STUDIES ON THE MANUFACTURE OF CANNED MACKEREL.

PART V. STUDIES ON THE FORMATION OF CURD IN CANNED MACKEREL.

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Curd is the name given to the coagulated protein formed on the surface of the content of canned fish meat. In canned mackerel curd is formed as well as in canned salmon. The curd is said to be formed by the steaming in the exhaust box. That is to say, when the soluble protein in the fish meat is gradually heated, and the meat in the cans is gradually heated, the soluble protein penetrates into the fluid and it becomes coagulated on the surface of the meat thus forming the curd[1].

However the present writers have learned from the experimental results described in the foregoing Reports "Ⅲ" and "Ⅳ" that the formation of the curd is not only due to the steam exhausting of can, but also to sterilizing heat. That is to say, the soluble protein which penetrated into the fluid is considered to be heated to form the curd by the steam exhausting or sterilizing heat.

The writers have steeped the meat of mackerel in various brine concentrations and have estimated the amount of the NaCl soluble protein which is coagulated by heating; next they have applied the thus obtained results to the processing of canned mackerel, and then have studied how to prevent the formation of the curd.

EXPERIMENTS

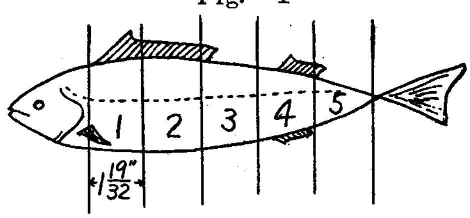
I. Fundamental Experiment.

1. The determination of the amount of NaCl solution (various concentrations) soluble protein nitrogen and the amount of soluble coagulable matter.

(1) Sample

Three bodies of frozen mackerel, large size, Pacific Ocean Group (weight 900~1,100 gm, 38~42 cm in length), were defrosted in tap water for 1 hour, parts 4 and 5 of Fig. 1 were cut and crushed and the crushed meat was used for the sample.

Fig. 1



(2) Procedure.

Estimations were made of three characters of the material: (1) The amounts of NaCl solution soluble nitrogen or cold water soluble nitrogen; (2) The amounts of NaCl solution soluble protein nitrogen or cold-water soluble protein nitrogen; (3) The amount of NaCl solution soluble heat coagulable matter or cold water soluble heat coagulable matter. Procedure was as follows.

Sample 10 gm. → add saline water of various concentration (0.3, 0.58, 1.0, 5.14, 10.9, 13.4, 18.3% NaCl were contained respectively) to 100 c.c. total volume → infuse for 45 minutes → filter → {residue
filtrate → (A), (B), (C).

→ (A) filtrate 10 c.c. (or 5 c.c.) → digest with conc. H_2SO_4 → dilute to 50 c.c. with water after digestion → distillate nitrogen with 20 c.c. of the diluted solution (cold water soluble nitrogen or NaCl soluble nitrogen).

→ (B) filtrate 10 c.c. (or 20 c.c.) → heated for 15 mins. on the water-bath → filter → {filtrate
residue (coagulated matter) → dry-weight (cold water soluble heat coagulated matter or NaCl solution soluble heat cogulated matter).

→ (C) filtrate 10 c.c. (or 20 c.c.) → heat with 20 c.c. of 10% CCl_3COOH on the water-bath → filter → {filtrate
residue → digest precipitated protein with conc. H_2SO_4 → dilute the digested solution to 100 c.c. → distillate nitrogen of the diluted solution (cold-water soluble protein nitrogen or NaCl solution soluble protein nitrogen).

The difference between the amount of NaCl solution soluble nitrogen and the amount of NaCl solution soluble protein nitrogen was considered to be the amount of NaCl solution soluble non-protein-nitrogen.

The estimated values are indicated by percentage for the amount of the sample used. The dissolving ratio of the solved nitrogen was shown by percentage of the amount of the dissolved nitrogen for the amount of total nitrogen in the sample.

2. Results of Experiments.

The results obtained by the operations above described are shown in Table 1, while Fig. 2 illustrates the results in Table 1. From the results as shown in Table 1 and Fig. 2, the following conclusions may be summarized.

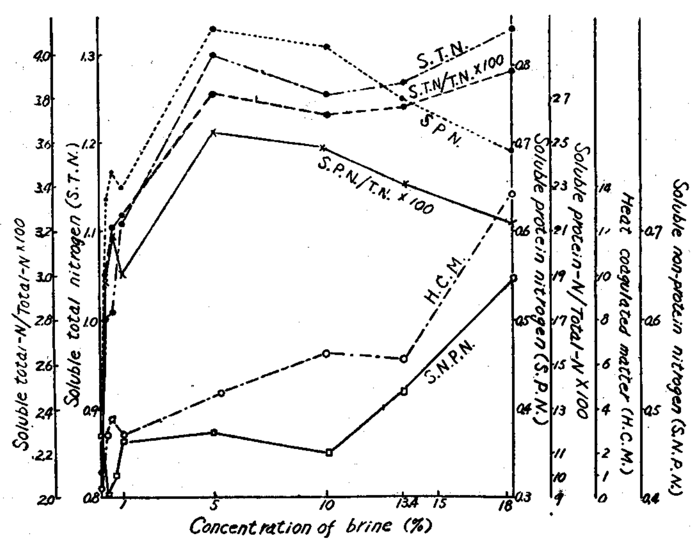
(1) The amount of NaCl solution soluble nitrogen increased in proportion with the increasing of the concentration of NaCl, but when the concentration of NaCl was above 5%, the amounts of dissolved nitrogen were almost the same. For example, when the concentration of NaCl was above 5%, the amount of dissolved nitrogen was about 1.3% of the amount of sample used, and was about 39% of the total amount of nitrogen in the sample. (2) The amount of the soluble heat-coagulated matter in the sample increased with the increasing of the concentration of NaCl. (3) When the amount of the soluble protein ($N \times 6.25$) (%) and the amount of the heat-coagulated matter (%) were

Table 1. Relation between the concentration of brine and the amount of soluble nitrogen when the frozen mackerel from the Pacific Ocean catch has been steeped.

Conc. of brine (%)	Soluble total nitrogen (%)	Soluble total nitrogen/total nitrogen ×100	Soluble protein nitrogen (%)	Soluble protein nitrogen/total nitrogen ×100	Soluble protein nitrogen (N×6.25) (%)	Percentage in soluble total nitrogen (%)	Heat coagulab'e matter		Soluble non-protein nitrogen (%)
							%	for soluble protein nitrogen (%)	
0	0.80	23.7	0.33	9.76	2.06	41.25	0.53	26	0.47
0.3	1.03	30.5	0.64	18.93	4.0	62.1	2.89	72	0.39
0.58	1.09	32.2	0.67	19.81	4.2	61.5	3.58	85	0.42
1.0	1.11	32.8	0.65	19.22	4.1	58.6	2.86	70	0.46
5.14	1.30	38.4	0.83	24.55	5.2	63.8	4.69	90	0.47
10.9	1.26	37.3	0.81	23.95	5.1	64.3	6.52	128	0.45
13.4	1.27	37.6	0.75	22.20	4.7	59.1	6.39	136	0.52
18.3	1.33	39.4	0.69	20.42	4.3	53.7	13.30	310	0.64

Note: Separately estimate the total nitrogen of mackerel meat.

Fig 2.



compared, in the case of 0~5% of the concentration of NaCl, the amount of the heat-coagulated matter was 26~90% of amount of the soluble protein.

(4) If the formation of the curd is due to the NaCl solution soluble protein, in order to remove this protein in the maximum amount into the NaCl solution, 10~11% of the concentration of the NaCl solution is considered to be the most suitable concentration. However, it has been long known that the NaCl-solution soluble and heat-coagulated matter may be removed to as large a degree as possible by steeping the meat in a high concentration of NaCl solution. In such a case, the larger quantity of heat coagulated matter will be accumulated in the fish meat steeped in the NaCl solution, and then this considered to appear and coagulate as curd by the steam-exhausting and sterilizing heat. Therefore, enlarging the concentration of NaCl solution does not result in preventing the formation of the curd.

This fact was also observed in the practical processing of mackerel cans.

II. Experiments in the Practical Processing of Canned Mackerel.

1. Sample and method of experiment.

As in the previous fundamental experiment large frozen mackerel of the Pacific Ocean Group (38∼42 cm in length, 900∼1,100 gm, in weight,) were employed as raw materials. After dressing the mackerel, 115 gm each were taken from three parts cut in round slices. from parts 1, 2, 3 as shown in Fig. 1 as samples. One piece each of these samples was steeped in NaCl solution of various concentrations for 45 mins., and the amounts of total nitrogen and protein-nitrogen solved were compared. Each piece of mackerel meat (240 gm) steeped in NaCl solution of various concentrations was taken and the surface of the meat was washed with water, and then each 240 gm of the meat was packed in flat half-pound cans as usual, and steamed at 100°C for 10 mins. After steam-exhausting of cans, the condition of the formation of the curd was at once observed. After the observation, the cans were poured with NaCl solution, seamed and heated (sterilized at the pressure of 10 lbs. for 1⅔ hrs.). After sterilization, the cans were opened to observe the formation of the curd in the cans.

Next, the canned mackerel was prepared with iced mackerel of the Pacific Ocean Group and the formation of the curd was observed as above and compared. The amount of total nitrogen and protein nitrogen dissolved by the salting before packing, was estimated as follows.

Sample 115 gm. → add with water or NaCl solution (0.27, 0.57, 0.81, 13.5, 15.6, 21.2%) to 500 c.c. in total amount → infuse 45 mins. → filter → $\begin{cases}\text{residue (meat pieces)} \rightarrow \text{canned mackerel.}\\ \text{filtrate} \rightarrow \text{(A), (B).}\end{cases}$

→ (A) filtrate 10 c.c. → digest with H_2SO_4 → dilute the digested solution to 100 c.c. → estimate the amount of nitrogen in 2 c.c. (or 10 c.c.) of the diluted solution (NaCl solution soluble total nitrogen).

→ (B) 50 c.c. → add 25 c.c. of 10% CCl_3COOH → heat on the water-bath for 20 mins. → dilute with water to 100 c.c. → filter → $\begin{cases}\text{precipitated protein}\\ \text{filtrate} \rightarrow \text{(C)}\end{cases}$

→ dried matter (NaCl solution soluble heat coagulated matter).

→ (C) filtrate 10 c.c. → digest with H_2SO_4 → estimate the amount of nitrogen (NaCl solution soluble non-protein-nitrogen).

2. Results of Experiments.

The results obtained by the examination of canned mackerel which was produced (exhausted 100°C, sterilized at the pressure of 10 lbs. for 1⅔ hrs.) by using iced mackerel of the Pacific Ocean Group steeped in brine of various concentrations are shown in Table 2.

Table 2. Formation of curd in boiled mackerel can of which the Pacific Ocean catch was ice storaged, packed after steeping in various concentrations of brine.

Conc. of brine (Bé) / Items	3°	5°	7°	9°	11°	13°	15°	17°	17° (standard method)
Steeping time	60	60	60	60	60	60	60	60	25
Vacuum (inch)	1	2	6	0.5	0	4	5	1.5	4
Curd {upper part	⧺	⧺	卄	卅	卅	+	+	⧺	+
Curd {lower part	+	+	—	±	±	—	+	卄	+
Liquid {content	medium	〃	〃	〃	〃	〃	〃	〃	〃
Liquid {condition	clear	〃	〃	〃	〃	〃	〃	〃	〃
Meat	good	〃	〃	〃	〃	〃	〃	〃	〃
Salty	lack of salty	〃	〃	〃	good	〃	excess of salty	〃	〃

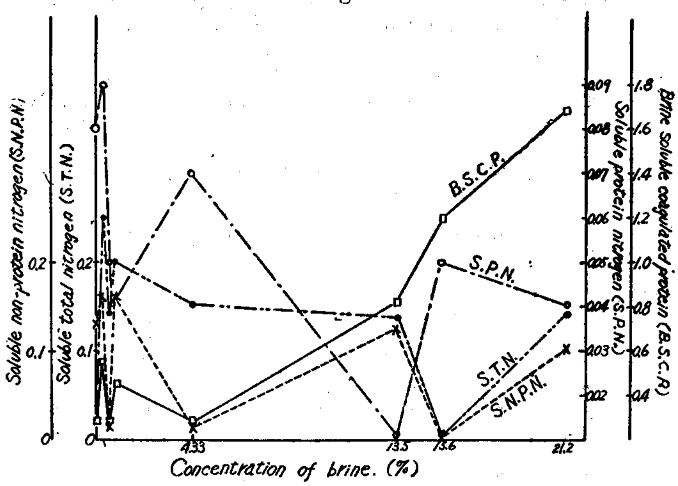
Note: Curd ± Ordinary, + Comparatively small, ⧺ rather a great, 卅 a great quantity, — none.

Table 3. Amount of soluble nitrogen and the formation of curd when the frozen mackerel from the Pacific Ocean catch has been steeped in various concentrations of brine.

Conc. of brine (%)	Soluble total nitrogen (for the amount of weighed sample)	Non-protein nitrogen	Soluble protein nitrogen		Soluble protein (N × 6.25)	Brine soluble heat coagulable protein		Curd	
			for the amount of weighed sample	for the soluble total nitrogen (%)		for the weighed sample	for the soluble protein (%)	After heating by exhausting	After heating by retorting
0 (Dist. water)	0.21	0.13	0.08	38	0.50	0.29	58	卅	卅
0.27	0.25	0.16	0.09	36	0.56	0.56	100	⧺	+ (poured the brine)
0.57	0.14	0.09	0.05	35.6	0.31	0.26	84	⧺	⧺
0.81	0.20	0.16	0.04	20	0.25	0.46	184	⧺	+ (poured the brine)
4.33	0.16	0.09	0.07	43.4	0.44	0.94	168	⧺	卄
13.5	0.14	0.13	0.01	72	0.06	0.83	1.380	+	+ (poured the brine)
15.6	0.07	0.02	0.05	72	0.31	1.22	394	+	+
21.2	0.14	0.10	0.04	28.6	0.25	1.69	180	卄	+ (poured the brine)

Note: 1. Soluble protein nitrogen was calculated from the difference of the amonnt of soluble total nitrogen and that of non-protein nitrogen.
2. Trichloracetic acid was used for the precipitant of protein which protein nitrogen was estimated.
3. The marks of curd is followed as Table 2.

Fig. 3



The amounts of soluble total nitrogen and of NaCl solution soluble heat coagulated protein-nitrogen and the condition of the formation of the curd in the canned mackerel which was processed with refrigerated mackerel of the Pacific Ocean Group are shown in Table 3. The amounts of soluble total nitrogen and of NaCl solution soluble heat coagulated protein nitrogen were illustrated in Fig. 3.

The results obtaind from the experiments are summarized under the following six points.

(1) The total soluble nitrogen dissolved in the maximum quantity in the case of 0.3% of NaCl solution, and the more the concentration of the brine increased, the less was the amount of the total soluble nitrogen. (2) The total nitrogen showed as well as the total soluble nitrogen. The ratio of the protein-nitrogen to the total nitrogen decreased with the increasing of the concentration of the NaCl solution. (3) The amount of soluble non-protein-nitrogen decreased with the increasing of the concentration of NaCl solution. Above about 0.8~1% of the concentration of NaCl solution, the amount of soluble non-protein-nitrogen showed the reverse relation with amount of the protein-nitrogen. However, in the range of 0~1% of the concentration of NaCl solution, the amount of the total soluble nitrogen changed proportionally with the concentration of NaCl solution. (4) The amount of soluble (heat coagulable) protein increased with the increasing of the concentration of NaCl solution. In the case of the concentration of NaCl solution above 0.6%, the ratio of the amount of soluble (heat cogulable) protein to the amount of soluble protein showed abnormally large even as above 100%. That is to say, the quantity of coagulable matter is abnormally abundant. (5) In 0.6% concentration of NaCl solution, the amount of various components above described showed generally lower values. (6) The formation of the curd is comparatively less at above 10% of the concentration of NaCl solution, the flavour of the content was good and the taste was well seasoned with salt. The quality of the canned mackerel treated with brine was better than that not so treated.

DISCUSSION AND CONCLUSION.

Both fundamental and practical experimental results have been discussed and conclusions may be drawn as follows: It is known that the formation of the curd in canned boiled fish meat happens more frequently when too fresh material is used. This is observed also in the experimental results of Report II which discussed the relation between the freshness of mackerel meat and the quality of the canned product.

The formation of the curd is mainly due to the presence of heat coagulated protein in the NaCl solution soluble protein, on account of which fact, the salting of fish meat in brine before canning is necessary. What concentration of NaCl solution is suitable to dissolve out the largest amount of heat coagulable matter in NaCl-solution soluble nitrogen compounds ? As becomes clear from the results of both fundamental and practical experiments, the greater the concentation of NaCl solution is, the larger the amount of heat coagulable protein dissolves out. Therefore when the concentration of NaCl solution is high, it is effective to dissolve out the heat coagulable protein. However, from the results of the observation of the formation of the curd, in the case of 10～15% concentrations of NaCl solution the formation of the curd was comparatively small, and in the case of concentrations below 10% or above 20%, the formation of the curd was reversely remarkable. Therefore it is considered that 10～15% concentration of NaCl solution is the most suitable for steeping mackerel meat before the packing in the cans. When the meat is steeped in the dilute solution of NaCl, though a larger amount of total soluble nitrogen dissolves out, a less amount of heat coagulable protein dissolves out. Therefore in actual usual practice a large amount of NaCl-soluble and also of heat-coagulable matter is considered to remain in the mackerel meat after the salting in brine. The steeped mackerel meat is taken out and packed with little dried salt or conc. brine in the cans. When these cans are steam exhausted or sterilized by heat, a large quantity of the curd will be newly formed.

When the meat is steeped initially in a strong NaCl solution, such as 20%, even if the surface of the meat was washed with water, the heat-coagulable matter is considered to remain undissolved yet in large quantity. This heat-coagulable matter will be coagulated by the heating to form the curd.

In conclusion, the way to prevent the formation of the curd is after the dressing of the raw material of mackerel, and cutting in round slices to the depth of the cans, the meat must be steeped in 13～15% of NaCl solution for 25～30 mins. and then washed with water, packed in the cans, then finally, passed through the steam exhaust box and sterilized, or seamed by vacuum seamer and sterilized.

There also the question of "adhesion" by which is meant the coagulated protein attached to the undersurface of the top of cans in canned mackerel and in canned salmon. The cause of the adhesion is known to be that the soluble protein sticks fast on the undersurface of the top of cans because of heating. The formation of the adhesion can be prevented by moistening the surface. This subject has already been settled.

Literature cited

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PART VI. STUDIES ON THE CAUSE OF THE SPRINGER OF CANNED MACKEREL.

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The writers have studied the cause of the springer of canned salmon, and made it clear that the mechanism of the happening of the springer of canned salmon as follows: In the machine packing, tail meat or other meat blocks are cross-packed leaving the clearance in meat. To the surface of the meat is added some crushed meat, then pressed by the flat of the hand in order to make a clean appearing top. The gas in the clearance in the meat is expanded by the change of the atmospheric temperature, with the result that the end of the can is bulged. These facts have been demonstrated by also using mackerel as in "The studies on the cause of the springer of canned salmon". To prevent the occurrence of the springer some clearance must be left between the can wall and the meat or there must be longer exhausting as described in the previous Report.[1]

Literature cited

(1) E. Tanikawa and Y. Inoue (1951): Bull. of the Faculty of Fisheries, Hokkaido University (in English), Vol. 2, No. 2, p. 118.

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