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THE PRESERVATION OF SCALLOP

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The Preservation of Scallops

By Ernest Hess

Introduction

The following investigations were undertaken primarily to study the difficulties with which the manufacturer of canned scallops is confronted, to ascertain their cause and find methods of preserving scallops free from the present faults. The work was carried out partly at the Fisheries Experimental Station in Halifax and partly at the Biological Station at St. Andrews, N.B., under the direction of Dr. A.G. Huntsman.

A. General

1. Edible Parts of the Scallop

The soft parts of the bodies of a number of molluscs (oysters, clams, and scallops, for example) have long been known as delicacies to the human palate, but while in the case of the oyster and clam practically all parts are usually consumed, it is only the large adductor muscle ("eye") that has been considered edible among the consumers of scallops (at least/North America), and the other soft parts have only been used as bait, fertilizer, or were discarded altogether.

The soft parts of the fresh scallop body make up about 38% of its total weight (as compared with about 54% in the case of the soft clam), in medium sized scallops, while the relative weight of the shells increases with the age of the scallops.

The muscle makes up about 40% of the soft parts, while the visceral mass accounts for the other 60% (stomach, liver, heart, gonads, etc.)

The Adductor Muscle: No data are available for the Giant Deep water Scallop (Pecten tenuicostatus); for the Shallow water Scallop (Pecten irradians) the following figures are given by Smith:

Water	80.3%		Protein	14.7%
Solids	19.7%		Fats	0.2%
			Carbohydrates	3.4%
	100.0%		Minerals	1.4%
			Solids	19.7%

The major portion of this large muscle consists of cross-striated muscle fibres running from one shell to the other, and serves to close the two shells together. A small crescent like part of smooth fibres will keep the shells closed after the large part of the muscle has contracted.

The adductor muscle of the scallop is relatively large, weighing 50 and more grams (1¾ to 2 oz.) in a good sized scallop.

The Visceral Mass: The main parts of the visceral mass are the heart, liver, stomach and intestines, gonads and the gills. They are all edible, with no objectionable, although perhaps rather rich flavour, but the appearance of most of these parts is not very attractive and creates prejudice against their consumption.

The same is true of the Mantle, consisting mostly of muscle fibres, lying along the inside edge of both shells, and exhibiting a large variety of colours in different scallops from white and black, to grey, dark black and yellowish red.

2. Fresh Scallops

As long as the supply of scallops is limited they are practically all marketed fresh, i.e. the "eyes" are removed from the scallop after landing, or perhaps already on board the boat, and shipped fresh, by chilling them with crushed ice, to nearby markets. As the fresh muscles are very perishable, they are hardly ever shipped to inland points, the chief markets being Boston and New York. The shallow water scallops are usually "plumped" by allowing the eyes to soak in water over night, whereby they increase in volume by about 40%. This method decreases their keeping quality still more. These fresh scallop /are usually served fried.
muscles

3. Preserved Scallops

With increased supplies and limited markets of fresh scallops, the problem of preserving them for a longer period of time arose. In most methods of preserving foods one or more of their characteristic properites are usually changed. This is especially the case with canned scallops.

a. Canned Scallops: Canning, i.e. enclosing the food in an air-tight receptacle (usually of tin or glass) and sterilizing it by means of heat in the so-called processing, has been used successfully for a variety of sea foods, especially lobster, salmon, shrimp, etc. It was a natural step therefore to try the canning of scallops to improve their keeping quality. Such attempts were made as long as 50 years ago, and on various occasions since, but apparently without much success. No method of canning scallops is recorded in the literature on the preservation of sea foods. The difficulties encountered in canning scallops shall be treated in detail in the second section of this report.

b. Frozen Scallops : While scallops are often kept in cold storage over a glut period, to be later thawed out again and marketed as fresh, the recently advanced method of rapid brine freezing of fish has opened a new way of marketing scallops.

In our investigations fresh scallop eyes were frozen in two ways:
1. In the form of a cake, consisting of three to four eyes, and weighing approximately half a pound, similar to the frozen cakes of fish (ice fillets) put up by the Biological Board.

These cakes were frozen in brine at 0°F. for 30 minutes, and kept in cold storage. Some were examined after one day, others after 6 weeks, and the rest are still in storage for future examination. After thawing the eyes could not be distinguished from fresh scallop muscles, they were identical in colour, firmness, odour, flavour and general appearance.

2. A second lot of scallop "eyes" were packed fresh into cans. The cans were sealed and immersed into the brine at 0° F. for 40 minutes. Some cans were opened after one day in cold storage, the rest after 6 weeks. The "eyes" after thawing had the appearance of fresh scallop muscles in every respect. They could be fried very easily without breaking apart. Special care has to be taken, however, to prevent rusting of the outside of the cans in cold storage

With the introduction of cold storage facilities for shipping, in whole-sale houses, and retail stores becoming more and more general, the preservation of scallop muscles by rapid brine freezing will become one of the best, if not the best method.

B. The Canning of Scallops

The main problems in canning the scallop muscles are connected with the changes the muscles undergo upon heating during the processing of the cans (sterilisation by heat). They are mainly changes in colour, in volume and weight, and in strength of the interfibrillar tissue.

1. Colour

Upon coagulation the originally clear translucent muscles change into a pure white opaque colour. This coagulation of the muscle proteins may either be brought about by salts or by heat. Immersion of the scallop muscle in 50% saturated Sodium chloride will coagulate the surface layers within 3 to 4 minutes.

Temp. °C.	Time interval min.	Treatment	Method of cooling	Increased Darkening of Colour of Muscle pieces																			
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
30	60	Tap water	water			6	1 2		4 5		3												
"	"	dry	"			2			5		4 6	1 3											
100	30	sea water	water		1 3 4		2			6 5													
"	"	"	air	3		4		5 1		3 6													
"	"	tap water	water	1	2			4 5 6				3											
"	"	"	air	1	2							3				4		5 6					
115	10	"	water				1						2	3	4				5	6			
"	"	"	air										1	2	3		5		4	6			
100	30	dry	water			1						2		3				5			4 6		
"	"	"	air						1				4		2 3				6			5	
"	"	soaked 10 min. in 50% sat. NaCl dry	Water											1			2			3		4	5
"	"	"	air														1 2						3 4 5 6

1,2,3,4,5,6 = Consecutive time intervals.

▨ - 1 hour exposure to heat

TABLE I

Upon gradual heating, the different proteins the muscle consists of, coagulate at different temperatures. Coagulation in a 6 hours extract of scallop muscle in distilled water takes place at 58-59°C. and at 75°C while the proteins in a 5½ hours' extract in 1.5% sodium chloride solution, coagulate at 44°C., 66°C and 75°C. respectively.

The pure white colour of the freshly coagulated muscle changes to greyish, yellowish and brownish shades depending on the treatment to which the muscles are subjected subsequently.

Pieces of scallop muscle were exposed in test tubes in different ways to the action of heat and the colours of the pieces were compared after the different treatments, by grading the whole set of test tubes into twenty graduations from the lightest coloured to the darkest coloured one. (See Table I). Some of the muscle pieces were put into the tubes without adding any liquid ("dry"), to other tubes 10 cc. of tap water was added in addition to the muscle pieces, and to one set 10 cc. of sea water was added. In one case the pieces of muscle had been immersed into 50% saturated NaCL for 10 minutes and then put into the tubes "dry". All test tubes were closed by means of a cork. One set of tubes was immersed in a constant temperature water bath at 50°C. and two tubes each removed at 60 minute intervals. One of these tubes was always allowed to cool slowly at room temperature, while the other was cooled rapidly by immersion in cool running tap water. One set of tubes was immersed in a paraffine bath at 115°C. and the tubes removed at 10 minute intervals. The rest of the sets of test tubes were immersed in boiling water at 100°C. and the tubes removed in pairs at 30 minute intervals.

Table I indicates that on the whole an increase in the length of time of heating causes an increased discolouration of the muscle, the same effect is produced by increasing the temperature of heating from 100 to 115°C. The muscle pieces heated in sea water were lightest in colour, those heated in tap water slightly darker, the ones heated "dry", darker still, and the ones which had been immersed in the 50% saturated brine first turned out to be the darkest of all after heating.

The more thoroughly all traces of the visceral mass are removed from the muscles the less danger of discolouration there is. Especially if traces of the excretory organ are left on the muscle, the muscle is liable to turn darker. (This was found to be true also in the case of freezing the scallop muscles). Table II shows the influence of traces of the excretory organ added to the pieces of muscle before heating.

TABLE II

Treatment	Muscle pieces alone	Muscle pieces tissue from excretory organ
Pieces in sea water tubes closed	1	2
Pieces in sea water tubes open	1	3
Pieces "dry" tubes closed	3	4

NB. 1,2,3,4 = increasing grades of darkening of muscle pieces.

The temperatures and time periods necessary for proper sterilization of the contents of the cans are so high that they cannot help but change the colour of the fresh muscle. (Processing temperature and period for 3 oz. can : 212°F. for 3 hours, 240°F. for 40 min.). Any reduction of these figures, to safeguard the white colour, would result in under-sterilization of the cans. Immediate cooling after processing produces less dark meat, than if the heated muscle is allowed to cool slowly. (See Table I).

2. Shrinkage

When the fresh muscle, which contains approximately 80% of water, is heated, it shrinks both in volume and weight. The loss in weight varies from 20 to 30% during processing. The less this shrinkage during processing the better is the appearance of the can. If the muscles are shrunk previous to canning (by steaming of plunging in boiling water from 15 to 20 Minutes) they will not shrink any further during the processing, and the cans will give a packed full appearance. Of course a larger amount of fresh muscles are necessary to fill a can by this latter method. It is, however, common practise in the canning of similar products such as clams, oysters, lobsters, haddock, etc.

The great disadvantage of the heating of scallop muscle, previous to the canning, is the increased amount of heating the muscles are exposed to, with its injurious effect on the colour of the muscles. Scallop muscle which has been treated in this way is usually of darker appearance still, than the freshly packed muscle, the subsequent method of processing being identical.

5. Strength of interfibrillar tissue

As the connective tissue between the myomes in fish (haddock for example) weakens on heating, (Forbes) as noticed in the flaking of the flesh, so does the connective tissue between the long parallel fibres of the adductor muscle weaken under the same circumstances, and the individual fibres and fibre bundles are shredding apart, especially if no protective membrane surrounds the muscle to hold them together.

All parts of the visceral mass surround the adductor muscle closely, and are in direct connection with it by means of connective tissue. If the scallop "eyes" are dressed by hand, the visceral mass is usually torn off in one movement and with it also the connective tissues that hold muscle and visceral mass together, including a fine membrane which surrounds the whole muscle. The muscle fibres fall much more easily apart, if this membrane is removed, than if the muscle were dressed carefully, i.e. the visceral masses cut off by means of scissors without injuring this thin membrane. This membrane helps to hold the muscle fibres together although the interfibrillar tissue may be weakened, unless by mechanical shaking the fibres are thrown out of this "heap".

In order to measure the strength with which the fibres are held together, a simple apparatus was built, in which the weight necessary to cut through the muscle between the fibres, in different directions, was determined, first by cutting through the muscle diametrically, and then by cutting each half, one from the perifery to the centre and the other in the opposite direction.

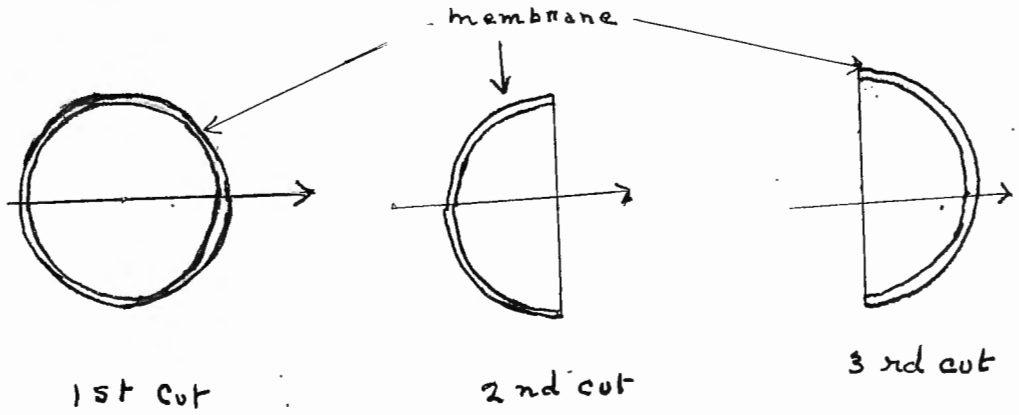


Fig. I.

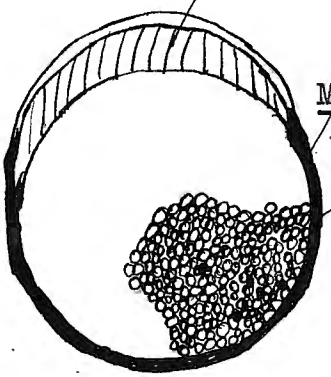


Fig. 2

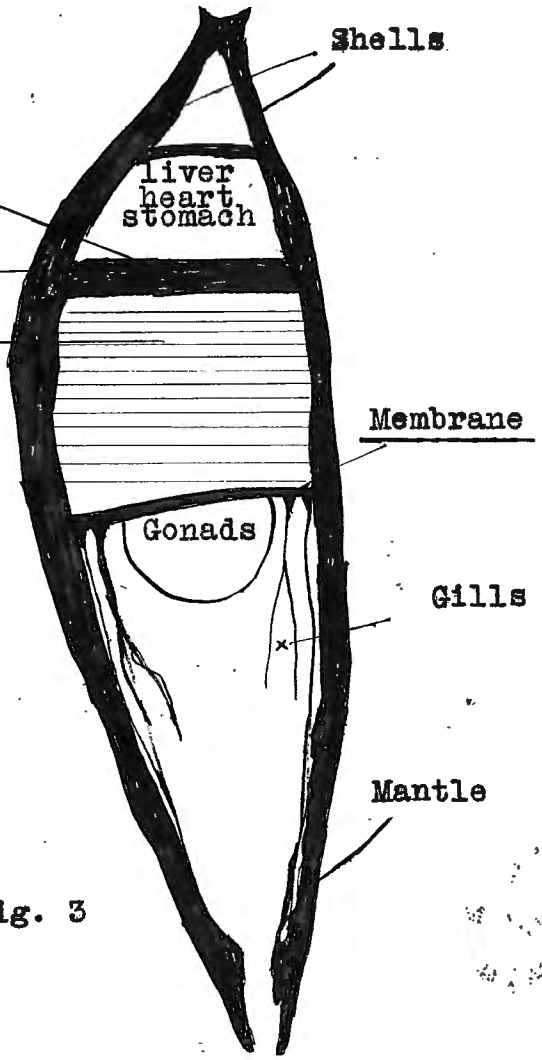


Fig. 3

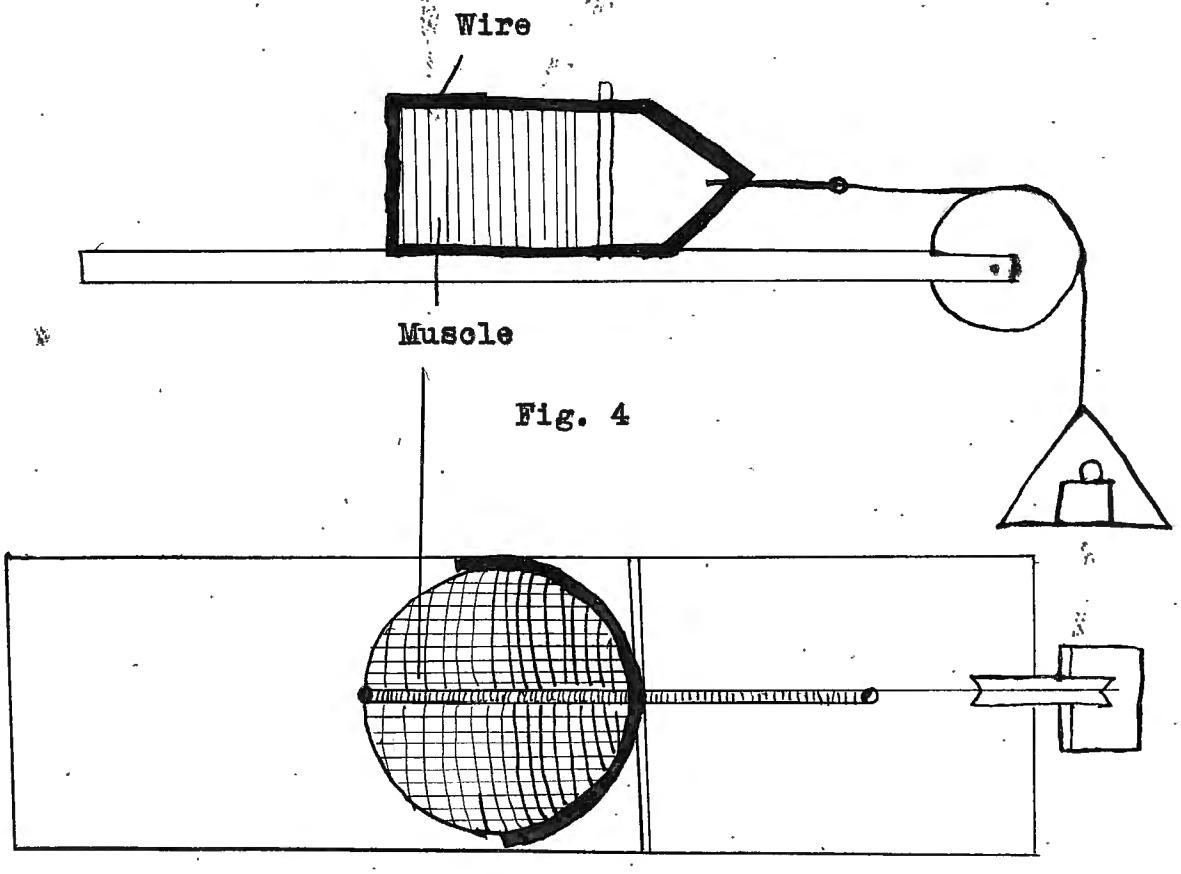


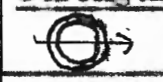
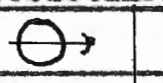
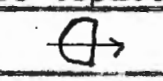
Fig. 4

While by this method various weakening and strengthening effects after different treatments could be observed, it does apparently not give a true picture of the factors causing the breaking apart and shredding of the fibre bundles. Although treatment of the fresh muscle such as soaking of the muscle in 100% saturated NaCl alone, and with the addition of small amounts of formaldehyde, will increase the values of our test figures, the muscle fibres will shred apart on subsequent processing, while the rapid brine freezing of the muscles will weaken it according to our test, and yet it will not break apart into muscle fibre bundles and individual fibres, but behaves like fresh muscle. Often muscle may give a fairly high test on our apparatus, and yet break very easily apart on mechanical shaking. No treatment was found that would prevent the shredding apart of the muscle fibre bundles and fibres on subsequent processing of the cans. A few of the typical results of our tests are given in the following table:

TABLE III

Treatment of fresh muscle	Strength (resistance to cutting) in Grams			
	⊖→	⊖→	⊖→	⊖→
Fresh Dressed by hand	-	650	750	350
" " with scissors	1160	-	800	370
" " " "	1150	-	450	270
Boiled 5 minutes	1340	-	1050	300
" 60 "	±	-	-	300
Steamed 10 minutes no pressure	-	290	-	-
" 30 " " "	-	270	-	-
Steamed 5 " 14 lbs. pressure	1500	-	550	400
Frozen in cakeform (30min. 0°C.)	1155	-	400	150
" " cans 45 "	1000	-	600	200
" " " dressed by hand	-	200	200	100
NaCl 50% sat. 15 min.	1150	-	750	150
30 "	800	-	700	150
50% sat.+0.5% HCHO 15 min.	1900	-	750	350
30 "	1560	-	1530	300
50% sat. boiled for 15 "	1330	±	920	450
NaCl 100% sat. 15 min.	1500	-	650	250
30 "	1600	-	?	450
100% sat.+0.5% HCHO 15 min.	1900	-	600	600
100% sat.+0.5% CH_3COOH 15 min.	1610	-	800	400
30 "	1560	-	600	300

Table III continued.

Treatment of fresh muscle	Strength (resistance to cutting in Gram			
				
Formaldehyde 40% 30 seconds.	1410	-	800	450
" 2% 10 minutes	1900	-	800	200
20 "	1200	-	850	350
Acetic Acid 2% 10 minutes	1780	-	350	200
20 "	700	-	700	400
Canned muscle:				
Canned fresh, dry, 3 hrs. 212°F.	1000	-	350	650
" " seawater pickle 212°F.	850	-	450	350
Steamed 15 minutes, canned dry	1050	-	450	150
" " canned with seawater pickle	900	-	250	350
Canned fresh, exhausted 10 minutes	900		650	650
" " " "	400		150	200
Fried, then canned 45 min. 240°F	850		400	150
" " " "	450		300	400

Other canning experiments show that the muscle when packed fresh is usually weaker, than when either boiled of steamed previous to packing. At the same time however, the muscle packed fresh is lightest in colour after processing, and although weaker according to our test, it shakes apart less easily during mechanical shaking of the can.

The cans that were processed by means of intermittent sterilization (one hour at 212°F. each on three consecutive days) were lighter in colour of muscles than any of the others, processed for 45 minutes at 240°F., 70 minutes at 228°F., and 3½ hours 212°F., respectively; they were, however, weaker according to our test.

Although scallop muscles can be canned, especially if the membrane around the muscle is left intact, without breaking into shreds in the can, at least if the can is not shaken in handling and shipping, these muscles are not firm enough to withstand any subsequent handling in cooking without breaking apart. If the cans are exposed to much shaking in shipping, especially if much shrinkage has taken place in the can and left much empty space, then the muscle mostly fall into shreds right in the can, and are unsuitable for the customary ways of preparation for the table.

C. Use of Visceral Mass

As the appearance of the different parts is not very appetizing in the fresh state, the possibility of preparing a paste from the ground up material was considered.

Male and Female Gonads, the Mantles, the Gills, and the Livers, (with heart and stomach) were all collected separately, boiled for 15 minutes to remove part of the water, and then ground finely through a meat grinder. Each lot was canned separately in 3 oz. cans at 240°F. for 45 minutes. Organoleptic tests showed that both gonads and mantles had a pleasant flavour and appearance, while the liver had rather an objectionable colour (dark green) and very rich odour and flavour. The gills did not shown any distinctive flavour.

A combination of the first three, i.e. male and female gonads and the mantles, ground up together finely, after having been steamed or boiled, and with the addition of a small amount of table salt and possibly some spices, results in a very tasty, pleasant looking and smelling paste. This paste can easily be canned (in enamel can preferably to prevent "smut"), and furnishes a nice relish, especially suitable as a sandwich filling, as, on account of its rich flavour, it does not want to be consumed in large quantities at one time.

SUMMARY

It has been shown that the preservation of the scallop muscles by means of heat sterilization in the form of canning is not successful, at least, from the point of view of producing a product resembling the fresh muscle as much as possible. The main changes in the canned product are: a considerable shrinkage in volume and weight; an undesirable darkening of the colour of the muscle, due to the time and temperature of heating necessary to sterilize the can contents; and a very undesirable breaking apart of the muscle fibre bundles into shreds of fibres, due to the weakening of the interfibrillar tissue during the processing.

It has been shown that the preservation of the muscle by rapid brine freezing, on the other hand, has none of the above disadvantages, and results in a perfect product, which upon thawing cannot be distinguished from the fresh scallop muscle. (Tests were as long as 6 weeks cold storage).

The utilization of the visceral mass, in part at least, has been shown to be feasible, by means of a preparation of a Paste from the gonads and mantle, which has been found to furnish a very tasty sandwich filling.