other sub-order belong the truly oceanic squid like the useful and palatable Illex and Todarodas which dwell usually beyond the edge of the shelf, though they come periodically inshore and are then caught by fishermen.

B. The Resource

According to Voss of the School of Marine and Atmospheric Science at the University of Miami in Florida,* our knowledge of cephalopod fisheries at the present time is lacking many important data. It is almost impossible, also, to attribute much credence to estimates of catch or catch potential. According to Voss, we lack almost all reliable data on egg production and distribution, growth, longevity, stock sizes, fishing efforts, and even landing statistics. However, some data are available and some rough estimates of potential harvest can be made. The table at the end of this paper taken from Voss's discussion of the subject summarizes the catch statistics available for a number of regions and the estimated harvesting potential as gathered from various sources.

It is not improbable, according to Voss, that at the present time the total cephalopod catch of the world lies somewhere between one and one half and two million metric tons. The estimated potential of the continental shelf and upper slope regions may lie between eight and twelve million metric tons.

Probably less than 10% of the ocean's surface is at present fished for cephalopods and from this area almost all of our present cephalopod catch is taken. At least, to quote further from Dr. Voss, 90% of the ocean's area is unexploited and yet is the home of very large numbers of species of cephalopods that seldom stray inshore and spend their entire life cycle on the high seas. Attempts to assess the potential productivity of the oceanic area have

*Voss, Gilbert L., Cephalopod Resources of the World, FAO Fisheries Circular NE 149, FAO, Rome, April 1973.

yielded a very wide range of estimates. Clarke told Voss in a personal communication that on the basis of his work on sperm whales, he estimates that the southern hemisphere population of about half a million sperm whales consumes between 40 and 100 million tons of squid a year. Clarke believes that 50 million tons is probably a reasonable estimate if one single figure were needed. If we accept Clarke's figure, we can make further estimates. Certainly, the present state of sperm whales represents no more than one-fifth of its original population which may have been of the order of two and a half million individuals for the southern hemisphere. It is, therefore, possible that the annual potential catch of oceanic squid lies within the range of from 100 million to 300 million tons and may be as high as 500 million tons.

C. <u>Locating, Harvesting, and Preserving the Catch</u>

Almost no modern technology has been developed to locate schools of squid, but it is expected that acoustical methods will eventually be employed to facilitate the search operation. As far as harvesting the catch is concerned, a large number of methods is in use at the moment.

1. Spearing or hooking are probably the oldest and most successful of all small-scale methods, They are used at night with the help of lights.

2. In the Mediterranean, a female squid is slowly trolled at the stern of the boat to attract the males. In the Orient, weighted jigs or jig type lines are used.

3. Floating or anchored traps are used in Newfoundland.

4. Baited baskets and pots are used elsewhere.

5. Otter trawls seem to be the most productive of all harvesting implements.

6. Purse seines are in use in the Mediterranean, off the coasts of Africa and Japan. Light is used to attract the squid and when the seine is pursed, the catch is brailed or pumped out.

As to the preservation of the catch on board ship, great care must be taken in the way the animals are handled since the squid is extremely sensitive and bruises easily. Research is needed to devise methods to keep squid fresh on board ship. Squid cannot be packed in large amounts of ice because the weight of ice and squid would squash the animals at the bottom of the pile.

D. Mariculture

This brief sketch of the potential of squid as a food source would be incomplete without mentioning that the artificial rearing of squid from the egg to commercially sized animals has been successfully accomplished and is particularly attractive on account of the extremely rapid growth of the animals and the short overall period of time that is required by them to reach maturity.

E. Processing of the Raw Squid

Squid is widely and abundantly available in the world's oceans, can be harvested by a number of means and represents a source of high quality protein.

Several important social, economic, and technological problems must, however, be addressed and resolved if squid is to enter the American diet or if it is to be processed on a large scale for export. One of these problems concerns methods and equipment for eviscerating and skinning the raw material. These two operations, including the removal of the ink sack are essential for esthetic reasons. Squid ink and the sack in which it is contained are integral parts of the animal's viscera. The ink has powerful dying properties. Should the ink sack burst and the ink spill, the animal's muscle tissue would become discolored.

Removal of the skin enveloping the mantle is also important, since only when the skin has been peeled does the snow-white muscle become easily suitable for further processing into different food forms and is attractive enough to compete with other similar raw materials such as clams, oysters, etc.

In this country, evisceration and skinning of raw squid are performed manually. These are expensive and inefficient operations. In an attempt to improve this situation, Prof. Berk developed a simple automatic eviscerating and skinning machine which is described in the next paper. Funds are now sought to develop the machine one step further, to bring it a little closer to industrial usefulness and application.

F. Consumption

The edible parts of the squid containing 18% of highly valuable protein represent almost 70% by weight of the whole animal, an unusually large proportion if compared to that of edible material in either finfish or crustaceans.

Squid have been consumed since antiquity and are presently eaten as regular dietary components in many parts of the world, especially in Japan, where several hundred thousand tons are annually consumed, and in the Mediterranean countries. In the U.S. only small quantities are consumed by certain ethnic groups; the American people as a whole have not yet learned to accept and appreciate this delicate and nutritious food which, as the following paper shows, can be prepared in many attractive ways.

The crisis in the world's natural resources has only just started in earnest for the industrialized countries. Today it is a shortage of energy in the form of oil that worries us. Tomorrow it will be a shortage of energy in the form of food. There are enormous unutilized and underutilized food supplies that we have not yet begun to husband and exploit wisely. Squid is one of them. This Sea Grant supported program of investigation was undertaken in an attempt to draw attention to this resource and in the hope that more engineers and scientists will become interested in contributing to make this food more widely available.

Regions	Landings (tons)	Estimated potential (tons)
Northeast Atlantic	12,000	>100,000
Mediterranean Sea	42,000	100,000
Northwest Atlantic	27,000	500,000
Central Eastern Atlantic	300,000	1,000,000
Caribbean Sea	900	>100,000
Southeast Atlantic	?	> 200,000
Southwest Atlantic	5,400	500,000
Northeast Pacific	15,000	600,000
Central Eastern Pacific	500	>100,000
Southeast Pacific	1,000	500,000
Northwest Pacific	1,000,000	2,000,000
Western Central Pacific	40,000	500,000
Southwest Pacific	500	200,000
Oceania	500	500,000
Indian Ocean	500	500,000
Total	1,445,300	>7,400,000

From: Gilbert L. Voss, Cephalopod Resources of the World FAO Fisheries Circular NE 149, FAO, Rome, April 1973.

PART II

PROCESSING SQUID FOR FOOD

by

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A. INTRODUCTION

A program of investigations was initiated in 1971 in the Department of Nutrition and Food Science at M.I.T. to determine and develop the potential value of squid as food for the American consumer. The project was funded in part by the M.I.T. Sea Grant Program and was specifically designed to study

1. Methods of processing squid for the manufacture of food products,
2. the chemical characteristics of squid muscle proteins,
3. the acceptability of squid and squid products by the American consumer.

This report is a summary account of the work done by the author in 1972 and 1973 to develop processing methods for the production of foods suitable for the American market; the studies had been initiated in 1971 by Professor I.T.R. Nickerson, under the direction of Samuel A. Goldblith, Underwood Prescott Professor of Food Science and E.R.Pariser, Senior Research Scientist of the Department of Food Science and Nutrition, and Advisory Service Officer, M.I.T. Sea Grant Program.

Professor Nickerson's exploratory work included heat processing, spray and drum drying (of squid tissue homogenates), freeze drying and freezing.

Conversations with Professor Nickerson, a study of his previous reports, an evaluation of samples of the experimental products, a survey of the literature, consultations among Professor S. A. Goldblith, Mr. E. R. Pariser, and the author, meetings with fishing, processing and marketing experts led to the formulation of the following basic assumptions to serve as guidelines for the conduct of these investigations:

Squid (Loligo or Illex species) is available in the New England area in quantities to permit industrial exploitation.

The price of squid, when fished, transported and landed as food fish, is low compared with the price of other fish and seafood.

The conventional ways in which squid is used in Japan, the Mediterranean countries and South America do not appear to be initially suitable for large volume marketing in the U.S. New products must therefore be developed which might attempt to simulate and/or replace presently accepted seafoods such as clams, oysters, shrimp and fin fish.

Considerable market resistance can be expected in the U.S. to any food products labelled squid, and the magnitude of such resistance must be tested.

The processes to be developed to produce these new food products should, as far as possible, fit into the framework of processing facilities at present existing in the U.S. food industry and require minimal financial investment.

In the U.S., handling of squid by existing technologies is labor intensive: mechanized or machine-assisted handling methods must be developed.

This report deals primarily with experimental work designed to answer three fundamental questions:

What is the proportion of edible parts of squid that can be expected as the result of processing the animals?

Can a simple and inexpensive eviscerating and skinning machine be designed and constructed to make the preparation of squid more efficient?

What food items can be prepared from squid that hold out promise to be accepted by the American consumer?

B. EXPERIMENTAL WORK

1. Yield of edible parts of squid

The objective of this series of investigations was to determine the proportion of different anatomical components of the raw animal, and especially to find out what proportion of edible parts can be obtained.

Procedure

The squid (either fresh or frozen - thawed) were separated into four sizes: very large animals (V.L.), weighing between 250 g (8.8 oz) and 500 g (17.6 oz) each, an average of 330 g (11.6 oz) per animal; large animals (L), weighing between 170 g (6 oz) and 250 g (8.8 oz) each, an average of 200 g (7 oz) per animal; medium animals (M), weighing between 120 g (4.2 oz) and 170 g (6 oz) each, an average of 135 g (4.7 oz) per animal, and small animals (S), weighing less than 100 g (3.5 oz), an average of 85 g (3 oz) each; the animals were then eviscerated and skinned by hand. Tentacles were cut at the beak level, and the viscera separated from the head at the neck. The different parts of the animal were weighed separately.

Results

New England Loligo

Sixteen batches of fresh squid, weighing a total of 320 kilograms (704 lbs) were purchased from Giuffre's Fish Market in Boston. The exact origin of the squid is unknown. It was bought in the fresh fish auction. According to the salesman, most batches were caught "off Rhode Island."

The results obtained with the New England Loligo (Bone Squid) are given in Table 1, in which the proportions of anatomical components are indicated as percent by weight of the whole animal. Figures in brackets indicate percentages by weight of secondary components present in the whole squid.

Table 1. Breakdown of New England Loligo (Bone Squid)

Anatomical Components	Proportion of components expressed as % by weight of whole animals, classified by size				Overall proportion of Components		
	V.L.(%)	L(%)	M(%)	S(%)	Av(%)	Max(%)	Min(%)
Viscera	13	15	16	19	15		
Heads	11	12	10	10	11		
Tentacles	14	12	13	12	13		
(Cleaned tentacles)	(9)			(8)			
Pens	1.1	1	1	1	1		
Mantles	61	60	58	58	60	64	58
(Skin)	(4)			(5)	5		
(Fins)	(14)			(11)	12		
(Skinned body)	(43)			(42)	43	48	41

V.L. (Very large)	330 g. ave.(11.6 oz)	(250-500 g)(8.8-17.6 oz)
L (Large)	200 g ave. (7 oz)	(170-250 g) (6-8.8 oz)
M (Medium)	135 g. ave. (4.7 oz)	(120-170 g) (4.2-6 oz)
S (Small)	85 g. ave. (3 oz)	(below 100 g) (3.5 oz)

New England Illex

Only one batch of animals weighing 13 kilograms (28.6 lbs) could be obtained. The yield of various fractions in this batch is shown in Table 2.

Table 2: Breakdown of New England Illex

Component	Weight g	%
Heads	1145	11.1
Viscera	1751	13.4
Tentacles	1790	13.8
Pens	142	1.1
Skin	542	4.2
Skinned fins	1890	14.5
Skinned body	5436	41.9
	12,996	100.0

California Loligo

A 5 lb. box of frozen Monterey squid was thawed at room temperature and cleaned by hand. The breakdown into various components is given in Table 3. The average weight of the squid in this sample was 58 gr. (2 oz).

Table 3: Breakdown of California Loligo

Fraction	Weight g	%
Heads & Viscera	800	34.8
Pens	40	1.7
Tentacles	282	12.5
Mantles	1108	47.3
Liquid loss (drip)	72	3.7
Total	2302	100.0

Discussion

The average yield of edible parts (mantles and cleaned tentacles) in the New England Loligo is 68-69% by weight. The yield of skinned mantles alone is approximately 55%. This latter fraction is the one to be utilized for fillets, cocktail strips, etc., where the presence of skin and tentacles is objectionable from the point of view of product appearance.

The yield of edible parts varies only slightly with body size. The yield of edible parts seems to be considerably lower in California squid.

2. Mechanical Evisceration and Skinning of Squid

In the processing industry of today, evisceration and skinning of squid are carried out manually. Tanikawa (1971) has described the method of manual cleaning of squid in Japan. The operation consists usually in splitting the mantle longitudinally and scraping off the viscera from the dorsal wall of the mantle.

In the course of work with New England squid, it was first observed by Professor Berk that the viscera could be removed from the body without splitting the mantle, by squeezing the squid between two fingers, from the tail towards the head, while pulling the head away from the body at the same time. The same result was obtained when the squeezing action was applied with a roller, pressing the squid over a flat surface, or by squeezing the animal between two rollers. On the basis of these observations, a motor driven device consisting of two rubber rollers was built. One roller was fixed and the other was spring loaded. Using this simple device the following observations were made:

It is possible to remove the viscera by squeezing the squid between two rubber rollers rotating one roller against the other.

The movement of the squid through the rollers can be vertical, horizontal or inclined.

Both Illex and Loligo species are eviscerated with the same efficiency.

Squid which has been frozen and thawed has a more slimy surface which causes slippage over the surface of the rollers. Using rollers with a rough surface (as, for instance, by wrapping wire mesh around the rollers, or driving spikes into the rubber) solves the problem.

After passing between the rollers, squid had sometimes the tendency to wrap around one of the rollers and block the machine. The installation of doctor blades for each roller solved this problem.

The removal of viscera is usually complete after one pass through the rollers. However, in the case of larger squid, some visceral mass in the lower body cavity may remain attached to the inner wall of the mantle. Visceral residue can be removed by passing the squid through the rollers a second time, after increasing the roller-to-roller pressure.

These observations led to the construction of a machine with three pairs of rollers (the two upper pairs for squeezing, the third pair, placed wide apart, serving only to pull the animal through the machine). Using this machine, complete evisceration was achieved with every size of squid.

A large proportion of the skin can be removed by the rollers if the squid is not allowed to run through the rollers freely. In the multiroller machine this effect is achieved by rotating each pair of rollers at a peripheric speed lower than that

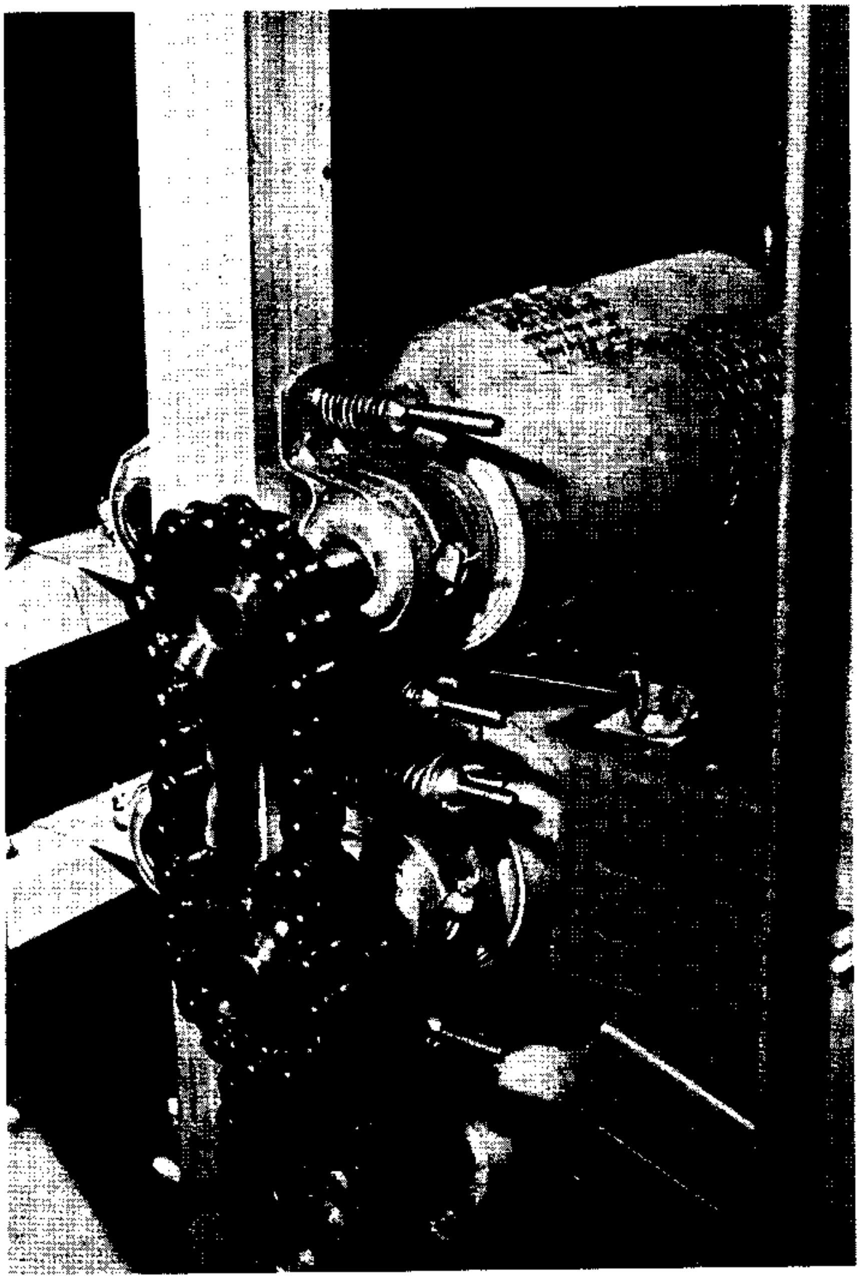


FIGURE 1. Detail of Squid Eviscerating Machine

of the following pair. The first pair retains the body while the following pair pulls it. The pulling action disrupts the skin and causes the removal of a large portion of it. The removed skin wraps itself around the rollers and is removed by the doctor blades or, more often, runs between the rollers, along with the partially skinned mantle.

The removal of skin by this method is never quite complete. Squid which had been frozen and thawed resisted machine skinning probably due to the slippery nature of the skin. Blanching the squid in water at 65°C (149°F) for 2 minutes increased the ease of skinning, especially in the case of frozen-thawed squid and tough-skinned (larger) squid.

A patent application has been filed covering the principle of the operation and the mechanical device. Figure 1 is a picture of the machine.

Most of the work consisted in solving mechanical problems associated with the building and improving of the prototype machine. The following observations are suggested in way of conclusion:

The possibility of cleaning squid by the squeeze-pull action of revolving rollers has been demonstrated.

The prototype device is useful for cleaning squid on a pilot plant scale, or for further investigations of the cleaning action itself.

The problem of automatic feeding and automatic removal of viscera must be solved.

The skinning effect must be improved by optimizing, among others, the following factors: roller surface roughness, speeds of rotation of successive rollers, roller pressure, pre-treatment (scalding of the squid).

The mechanical, safety and sanitary features of the device must be improved.

A film of the machine in operation has been prepared.

3. Development of Squid Products

a. Selection of Products

In the light of the guidelines (see Introduction) concerning the strategy for product development, it was decided to work on the following products:

Product	Method of Preservation	Proposed End Use	Type of accepted sea food simulated by the product
Breaded rings	Freezing	Fried snacks and entrées	Clam strips, possibly shrimp
Chunks	Heat processing (canning)	Seafood cocktail, salads	Oyster, shrimp
Minced squid	Heat processing (canning)	Chowders	Minced clams
Fillets and blocks (plain or breaded)	Freezing	Fried and baked entrées, "fish" sticks	Fin fish fillets and blocks

The sequence of operations for the preparation of some of the above products is given in Figure 2.

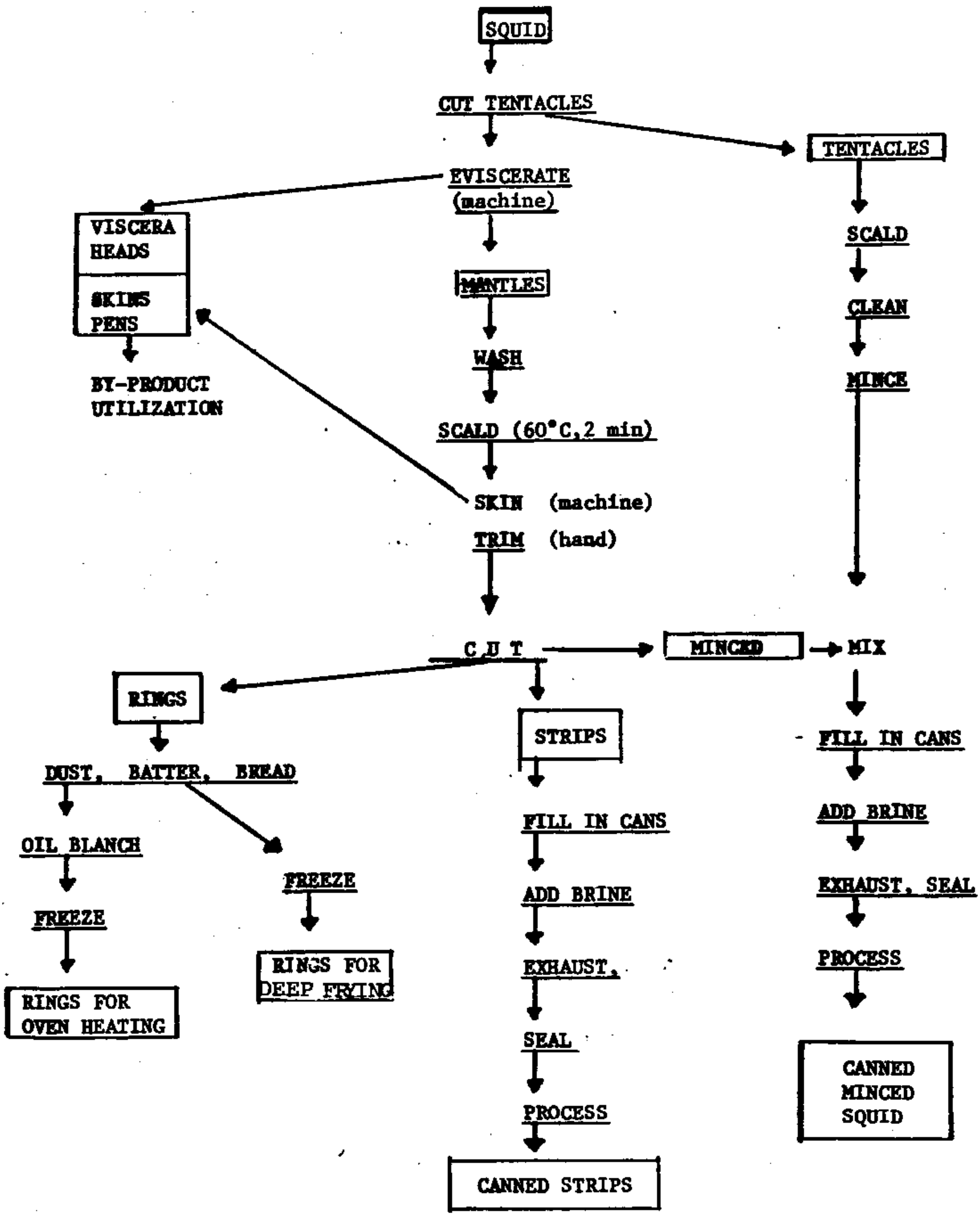
b. Breaded Rings

i. Description of the product

The product consists of squid "rings" obtained by cutting the conical mantle transversally. The width of the rings is approximately 6-8 mm. (0.2-0.3"). The rings are battered and breaded. They can be lightly fried (oil blanched) before freezing, or they can be frozen raw. In the first case, preparation for consumption consists in heating the frozen product in a pre-heated (180°C) (356°F) household oven for 25-30 minutes. In the second case, the rings are prepared for consumption by deep frying in a suitable edible oil at 200-210°C (392-410°F) for one minute.

Fig. 2

SQUID PRODUCTS, PROCESS FLOWSHEET



When prepared for consumption, by either methods, the product has an interesting, attractive shape (it resembles thick french fried onion rings) and a golden color. The crust is crisp and the squid "core" is chewy but not rubbery or tough. The core is essentially bland in taste. The flavor of the product is due to the breading and batter.

ii Description of the process

The production process for breaded frozen rings is summarized in Figure 2. Following is a brief discussion of the individual operations.

Cutting the tentacles. Squid tentacles are edible and can be incorporated in minced squid products. It is more convenient to remove the tentacles before the squid is eviscerated. The tentacles are cut from the squid at the level of the beak (above the eyes). This operation is done by hand. However, a mechanical cutter or the addition of a tentacle-cutter attachment to the eviscerating machine is contemplated.

Evisceration. This is done by machine. Obviously, evisceration techniques necessitating the splitting of the mantle cannot be used in the preparation of rings.

Washing. This is done in cold (12-15°C) (53-59°F) running water, to remove any dirt, ink, or viscera adhering to the surface of the mantles. The effect of washing on leaching losses will be discussed later. (Appendix 1)

Scalding. Scalding facilitates the skinning operation as discussed above. Scalding does not have any perceptible effect on product quality (adherence of breading, tenderness, etc.)

Skinning. Skinning is not essential for this product. The skin is masked by breading, does not impair the appearance, texture or flavor of the end product. Some people even prefer the unskinned product since it has a "more characteristic taste," but this was not observed by the majority of tasters. If the squid is not skinned, it is important to inspect the rings carefully and remove pieces of loose skin. Breaking of such pieces results in irregular clumps which impair the uniform, regular shape of the rings, without however, being objectionable from the view point of taste.

Cutting. If uniform, regular, circular rings are desired, the fins must be removed (they can be used for all other squid products, or breaded separately). The mantle is transversally cut into 6-8 mm (0.2-0.3") wide strips, starting from the wider, upper end to approximately 2 cm (0.8") from the lower, closed, mantle end. This operation is done by hand but can be easily mechanized.

Coating (breading). The rings are coated in three steps:

Dusting with all-purpose wheat flour or with dry batter mix.

Battering. In the present work, commercial batter mix (courtesy of the Gorton Co., Inc., Gloucester, Mass.) was used. The exact composition of the batter mix was not disclosed but it was said to be "starch based." The batter is prepared by blending one part of batter powder with 2.5 parts of water at 25°C (77°F). The batter is applied by dipping the rings in the mixture, followed by draining of the excess.

Breading. The breading was also supplied by the Gorton Co., Inc. This was a corn meal based product, used in the commercial production of fried clams. It contained salt but not spices or condiments. Breading is applied by placing the battered rings over a layer of breading, then covering with more breading, pressing slightly, then removing the breaded rings.

This procedure results in a product which consists of approximately 40% coating and 60% squid. A more heavily breaded product can be obtained by double-breading, i.e., by repeating the steps of battering and breading. The resulting product can be described as "heavy" or "soggy."

A typical material balance of the coating operation is given below:

Squid rings (100 rings)	540 g
Squid rings after dusting	610 g
Squid rings after dusting and battering	650 g
Squid rings after dusting and battering and breading	890 g
Squid rings, double breaded	1180 g
Squid rings, triple breaded	1380 g

Oil blanching. This operation can be carried out by cooking the breaded rings in cottonseed oil at 125°C (257°F) for two minutes.

Freezing. The breaded rings (raw or oil-blanched) were arranged in a single layer on trays and frozen in a blast freezer at -40°C (-40°F). The exact length of time necessary for complete freezing was not measured, but the rings were completely frozen after 20 minutes. They were then packed in polyethylene pouches or bags and stored at between -28°C and -40°C (-18°F and -40°F).

iii. Product evaluation

The formal evaluation of all squid products was carried out with the help of a taste panel consisting of 56 people. Details of this scoring test are given in detail in a separate report. This work was carried out by Mr. Paul Kalikstein, of the Sloan School of Management. The rings offered to this panel were double-breaded raw-frozen rings. Although the overall acceptability of the product was satisfactory (a score of 3.6 on a scale of 5.0 points), a number of tasters found the product tough or soggy. In informal tasting sessions in the course of product development and in two demonstrations with a large group of guests, the single-breaded product was liked much better.

The raw-frozen product (deep-fried before consumption) seems to be preferred to the oil-blanched product (oven-heated before consumption). However, this point must be tested further, probably by triangular evaluation.

Frozen storage for three months at -28°C and -40°C (-18°F and -40°F) did not alter the acceptability of the product.

c. Canned Squid Strips

i. Description of the Product

Squid chunks, canned "in their own ink" or in a variety of sauces, are produced in California, Spain, and Portugal. These are used for the preparation of Mediterranean squid dishes, usually eaten hot. Squid "au naturel" is apparently canned in Soviet Russia where an official standard exists for this product (Soviet Standard GOST 5.835-71, 1971).

Small squares of squid flesh, canned in brine, had been prepared by Professor Nickerson. Browning discoloration was reported to be severe. The use of SO_2 as a browning retarding agent was suggested. When Professor Nickerson's procedure was repeated and the product was offered to a small informal panel for evaluation, one of the tasters suggested that the product could be used as a chilled "cocktail," just as the better known shrimp and oyster cocktail. A small sample was prepared in order to test the idea, and the product was judged to be acceptable. It was decided to develop the product further.

The final product consists of strips of skinned squid mantle (approximately 10mm x 40mm) (0.4-1.6"), canned in brine. When properly prepared, the strips are white, tender, and have a pleasant taste.

ii Description of the process.

The process for the production of canned squid strips and other products is described in Figure 2. Following are details of the various operations.

Preparation. All the phases of preparation (washing, evisceration and cleaning) have been described above, in connection with the production of breaded rings. Complete skinning is essential. During heat processing, the skin tends to curl into dark clusters and impairs the appearance of the end product.

Scalding is important not only for the removal of skin, but also in connection with product quality. When scalding was omitted, extensive shrinkage of the squid occurred during heat processing in the can, and the brine turned milky.

In order to evaluate the effect of scalding on shrinkage, the following experiment was carried out: One batch of cleaned, skinned squid strips was canned without previous blanching. Another batch of squid strips was first blanched at 65°C (149°F) for two minutes, then canned in brine. In both cases, the weight of the squid strips placed in each can was exactly 80 g (2.8 oz), and the brine consisted of a 2% solution of NaCl. The cans were exhausted, sealed and heat processed (see below). Twenty-four hours after processing, the cans were opened, and the drained weight of squid strips was determined. The results given in Table 4 are the average of five cans for each batch.

Table 4. Effect of blanching on shrinkage of squid flesh during heat processing

Stage	Weight of flesh in grams		% shrinkage on basis of raw flesh	
	No blanch	blanch	No blanch	blanch
Raw	80	85	0	0
After blanching	80	80	0	6
After canning and 24 hour storage	55	72	31	15

Cutting. Cutting was done by hand. Most objections to the final product referred to the irregular shape of the strips. Machine cutting and sorting of the strips to remove irregular pieces may solve this problem.

Filling. The strips were filled into 211 x 400 (No. 1 Picnic) cans, coated with type M enamel. The capacity of this can is approximately 300 ml. 200 g (7 oz) of squid strips were weighed into each can. Hot brine at 80-90°C (176°-194°F) was added to approximately 4 mm (0. 16") from the top of the can.

Composition of the brine. A large number of common brine compositions containing salt, citric acid, sodium citrate, monosodium glutamate, sucrose, glucose, artificial seafood flavoring (shrimp, clam) were tried. Starting with a 2% solution of salt, it was found that all other additives were either unnecessary or harmful in so far as the taste and color of the final product were concerned.

Exhausting. The cans were exhausted in a water bath at 95-97°C (203-206°F) for 8 minutes. This was the length of time necessary to bring the temperature at the center of the can to 75°C. (167°F).

Sealing. The cans were sealed with lids carrying the same type of enamel as the main body of the can. A hand-operated sealing machine was used.

Heat processing. The cans were processed in a retort at 115°C (239°F) for 40 minutes. These process parameters were selected on the basis of recommendations in the literature for similar products and similar can sizes. They are not the result of a specific process calculation.

After processing, the cans were water cooled, dried and stored.

Storage. All the cans were incubated at 30°C (86°F) and 37°C (98°.6°F) for one month. No swelling or other indication of spoilage could be observed. There was no perceptible browning discoloration after four months of storage at 37°C(98.6°F).

iii. Product evaluation

The overall acceptance of the product as a chilled cocktail was evaluated by means of the scoring test described. A commercial seafood cocktail sauce was served separately. On a 5 point scale the product scored 4.0 for general acceptance as well as for taste, 3.9 for texture but only 3.5 for appearance. The shape of the pieces was found objectionable. These findings seem to indicate that these objections did not affect general acceptance. Improvement of the cutting operation is needed.

d. Canned Minced Squid

i. Description of the product

This product imitates canned minced clams. Minced clams are commercially produced both for the retail market and for institutional use. The principal end use of minced clams is in the preparation of clam chowder. The commercial product consists of minced clam tissue, loosely packed in brine.

According to Tanikawa, minced squid is canned in Japan. However, this seems to be a tightly packed "loaf" intended for use as a solid food.

Our canned minced squid consists of skinned mantles and scrubbed tentacles, all pre-blanched and minced, canned in a slightly sweetened and flavored brine. The product is off-white in color (commercial samples of canned minced clam were somewhat brighter in color, with some orange-colored specks).

The product is intended for use mainly as a "chowder base," However, highly acceptable "sauces" can be prepared from this product, for pasta and rice dishes, by replacing ground meat, fish, or other seafood in the original recipe with this minced squid product.

ii. Description of the process

The process flowsheet for the preparation of this product is described in Figure 2. Details of the initial operations, from evisceration to cutting are the same as described for strips. Other operations are discussed below.

Preparation of the tentacles. The tentacles bear suction cups and small, hard, bone-like "buttons." These must be removed. The tentacles are washed and scalded at 65°C (149°F) for 3 minutes. Most of the hard particles are detached from the surface by this treatment and the remainder, together with the skin, can be easily scraped off.

Mincing. Both the mantles and tentacles were ground after scalding, by means of a meat grinder. The plate perforation diameter was 6 mm (0.2").

Mantle/tentacle mixing ratio. Samples were prepared where 0, 20, 60, and 100% of the mantle tissue were replaced by tentacles. The samples were evaluated after heat processing as such or in chowder form. There was no difference in acceptance in either case.

Brine composition. Squid flesh is bland, while clams have a distinctive, slightly sweet and nutty taste. The following brine composition was found to imitate this taste quite closely.

Salt	20 g	or	0.8 oz
Sucrose	20 g	or	0.8 oz
Citric acid	1 g	or	0.04 oz
"Mertaste 5"*	2 g	or	0.08 oz
Water to	1 liter	or	1 quart

(* "Mertaste 5" is the trademark name of a commercial additive sold by Merck & Co. and consists of a mixture of monosodium glutamate and sodium inosinate.)

When canned minced squid was tasted as such, this composition was preferred to 2% plain NaCl brine. However, the preference was completely lost when chowders prepared from the different samples were evaluated.

Finishing operations. Filling, exhausting, sealing and processing followed the same procedure as for strips.

iii Product evaluation

For formal evaluation and scoring, the product was offered in the form of a "New England style chowder" and contained canned minced squid, milk, cream, potatoes, onions, butter, salt and pepper. The exact recipe is appended (Appendix 2).

The "squid" chowder was judged highly acceptable (Score 4.4).

e. Squid Fillets

Skinned, half-mantles of squid resemble, in appearance, thin fillets of fin fish. It seems possible that products of this type could replace fish fillets for frying or baking.

Unfortunately, large pieces of squid mantle tend to shrink and undergo immediate curling when fried or baked. They become extremely tough, and scalding does not alleviate the problem. Surface cuts, either in a longitudinal or transversal direction, did not affect curling and toughness. Piercing the fillets in various directions was also ineffective.

The possibility of producing an acceptable frozen squid fillet (plain, breaded or pre-fried) is very attractive from the marketing point of view. It is worthwhile to continue work to develop this product.

f. Squid Blocks

Re-texturized fish blocks are well known sources of raw material for the manufacture of fish sticks. These are produced by pressing into large blocks, pieces of fish muscle too small or irregular to be sold as fillets.

Skinned squid mantles were disintegrated to varying degrees: from coarse (knife chopping) to fine grind (meat grinder). The disintegrated tissue was placed in rectangular plywood boxes lined with aluminum foil. The box dimensions were 10 x 6 x 4 (depth) cm (3.9" x 2.3" x 1.6" deep). The boxes were covered with a loosely fitting board on which a weight of 1 kg (2.2 lbs) was placed. The forms were frozen in three different ways.

In a blast freezer at -40°C (-40°F)

By storing overnight in a refrigerated room at -40°C (-40°F)

By storing overnight in a refrigerated room at -18°C (0°F)

The frozen blocks were cut into 15 mm (0.6") thick slices with a mechanical band saw. The slices were battered and breaded and then dipped in cottonseed oil at 200°C (392°F). All the samples disintegrated completely in the oil. The preparation of squid muscle blocks from disintegrated tissue does not appear to be feasible by the method described here.

g. Other Canned Products

Three "exotic" squid dishes were prepared, following recipes found in various cookbooks. These were:

Squid in its own ink

Squid in wine sauce

Squid in tomato sauce

Stuffed squid.

The products were canned and processed as in the case of strips. No technological problems were encountered and the products were all palatable. The marketability of such products in significant volume has been questioned.

h. Suggestions for Further Development Work

Following is a summary of suggestions for possible future work:

i. The suitability of Illex and Loligo species as raw material for processed squid products must be investigated by means of comparative studies.

ii. The eviscerating machine must be improved, as suggested before. This should be done by those interested in the machine.

iii. Acceptance tests for squid rings must be repeated with the pre-fried oven-heated product.

iv. Further work is needed to develop squid fillets and squid blocks if these are to be produced.

v. The development of objective methods for the evaluation of toughness in squid products is necessary.

C. APPENDICES

Appendix I

LEACHING LOSSES

Introduction. A large proportion of squid proteins is soluble in water. This is the basis of a separate program on squid protein isolation, now under investigation at M.I.T. On the other hand, the processes for the preparation of squid products described in this report call for a number of operations in which squid tissue comes into more or less prolonged contact with water (blanching, washing). It was therefore decided to evaluate quantitatively the leaching losses which can be expected to take place as a result of such contact.

Procedure. Squid of the Loligo type and of New England origin was eviscerated and skinned by hand. Contact with water was avoided. The skinned mantles were cut into strips 2-3 cm wide.

100 g of squid strips were mixed with 1000 ml of water or a 2% solution of NaCl at constant temperature and stirred constantly during a measured length of time. At the end of the measured period of time, the squid strips were separated by screening, shaken and drained to remove excess surface water and then weighed. The gain or loss in total weight was recorded.

A portion of the "leached" squid was cut into small pieces (2-3 mm) (0.08"-0.1") weighed, and oven dried at 102°C (215°F) to constant weight.

Results. The results are given in the following table.

TABLE : LEACHING LOSSES OF SQUID STRIPS IN WATER AND 2% NaCl

Temp. °C (°F) and medium	Contact time min.	Weight g	Dry matter content %	Total dry matter g
10°C (water) (50°F)	0	100	20.7	20.7
	2	103	20.0	20.7
	4	113	-	-
	6	112	17.5	19.6
	10	113	16.6	18.7
	30	115	14.6	16.9
20°C(water) (68°F)	0	100	20.7	20.7
	2	104	19.7	20.5
	4	106	-	-
	10	112	16.2	18.2
	30	112	15.1	16.9
20°C(2% NaCl) (68°F)	0	100	20.7	20.7
	30	115	18.5	21.4
45°C (water) (113°F)	0	100	20.7	20.7
	2	108	-	-
	4	111	-	-
	10	114	15.7	17.9
	30	116	14.1	16.4
65°C (water) (149°F)	0	100	20.7	20.7
	2	98	20.2	19.8
	4	94	-	-
	10	87	-	-
	30	70	17.0	11.9
100°C (water) (212°F)	0	100	20.7	20.7
	2	66	-	-
	10	53	-	-
	30	46	27.9	12.9

DISCUSSION

In contact with water at temperatures up to and including 45°C (113°F) squid flesh adsorbed water and gained weight. Loss of dry substance was considerable after 30 minutes of contact: approximately 20% of the total dry substance content was lost at temperatures up to 45°C (113°F), 45% at 65°C (149°F) and 40% at 100°C (212°F). The slight decrease in leaching losses between 65°C (49°F) to 100°C (212°F) may be due to the rapid denaturation of the protein at these temperatures. It must be pointed out that a contact period of 30 minutes is much longer than needed for washing and scalding. Therefore, leaching loss data after two minutes are more relevant. After two minutes the loss in dry matter on the basis of original dry substance content were: 0% at 10°C (50°F), 1% at 20°C (68°F), 5% at 65°C (149°F). Thus, leaching losses due to the washing and scalding operations can be expected to be small.

Appendix II

Squid Chowder (12 Servings)

Ingredients: 6 tablespoons butter
1/2 cup chopped onion
2 cups boiling water
4 cups potato cubes
2 teaspoons salt
1/4 teaspoon pepper
4 cans minced squid
5 cups scalded milk and cream
(3 cups milk and 2 cups cream)

Preparation:

a. Saute onion in butter.

b. Add water, potato cubes, salt, and pepper.

c. Boil until potatoes are soft.

d. Add squid and heat.

e. Add milk and cream and serve.

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