Final Report: The Moisture Content of Scallops.

by

John Sumner
Food Technology Unit,
Royal Melbourne Institute of Technology
Vic 3001.

Summary and Comment

1. The mass of scallops sampled from processing plants in Melbourne during the period November, 1983-December, 1984 was found to vary according to fishing ground. Tasmanian scallops were larger (mean 11.6g) than those from Port Phillip Bay (9.9g) and Lakes' Entrance (9.4g).
2. Scallops caught in Port Phillip Bay or in Tasmanian waters had a higher moisture content than those caught off Lakes' Entrance; 78.94% and 78.67%, respectively, versus 77.60%.
3. Season did not affect moisture content, though it did affect mass; scallops taken in the winter months were larger than those caught in warmer seasons.

Thus the anecdotal information available from fishermen and processors regarding mass and moisture content of scallops and their variation according to season and fishing area appears borne out by the present investigation.

4. Two rapid methods of assessing whether scallops had been soaked to increase moisture content were developed; a cook test which measured weight loss before and after cooking, and a pressure test which equated moisture content with area of exudate when scallop homogenate was placed beneath a weight both proved effective in assessing moisture content of soaked scallops.
5. A survey of market scallops in Melbourne established (50 samples) a mean moisture content of 87.2% with a range of 84.7-89.7%. The pressure test correlated well with a reference method (dry weight) (r=0.761) and provides a rapid, cheap record of establishing whether scallops have been soaked

The present study quantified the practice of soaking scallops; all of 50 samples purchased had been soaked, irrespective of whether they were purchased from a market stall or a large supermarket chain. The pressure test can readily determine whether scallops have been soaked.

6. Drip loss from frozen scallops as they were thawed varied according to origin of scallops, Tasmanian losing significantly more fluid than those from Port Phillip Bay or Lakes' Entrance.
7. There was a marked difference in thaw loss depending on how long scallops were thawed.

The present study underlines the need for more effective quality control during packing and freezing of export scallops, together with the need for a standard thaw test.

1. Scope of the Investigation.

Among the areas considered commercially important by the Victorian Fishing Industry Council (VicFish) were:

(i) Is the moisture content of scallops affected by mass; anecdotal information from fishermen and scallop processors had suggested, *inter alia*, that scallops caught east of Lakes' Entrance were smaller than those from Tasmania or from Port Phillip Bay.

(ii) Is the moisture content affected by season.

(iii) Is the moisture content affected by catching area.

(iv) What is the range of water uptake of scallops which are soaked, and what is the water loss during cooking of soaked scallops.

(v) What is the thaw loss of scallops, and is this loss affected by thawing method.

(vi) Is there a method suitable for rapid assessment of moisture content of scallops.

2. Experimental Work Carried Out in the Present Investigation.

Scallops were purchased in a "dry" (unsoaked) form from four processors in Melbourne; Dellas Seafood Processors, Jimmy's Oyster and Seafoods Pty Ltd, VSFD Industries Pty Ltd (all located at the Footscray Fish Market) and Allied Shellfish Processing Pty Ltd, Dandenong.

Samples (around 2kg) were purchased and transported in a plastic bag to the laboratory where analyses were carried out immediately. Each sample was divided arbitrarily into 5 sublots on each of which was carried out a moisture determination, a pressure test and a cook test (see Appendix for full methodology).

To determine thaw losses scallops (ca. 500g) were weighed into plastic bags and frozen in an air blast freezer at -30°C and stored at around -20°C until thawed.

At thawing scallops (ca. 500g) were placed, within their plastic bag, on a mesh sieve beneath running cold water. When scallops just separated the entire mass was weighed after draining on the mesh for 2 min.

This thaw was termed "Separation Thaw".

To mimic the practice of some inspectors scallops were allowed to thaw for 1 h after separation, then weighed as before after draining. This was termed "Separation Thaw + 1h".

3. Results.

1. Mass of Scallops.

Over the period November, 1983 to December, 1984 some 93 samples of scallops were purchased and the masses of 30 scallops within each sample determined.

Scallops taken in Tasmanian waters (mainly around Babel Island) were, on average, larger than those taken from either Port Phillip Bay, or from Lakes' Entrance ($p < 0.001$). Tasmania scallops averaged 11.6g (34 samples), compared with 9.9g (28 samples) and 9.4g (31 samples) for scallops from Port Phillip Bay and from Lakes' Entrance, respectively.

The mass varied according to season; generally, scallops were larger in the winter months (Table 1) particularly in the case of "Tasmanian" scallops analysed during 1984 where, for most of the year large (up to 18g) scallops were taken from near Babel Is. while in December, 1984 small (7g) scallops were entering the market from around King Is.

Increased size during the winter months has also been shown by Gwyther et al. (1984), the increase paralleling maturity of the gonads.

Another measure of seasonal size increase may also be gained from the Summary of Catch/Effort Returns provided by Commercial Fisheries Branch of the Victorian Ministry for Conservation. The relative yield of scallop meat per bag, over the period 1979-1984 has been shown to increase from 8.3kg in April to 10kg in July, August and September; the December yield was 8.5kg of meat/bag.

2. Moisture Content of Scallops.

Over the period November, 1983 until December, 1984 some 120 samples of scallops were analysed for moisture content; for each sample each of 5 sublots was analysed in duplicate.

For all samples the mean moisture content was 78.52%.

Scallops from Tasmania and Port Phillip Bay had a higher moisture content than those from Lakes' Entrance ($p < 0.01$); 78.94% and 78.67%, respectively, versus 77.60% (Table 2).

There was no significant difference in moisture content according to season although scallops taken from near Babel Is. in December, 1984 were both small (7g) and rich in moisture (81.09%).

The present study therefore establishes the mean moisture content of dry scallops as 78.5%, with the maximum being 81.0%

Table 1. The mass of scallops versus season and catching area.

Month/Year	Tasmania	Port Phillip Bay	Lakes' Entrance
12/83	12.0 (4)*	5.9 (1)	-
2/84	14.9 (5)	-	9.9 (2)
3/84	10.0 (2)	-	10.4 (10)
4/84	11.5 (4)	9.4 (5)	8.8 (7)
5/84	13.8 (7)	10.1 (9)	9.3 (5)
6/84	18.4 (2)	10.3 (10)	8.7 (7)
10/84	-	11.7 (3)	-
12/84	7.2 (10)	-	-
Mean	11.6	9.9	9.4

Table 2. Moisture content of scallops versus season and catching area.

Month/Year	Tasmania	Port Phillip Bay	Lakes' Entrance
11/83	78.18 (3)*	-	-
12/83	78.62 (24)	79.13 (5)	-
2/84	79.84 (5)	-	77.73 (2)
3/84	78.99 (2)	-	77.85 (10)
4/84	78.59 (4)	78.83 (5)	76.77 (7)
5/84	77.26 (7)	79.11 (9)	78.27 (5)
6/84	77.44 (2)	78.04 (10)	77.55 (7)
10/84	-	78.55 (3)	-
12/84	81.09 (10)	-	-

* Number of samples in parentheses.

3. A Rapid Method for Assessing Scallop Moisture Content.

Two methods which allowed a rapid assessment of scallop moisture were carried out in parallel with moisture determinations decribed in Section 2. A Pressure Test, in which a sample of homogenised scallops was placed between filter papers to which a weight was added to speed up exudation of water, had the advantages of speed and a permanent record of the area of exudate.

A Cook Test, in which scallops were weighed both before and after cooking, and the percentage loss recorded, was also a rapid method but required accurate scales and did not provide a permanent record of fluid loss.

Dry scallops had a mean area of exudate following the Pressure Test of 19.6cm^2, with a range from 7.9-34.3 cm^2. There was no difference between the exudate from scallops caught in different areas (Table 3), and, compared with moisture determinations, there was no correlation between moisture content and exuded area ($r=0.186$).

Following the Cook Test the mean loss was 8.04% (range 2.4-19.6%) and Tasmanian scallops had a significantly greater cook loss ($p < 0.01$) than scallops from Port Phillip Bay and Lakes' Entrance (Table 4). Cook loss correlated poorly with moisture content ($r=0.334$).

For dry scallops, therefore, both Pressure and Cook Tests did not correlate well with the relatively small (77-80%) differences determined by dry weight analyses.

Table 3. Area of exudate in Pressure Test from scallops.

	Tasmania	Port Phillip Bay	Lakes' Entrance
number of samples	235	145	155
mean area (cm^2)	19.1	20.7	18.9
range	13.9-28.4	13.9-27.5	7.9-34.3
SD	3.5	4.4	3.7

Table 4. Loss during Cook Test from scallops taken from different fishing areas.

	Tasmania	Port Phillip Bay	Lakes' Entrance
number of samples	235	145	155
cook loss (%)	9.8	6.6	6.6
range	3.4-17.0	3.3-12.8	2.4-19.6

4. A Rapid Method for Determining Whether Scallops Have Been Soaked.

The Pressure Test was used to survey scallop moistures in market scallops; some 50 samples of scallops were purchased from retail outlets in fish markets, and from supermarkets and the moisture content determined by dry weight analysis. In each case, a sample of scallops was homogenised and one aliquot placed in a tared dish for dry weight determination while another aliquot was used for the Pressure Test.

The Cook Test was not used for this exercise since, from a legal standpoint, it was considered necessary to compare homogenised samples in both a reference test (Moisture by dry weight) and the rapid test (Pressure Test); clearly, the Cook Test, which utilises whole scallops could not be correlated directly with homogenate from the same batch.

Good correlation was obtained between exudate area and moisture by dry weight ($r=0.761$) for 50 samples of market scallops which had a moisture content of mean 87.2%, range 84.7-89.7% (Table 5).

The Pressure Test, therefore, offers a rapid method which can be used to distinguish between dry and soaked scallops (Fig. 1).

Table 5. Moisture content and price of retail scallops in Melbourne (July, 1984)

Source	Moisture (%)			Price ($/kg)	
	Mean	Minimum	Maximum	Wet basis	Dry basis *
Queen Victoria Market					
n=35	87.6	85.1	98.7	7.50	60.5
Supermarkets					
n=15	86.1	84.3	89.5	10.90	78.4

* Calculated on a dry weight basis (moisture free).

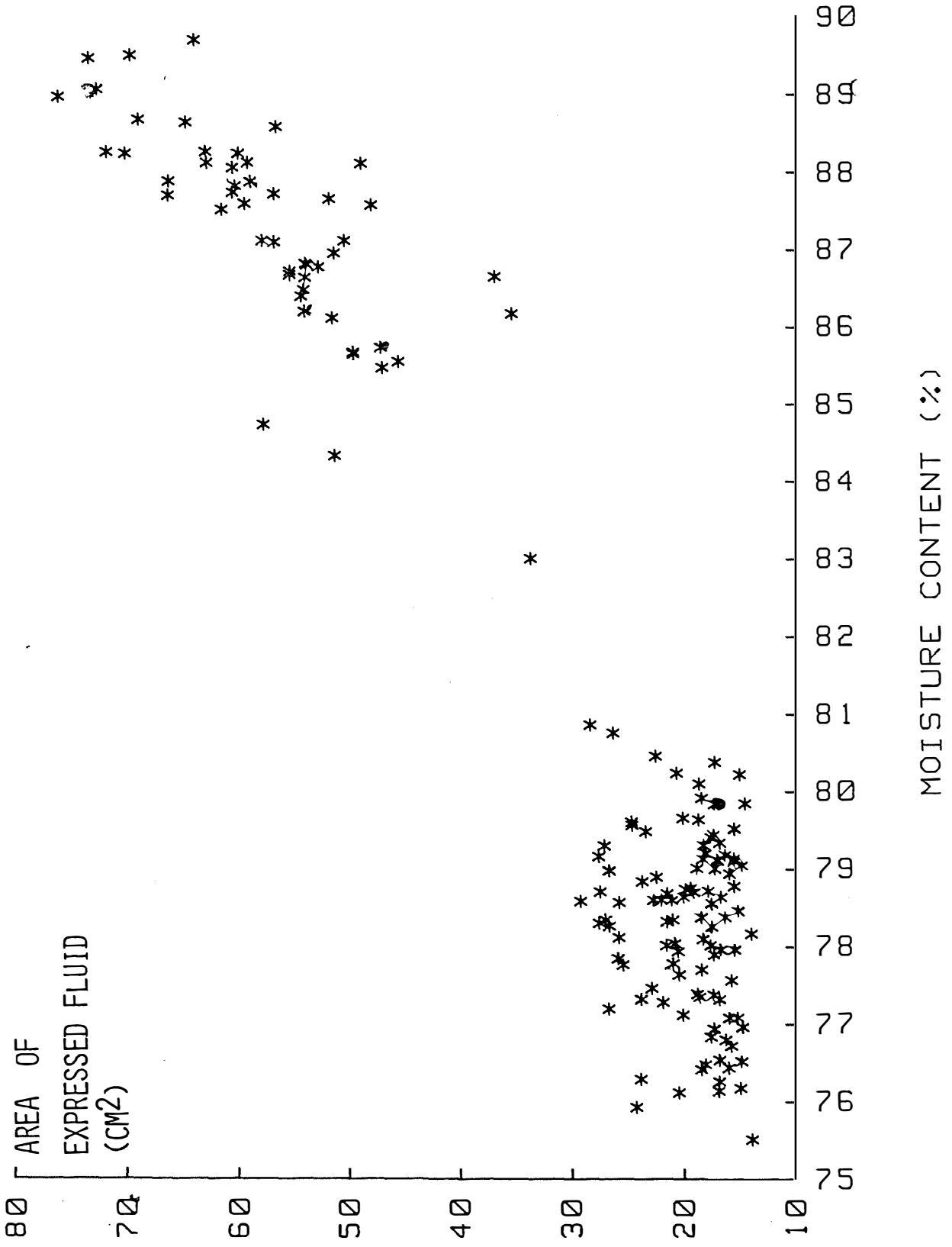

FIG. 1. Moisture content of dry and soaked scallops versus area of exudate produced in Pressure Test.

5. Moisture Loss During Cooking of Soaked Scallops.

Scallops soaked in cold ($5^{o}C$) water took up water progressively over a 30h period (Table 6), the moisture content rising from 77.4% (dry scallops) to 87.9% after 30h. On cooking weight loss was correlated with moisture content; for a 30s cook r=0.989 and for a 60s cook r=0.991 (Table 7).

Thus, scallops soaked, say, to 88% might be expected to lose over 30% fluid during cooking, a loss which some consumers may be expected to find unacceptable.

Table 6. Moisture content of scallops during soaking.

Soaking time (h)	Moisture content (%)	Standard deviation	95% C.I.
0	77.4	0.8	0.9
6	83.0	0.9	1.0
12	84.3	1.1	1.3
24	86.2	0.5	0.6
30	87.9	0.6	0.7

Table 7. Weight loss from soaked scallops during cooking.

Soaking time (h)	Weight loss (%)	SD	95% CI
30s Cook			
0	7.5	0.6	1.2
6	16.4	1.9	2.2
12	21.2	1.7	2.0
24	23.5	2.6	3.0
30	25.0	2.0	3.0
60s Cook			
0	8.6	2.9	2.7
6	19.3	2.8	3.3
12	25.6	0.8	1.0
24	29.5	3.6	4.1
30	33.2	3.6	4.1

6. Thaw losses from Frozen Scallops.

Scallops frozen in approximately 500g lots in plastic bags were thawed either to separation or to separation plus one hour and the thaw loss determined.

After 3-6 months frozen storage at around -20°C mean thaw loss for some 69 samples was 2.98% at separation, and 4.41% after a further hour at ambient. Tasmanian scallops lost significantly more moisture during thawing (both at separation and at separation plus 1 hour) compared with scallops from Port Phillip Bay and Lakes' Entrance ($p < 0.01$; Table 8).

Table 8. Thaw Losses of scallops.

	Tasmania	Port Phillip Bay	Lakes' Entrance
Separation	n=19	n=23	n=27
Mean loss (%)	4.1	2.9	2.2
SD	1.8	1.1	1.1
95% CI	3.2-4.9	2.5-3.4	1.7-2.6
Confidence interval			
Separation + 1h			
Mean loss (%)	5.9	4.4	3.3
SD	1.9	1.5	1.2
95% CI	5.0-6.9	3.7-5.1	2.8-3.7

Thaw losses in the present study have usefulness in two respects. Firstly, the difference between a separation thaw, and allowing a further thawing period, even as brief as one hour, has been documented. The difference, almost 1.5% is significant for a processor who already overpacks in order to allow for thaw losses during the thaw test carried out by Department of Primary Industry inspectors prior to export.

Secondly, the difference in thaw loss between scallops from different fishing grounds is also significant.

The present study makes no attempt to extrapolate the findings to commercial practice where freezing may be extremely slow, depending on the effectiveness of freezing equipment and practices used, as well as of the quantity to be frozen.

It is clear that the present "rule of thumb" assessment made by processors about how much overpack to include is both costly, and sometimes ineffective in meeting thaw test criteria.

APPENDIX

MATERIALS AND METHODS

Methods of assessing moisture content

Raw materials

Scallops, shucked but not rinsed were obtained from Canals J.J. and J., The Seafood Appreciation Centre (Carlton Nth., Victoria) and stored in plastic bags in ice prior to analysis.

Soaking

Soaking of Scallops was carried out as shown in Figure 2. Samples taken at each point marked '*' were drained for 2 min and moisture content determined.

Determination of moisture content

Scallops (10) were blended using a Bamix (model M122) mixer and a sample (10g) placed in an aluminium tin which had previously been dried (1h/105 °C), cooled in a desiccator and weighed. Tin plus sample were reweighed and heated in a Hot Air Oven (105 °C±1 °C/15h±1h), then cooled in a desiccator and weighed. Percentage moisture was determined as percent mass loss on drying. The test was carried out in triplicate. A flow diagram of the method is shown in Figure 3.

Rapid moisture determination

Two rapid methods of moisture measurement were developed, methods are as follows.

Pressure Method

From scallop slurry (prepared as above) a sample (2.00g±0.01g) placed on a filter paper (Whatmans No. 540), between 2 plastic sheets (Figure 4). A mass (100g) was placed on top of the plastic sheets for 30 min, filter paper was removed and moisture ring measured with a compensating polar planimeter (Keuffel and Esser Co.). The test was carried out in triplicate. Figure 4 shows the plastic sheets with filter paper and Figure 5 shows moisture zones obtained for wet and dry scallops.

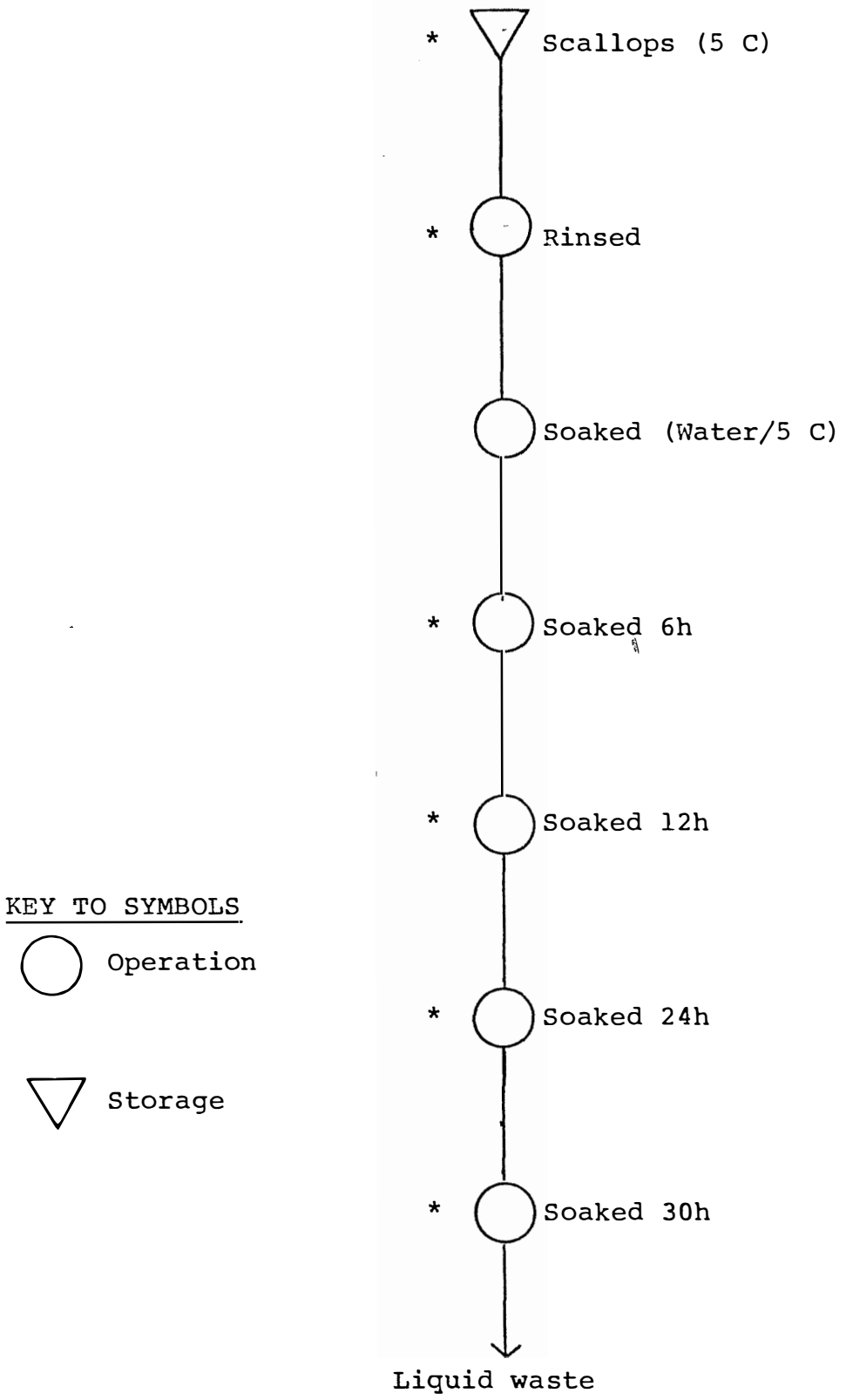

Figure 2. Flow process chart for scallop soaking trial

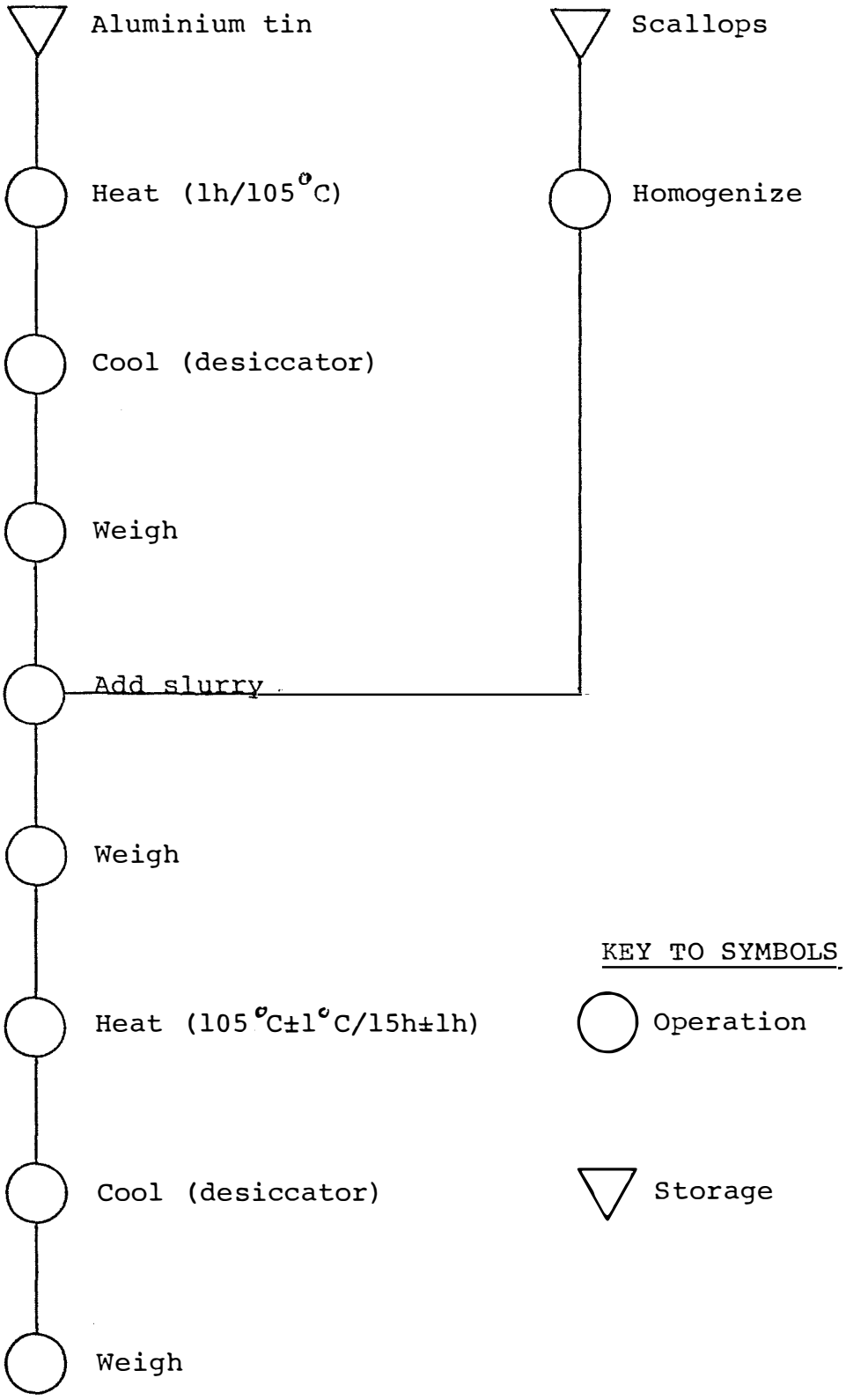

Figure 3. Flow diagram of Hot Air Oven Method

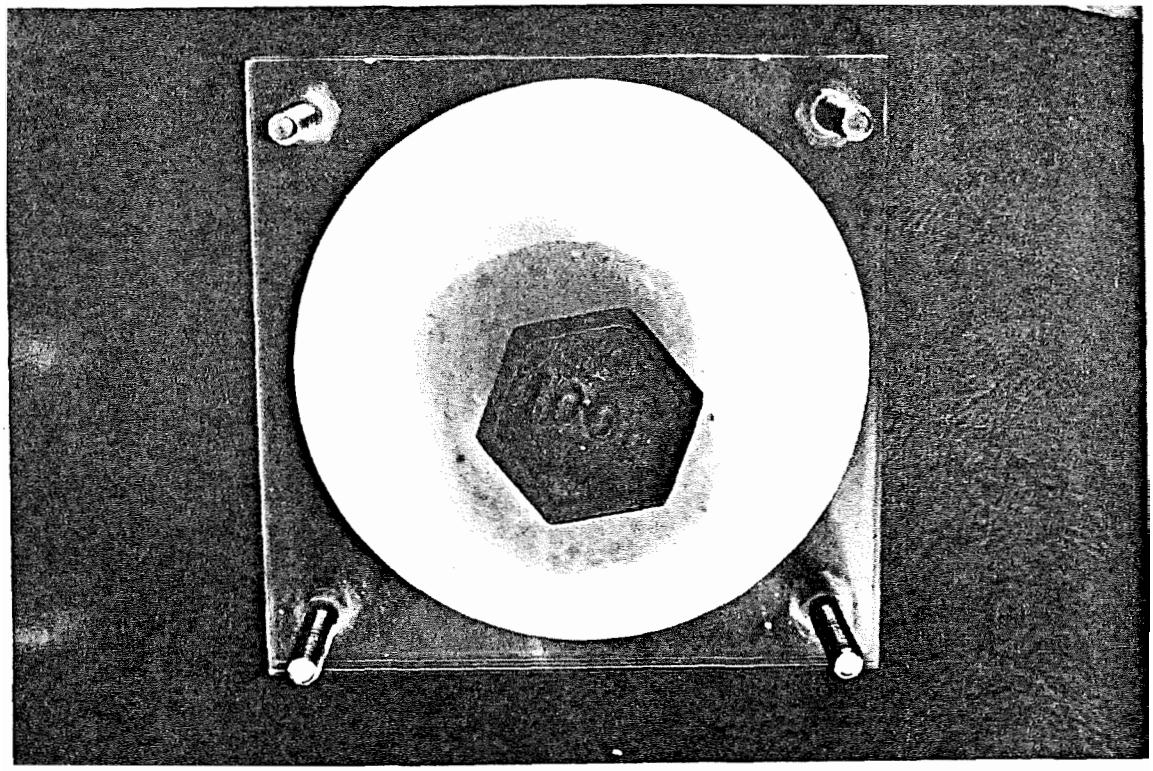

Figure 4 . Apparatus for Pressure method, showing plastic sheets, mass(100g), filter paper and sample.

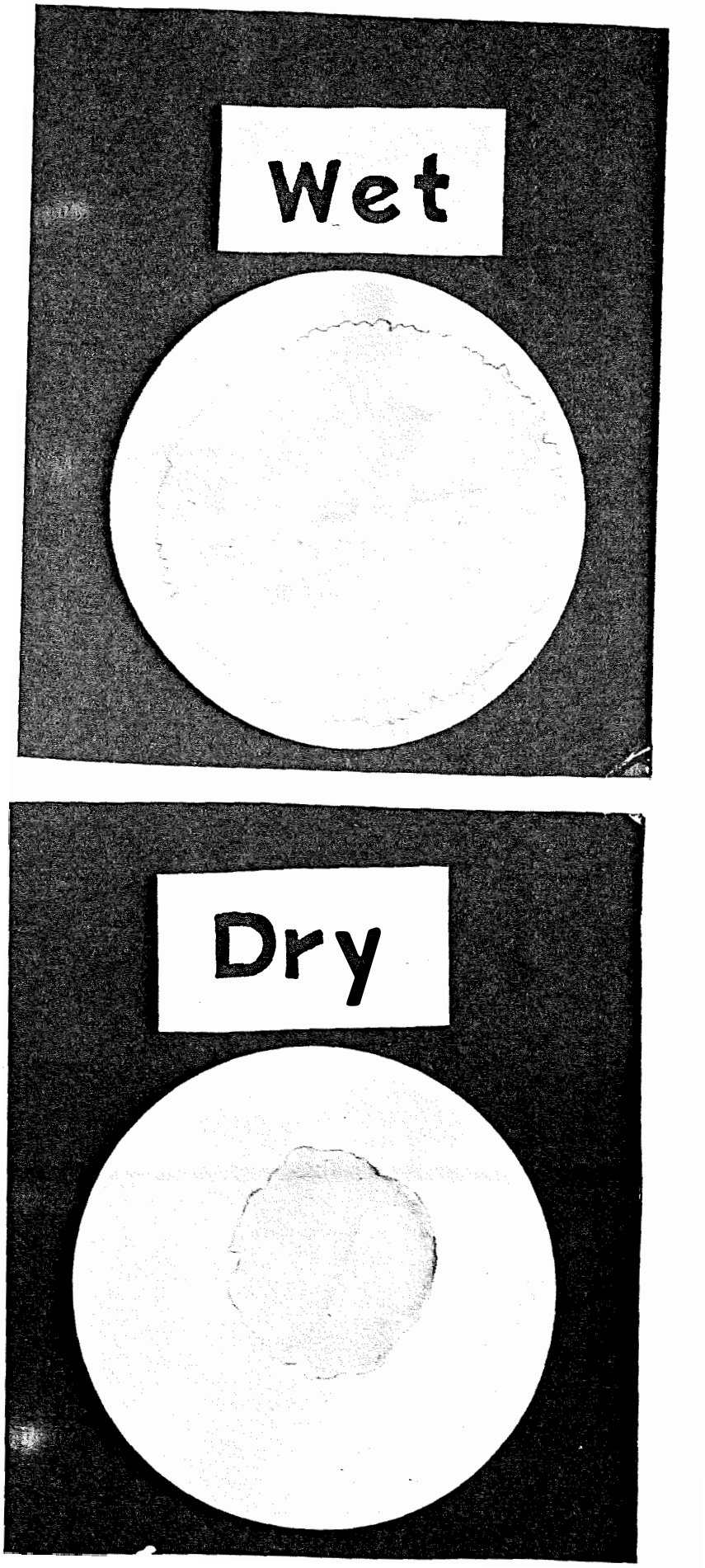

Figure 5. Moisture zones obtained using Pressure method for wet and dry scallops.

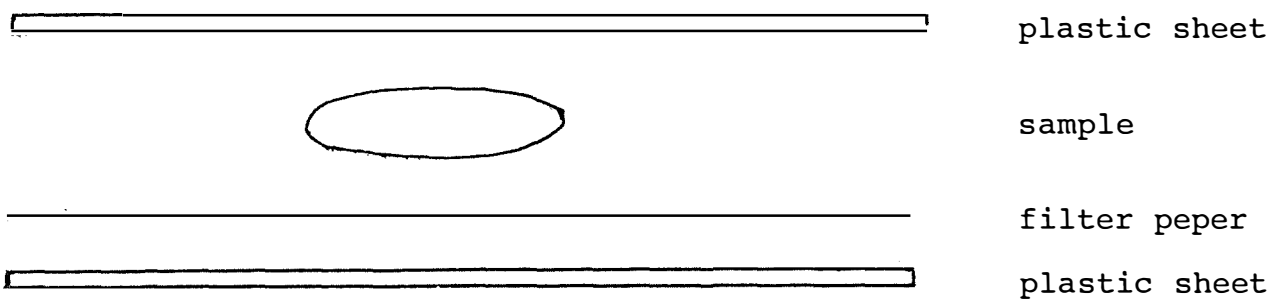

Figure 6. Diagram of Pressure Method apparatus

Cook test

The Cook test mimicked losses incurred by consumers upon cooking scallops and was carried out for 2 cooking times.

Cook test 60s

Scallops (10) were placed in boiling water and once the water had been brought back to the boil, cooking was continued for 60s. Scallops were removed from the water and reweighed. The percentage mass difference in raw and cooked scallops was determined as cooking loss. The test was carried out in duplicate.

Cook test 30s

Test was carried out using method above with a boiling time of 30s.

Soaking, polyphosphate soaking and dipping

The effect of soaking scallops in water or polyphosphate was examined using the procedure shown in the flow diagram Figure 7. Samples were taken at each point marked '*' and analysed by Hot Air Oven Method and Cook test 60s. The polyphosphate used was Fishphos (Solutech Food Systems Pty.Ltd., Ryde, N.S.W.), which was a combination of 2 soluble polyphosphates, and it was used at a concentration of 5%.

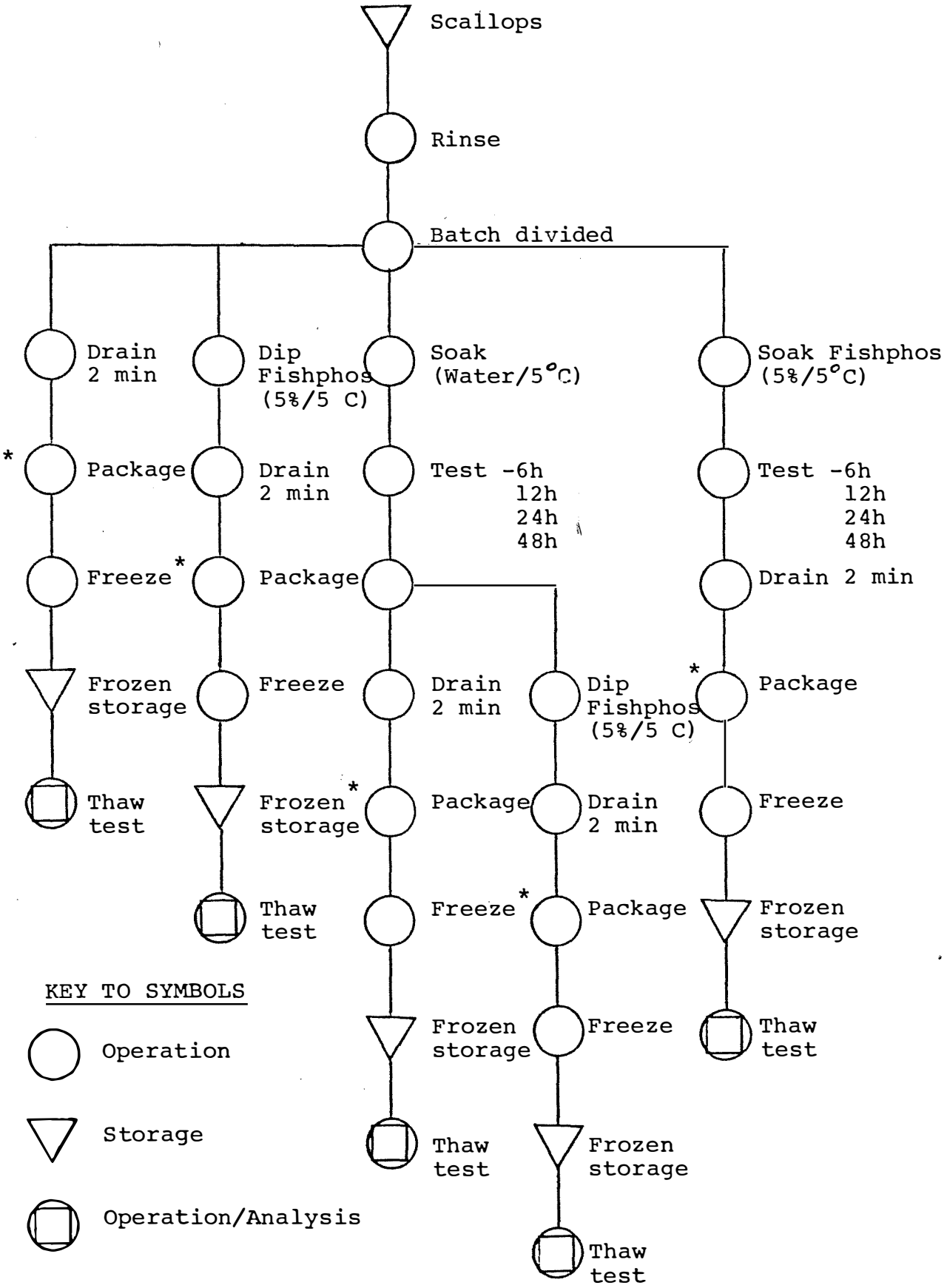

Figure 21. Flow process diagram of soaking trials for scallops using polyphosphate or water soaking solutions.

Thaw Tests

Thaw Tests were carried out on frozen samples to determine percentage mass loss on thawing as follows:

Separation Thaw

Frozen scallops(500g) were placed in a sealed bag under cold tap water until scallops were separated from the frozen mass, drained for 2 min, weighed and the percentage mass loss determined as separation thaw loss. (Figure 8).

2.32 Thaw Tests (Separation plus 1 hour)

Scallops which had been thawed to separation were placed in a refrigerator for 1h (total elapsed time since removed from the freezer). Scallops were drained for 2 min, weighed and mass loss calculated as thaw loss.

2.4 Statistical Analysis

Statistical analysis of result was carried out by determination of the mean, the standard deviation and a 95% Confidence Interval for the population mean for each set of data using the formulae below:

mean $$\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n}$$

standard deviation $$s = \sqrt{\frac{\sum_{i=1}^{n} y_i^2 - (\sum_{i=1}^{n} y_i)^2}{n - 1}}$$

For a small population, assuming normal distribution, a 95% Confidence Interval for the population mean

$$95\%\ C.I. = \frac{\pm t_{\alpha/2}\, s}{\sqrt{n}}$$

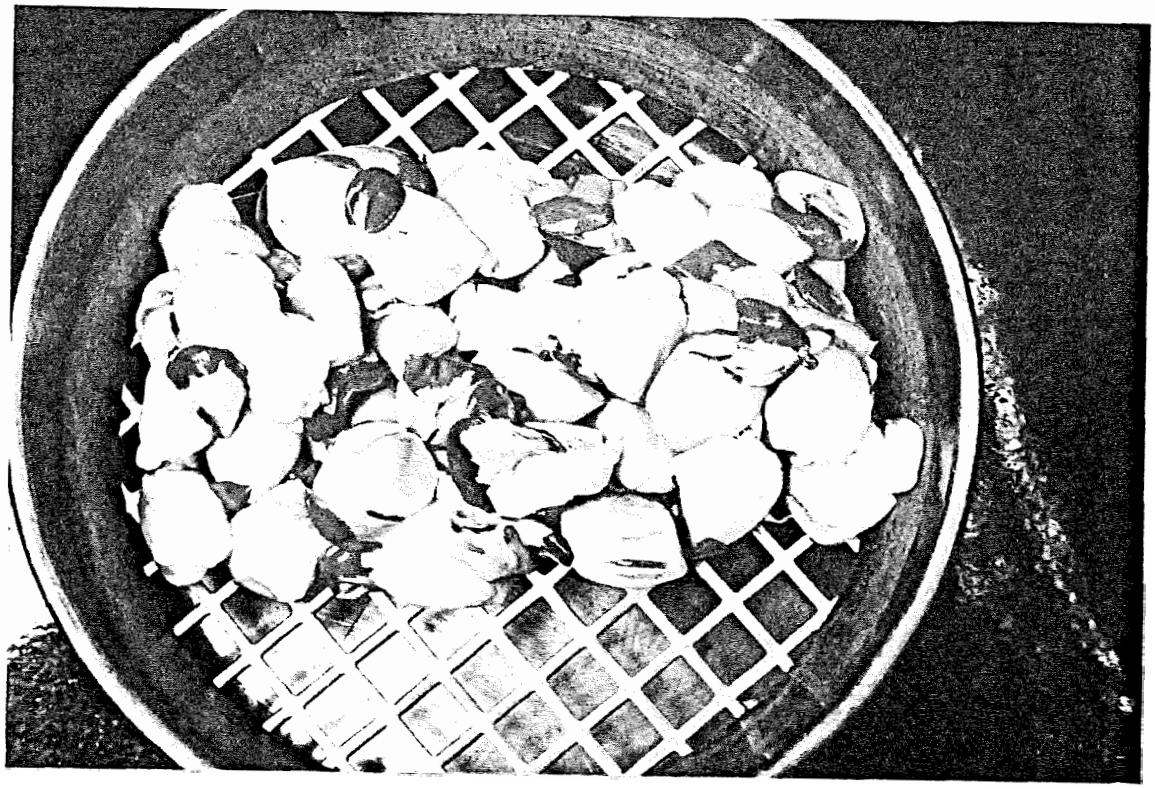

Figure 8 . Apparatus for thaw test, showing draining mesh and scallop sample.

$t_{/2}$ is determined from tables of critical values of t for (n-1) degrees of freedom.

The "best fitting" line for the set of points was determined by the Linear Least Squares Method.

Equation for the line: $y = c + mx$

where $$m = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sum x^2 - \frac{(\sum x)^2}{n}}$$

and $$c = \frac{\sum y - m\sum x}{n}$$

The Pearson Product Moment Coefficient of Correlation 'r' was determined for the regression equation:

where $$r = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\left[\sum x^2 - \frac{(\sum x)^2}{n}\right]\left[\sum y^2 - \frac{(\sum y)^2}{n}\right]}$$

The Pearson Product Moment Coefficient of Correlation 'r' assumes the same sign as 'm'. A value of r=0 indicates no linear correlation between y and x. A value $r \to 1$ indicates strong correlation between x and y.