5. **Summary**

Sample of raw crab meat (*Erimacrus isenbeckii*), boiled meat, canned meat which were removed from the crust and round body with crust were stored aerobically or anaerobically at various temperatures. The amount of volatile base nitrogen for those stored samples was estimated quantitatively ; the bacterial decomposition velocity was compared and the following conclusions were obtained.

(1) The bacterial decomposition velocity of crab meat (*Erimacrus isenbeckii*) was rapid with the rising of the temperature within the temperature limits 4°~35°C.

(2) The bacterial decomposition velocity of crab meat under conditions of aerobic storing was more rapid than that under anaerobic storing.

(3) Boiled crab meat decomposed later than raw meat, but when the spoilage began, the velocity of the decompsition became rapid.

(4) Canned crab meat decomposed more rapidly than raw meat or boiled meat.

(5) Raw or boiled crab meat with crust decomposed later than the raw or boiled which were removed from the crust. But in this case the boiled meat decomposed later than the raw meat which was as well found to be true in previous experiments.

(6) Shoulder meat decomposed more rapidly than leg meat.

(7) The temperature coefficient in the bacterial decomposition, "$Q_{10}$," of raw meat is 1.2 (within the limit of temperature 4°~35°C), that of boiled meat is 1.4, that of the raw meat with crust is 1.8.

(8) The temperature constant, "A, "of the raw meat is 2,910 (within the temperature limits of 4°~35°C), that of boiled meat is 6,000 (within the temperature limits of 4°~25°C), that of raw meat with crust is 11,050.

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(水産科学研究所業績 第155号)

## III. DISCUSSION OF METHODS FOR DETERMINING THE FRESHNESS OF MEAT OF *Erimacrus isenbeckii*

Eiichi TANIKAWA, Minoru AKIBA and Terushige MOTOHIRO

At the time of processing of canned crab, it is very important to treat the crab meat on the basis of judgement of freshness of raw material of the meat. For example, from the freshness of the meat the processing time to be completed may be concluded. There are many methods of determining the freshness of fish meat.

The authors wished to find an adequate method for that purpose in the case of crab meat, accordingly they conducted experiments as described and discussed below.

**1. Experimental Method**

The samples employed in this experiment were like those in the previous report.

Those of (i) Samples of raw meat which was removed from the crust and ground (Samples A, B and C), (ii) Samples of boiled meat which was removed from the crust (Samples E, F, G, and H), (iii) Canned meat (Samples I and J), (iv) Samples of raw meat with crust (Samples K, L, M and P) were stored under the various described conditions, and estimated chemically, bacteriologically and organoleptically. The results obtained were almost the same as in the earlier report. Here, the authors wish to discuss the results obtained from Samples B, D, K, L, M and N.

Sample-B ………… Raw meat (shoulder, leg meat) ground and stored aerobically at 24° ± 1°C.

Sample-D ………… Treated as above and stored anaerobically at 24° ± 1°C.

Sample-K ………… Round body meat without removing of carapace stored aerobically at 23° ± 1°C; shoulder meat only was used.

Sample-L ………… Treated as above, and was stored aerobically at 23° ± 1°C; leg meat only was used.

Sample-M ………… After removing of carapace, stored aerobically at 23° ± 1°C without washing; shoulder meat only was used.

Sample-N ………… Treated as above, stored aerobically at 23° ± 1°C; leg meat only was used.

The items of estimation for detecting freshness of crab meat are as follows:

(i) Moisture …… By usual drying method (drying temperature, 95°～100 °C).

(ii) Volatile base nitrogen …… After Weber and Wilson's method (140mm Hg, distilling temperature 45°～55 °C, time 40～50 minutes).

(iii) Water soluble matter nitrogen …… Ten gm of the sample was added with distilled water to 100 c.c. in measuring flask and stored for 40 minutes; after extraction the extract was filtered, the nitrogen of the definite volume of the filtrate was estimated after the micro Kjeldahl method.

(iv) Total nitrogen …… Five-tenths gm of the sample was estimated after the micro Kjeldahl method.

(v) Amino acid nitrogen …… After Pope-Steven's method.

(vi) Hydrogen ion concentration …… The extract of the meat with 10 times volume of distilled water was estimated by Toyo pH-paper.

(vii) Walkiewicz's reaction ($HgCl_2$-reaction) …… After Amano's method.

(viii) Eber's reaction …… Put Eber's reagent into the test tube and then the small pieces of the sample reaching to the surface of the reagent in about 0.5 cm space. The degree of generation of white smoke was judged. If white smoke is clearly seen, the sign is +, if a little white smoke is seen, the sign is ±, and no smoke is −.

(ix) Turbidity …… Extracted solution with 10 times amount of the distilled water from

Table 1. Raw crab meat stored aerobically at 24° ± 1°C.

| Time elapsed (hrs.) | Water content (%) | Volatile base-N (mg%) | Water soluble-N (mg%) | Amino acid-N (mg%) | pH | | W-reaction | | Eber's re-action | Tur-bidity | Bacterial number | Colour | Odour |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Meat | extra-ctant | A soln. | B soln. | | | | | |
| 0 | 77.2 | 12 | 0.41 | 153 | — | — | ± | + | + | ± | — | — | Fresh fish smell |
| 10 | — | 17 | 0.43 | 171 | 6.4 | 6.6 | + | + | + | ± | $34 \times 10^3$ | Pinkish white | 〃 |
| 15 | — | 24 | 0.44 | 221 | — | — | + | + | + | + | — | 〃 | Putrefactive odour |
| 20 | — | 34 | 0.48 | 256 | — | — | | | | | — | — | 〃 |
| 25 | 77.2 | 50 | 0.53 | 273 | 6.5 | 6.8 | + | + | ++ | + | $125 \times 10^3$ | Dark pink | 〃 |
| 30 | 77.0 | 74 | 0.70 | 308 | 7.0 | 7.0 | + | + | ++ | ++ | $108 \times 10^6$ | ↓ | ↓ |
| 35 | — | 103 | 0.88 | 324 | — | — | | | | | — | Darkish white | Strong putrefactive odour |
| 40 | 76.9 | 140 | 0.97 | 330 | 7.4 | 7.0 | ++ | + | ++ | ++ | $133 \times 10^6$ | | |
| 45 | — | 193 | 1.33 | 332 | — | — | | | | | — | | |
| 50 | 77.0 | 224 | 1.86 | 333 | 7.4 | 7.2 | ++ | + | ++ | ++ | $1,200 \times 10^6$ | | |
| 55 | 77.0 | 233 | 1.13 | 331 | 7.4 | 7.2 | ++ | + | ++ | ++ | $37 \times 10^6$ | | |
| 60 | — | 236 | 1.14 | 334 | — | — | | | | | | ↓ | ↓ |
| 70 | 77.2 | 240 | 1.13 | 329 | — | — | | | | | | | |

the sample was organoleptically observed. Apparently transparent solution is indicated −, apparently turbid solution is +, and out of judgement is ±.

(x) Bacterial number …… Plate culture calculation was used.

(xi) Organoleptic examination…Color and smell of the sample were organoleptically observed.

**2. Results of Experiments and Discussion.**

Using above described experimental methods the results obtained from raw crab meat which had been stored aerobically and anaerobically at 24° ± 1° were as follows.

From Tables 1 and 2 the changes of amount of volatile base nitrogen, amino acid nitrogen, water soluble matter nitrogen, moisture content and the hydrogen ion concentration may be shown as in Figs. 1 and 2. The change of bacterial number in raw crab meat stored is shown in Fig. 3.

As shown in Figs. 1 and 2, the amount of volatile base nitrogen in raw crab meat stored aerobically or anaerobically at 24°C ± 1°C increased with the elapse of time of storage and reached apparent-

Table 2. Raw crab meat stored anaerobically at 24°±1°C.

| Time elapsed (hrs.) | Water content (%) | Volatile base-N (mg%) | Water soluble-N (mg%) | Amino acid-N (mg%) | pH | | W-reaction | | Eber's re-action | Tur-bidity. | Bacterial number. | Colour | Odour |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Meat | extra-ctant | A soln. | B soln. | | | | | |
| 0 | 77.2 | 12 | 0.41 | 151 | — | — | ± | + | + | + | — | — | Fresh fish smell |
| 10 | — | 16 | 0.42 | 162 | 6.4 | 6.6 | ± | - | + | ± | | Pinkish white | 〃 |
| 20 | — | 24 | 0.50 | 193 | — | — | + | + | + | + | $29 \times 10^3$ | 〃 | 〃 |
| 25 | 77.1 | 33 | 0.59 | 219 | 6.8 | 6.8 | + | + | ++ | + | — | Dark pinkish white | Putrefactive odour |
| 30 | 77.6 | 51 | 0.70 | 259 | 7.0 | 6.8 | + | + | ++ | + | $358 \times 10^3$ | — | ↓ |
| 35 | — | 75 | 0.84 | 289 | — | — | | | | | | — | ↓ |
| 40 | 77.6 | 104 | 1.09 | 306 | 7.2 | 7.0 | + | + | ++ | ++ | $1,500 \times 10^3$ | Darkish white | Strong putrefactive odour |
| 45 | — | 134 | 1.20 | 313 | — | — | | | | | — | — | |
| 50 | 77.6 | 159 | 1.22 | 316 | 7.4 | 7.0 | ++ | + | ++ | ++ | $10.2 \times 10^6$ | — | |
| 55 | 77.8 | 174 | 1.19 | 318 | 7.4 | 7.2 | ++ | ++ | ++ | ++ | — | — | |
| 60 | — | 182 | — | 319 | — | — | | | | | $162 \times 10^6$ | — | ↓ |
| 65 | — | 184 | — | 311 | — | — | | | | | $837 \times 10^3$ | — | ↓ |
| 70 | 77.8 | 185 | — | 320 | — | — | | | | | | | |

ly to equilibrium after 40~50 hours.

The changes in the amounts of amino acid nitrogen and water soluble matter nitrogen are almost the same as the change of the amount of volatile base nitrogen in the initial storage period, but in the later period of storage the chages are irregular. Generally the increase in amounts of the amino acid nitrogen and of water soluble matter nitrogen are irregular in all periods of storage as observed in raw meat with crust. The amount of moisture-content decreased somewhat in the initial period of the storage and increased apparently with the period of decomposition in accordance with the increasing of volatile base nitrogen after 30~40 hours. The value of pH increased from the initial period, that is to say the value of pH was 6.4~6.6 in fresh meat, but when the decomposition reached equilibrium, the value of pH had changed to 7.2~7.4.

Next, as seen in Fig. 3 the increasing of bacterial number was logarithmically rapid in 40~50 hours of the period from the initial decomposition to equilibrium, while after 50 hours the bacterial number decreased. As seen

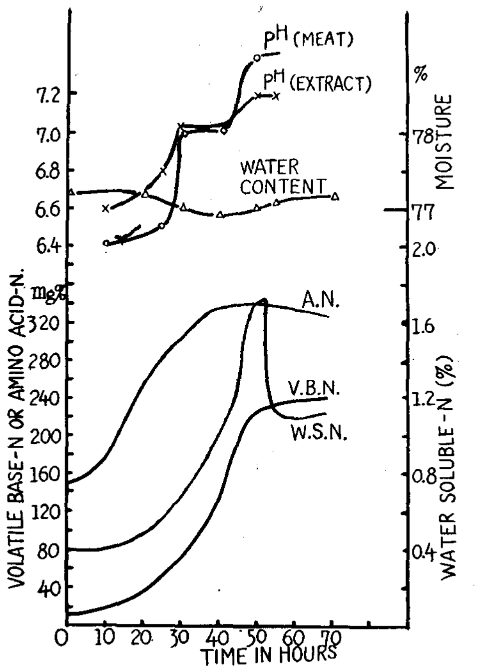



Fig. 1 The chemical changes of raw crab meat stored aerobically at 24°±1°C.
A.N.=Amino acid nitrogen, V.B.N.=Volatile base nitrogen, W.S.N.=Water soluble nitrogen.

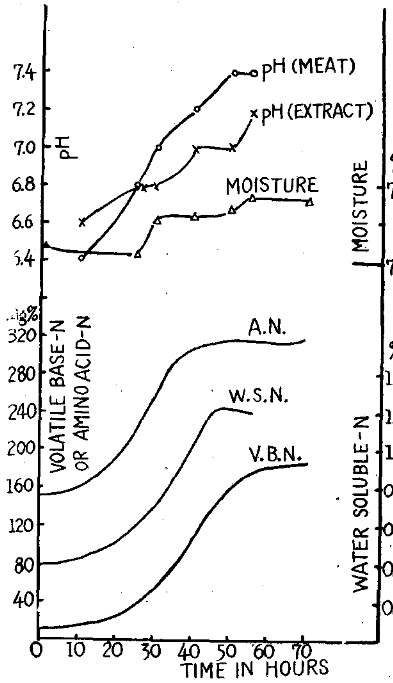



Fig. 2 The chemical changes of raw crab meat stored anaerobically at 24°±1°C.
A.N.=Amino acid nitrogen, V.B.N.=Volatile base nitrogen, W.S.N.=Water soluble nitrogen.

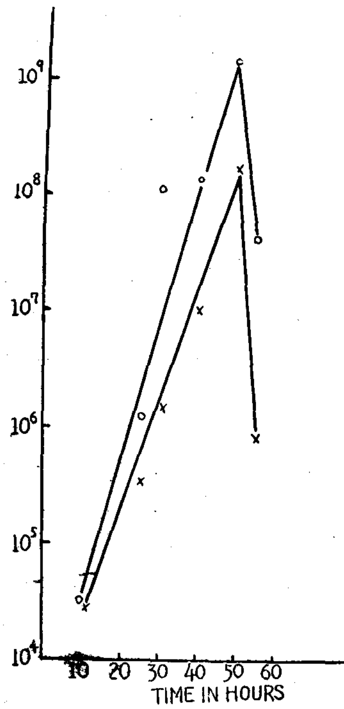



Fig. 3 The change of bacterial number in raw crab meat stored aerobically and anaerobically at 24°±1°C.
○—○ Raw crab meat stored aerobically at 24°±1°C.
×—× Raw crab meat stored anaerobically at 24°±1°C.

from the data in Tables 1 and 2, the result of detecting by W-reaction was that A-solution was ± and B-solution was + even when the raw crab meat was fresh, but the freshness of this meat will conflictingly be in the stage of incipient spoilage according to Amano's method. By Eber's reaction the raw meat was also found to be unfresh although the meat would generally be considered fresh.

The turbidity increased with the progress of the decomposition, that is to say the freshness was lost. When the amount of volatile base nitrogen reached to the range of 15~20 mg% in raw crab meat, the turbidity was signed +.
In comparing the amount of volatile base nitrogen

Table 3. The chemical changes of shoulder and leg parts of round crab body at 23°±1°C.

| Time elapsed (hrs.) | Shoulder meat (Water content 77.69%, Total-N 3.35%; Total-N per dried matter 15.01%) | | | | | | | Leg meat (Water content 77.68%, Total-N 2.86%; Total-N per dried matter 12.81%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Volatile base-N (mg%) | Amino acid-N (mg%) | Water soluble-N (%) | Bacterial number | pH | W-reaction A soln. | W-reaction B soln. | Volatile base-N (mg%) | Amino acid-N (mg%) | Water soluble-N (%) | Bacterial number | pH | W-reaction A soln. | W-reaction B soln. |
| 10 | 9 | — | — | — | — | + | + | 4 | — | — | — | — | | |
| 15 | 18 | 216 | 1.45 | $3.1\times10^5$ | 6.4 | ++ | + | 6 | 89 | 1.36 | $5.5\times10^5$ | 6.3 | + | + |
| 20 | 32 | 115 | 0.86 | — | — | ++ | ++ | 10 | — | — | — | — | | |
| 30 | 64 | 173 | 1.30 | $1.6\times10^6$ | 7.4 | ++ | ++ | 24 | 57 | 1.58 | $2.7\times10^6$ | 7.2 | + | + |
| 40 | 78 | — | — | $3.2\times10^6$ | 7.6 | ++ | ++ | 49 | 161 | 0.73 | $2.8\times10^6$ | 7.8 | / | / |
| 50 | 86 | 115 | 1.08 | $2.1\times10^7$ | 7.6 | / | / | 65 | — | — | — | — | / | / |
| 60 | 90 | 74 | 1.64 | $4.6\times10^7$ | / | / | / | 76 | 167 | 1.01 | $5.6\times10^7$ | 7.7 | ++ | ++ |
| 70 | 92 | — | — | — | / | / | / | 84 | 98 | 1.67 | $4.2\times10^7$ | — | ++ | ++ |
| 80 | 92 | 127 | 1.21 | — | / | / | / | 90 | 153 | 0.67 | — | — | ++ | ++ |

Table 4. The chemical change of shoulder and leg meat which were removed from the crust after removing carapace (23°±1°C.).

| Time elapsed (hrs.) | Shoulder meat (Water content 75.98%, Total-N 3.73%; Total-N per dried matter 15.53%) | | | | | | | Leg meat (Water content 74.32%, Total-N 2.51%; Total-N per dried matter 9.77%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Volatile base-N (mg%) | Amino acid-N (mg%) | Water soluble-N (%) | Bacterial number | pH | W-reaction A soln. | W-reaction B soln. | Volatile base-N (mg%) | Amino acid-N (mg%) | Water soluble-N (%) | Bacterial number | pH | W-reaction A soln. | W-reaction B soln. |
| 10 | 8 | — | 1.17 | $5.3\times10^3$ | 6.4 | + | + | 6 | — | — | $3.4\times10^5$ | 6.2 | + | + |
| 15 | 13 | — | 1.30 | — | — | / | / | 10 | 101 | 0.94 | $1.0\times10^7$ | 7.4 | / | / |
| 20 | 19 | — | — | — | — | / | / | 14 | 230 | 1.37 | $4.2\times10^6$ | 8.0 | + | + |
| 30 | 33 | 115 | 0.93 | $1.1\times10^6$ | 7.4 | ++ | + | 24 | 270 | 0.75 | $1.8\times10^8$ | 7.5 | ++ | + |
| 40 | 53 | 240 | 1.80 | $3.7\times10^5$ | 7.8 | ++ | + | 37 | 83 | 1.60 | — | — | ++ | ++ |
| 50 | 82 | 240 | 1.00 | $1.5\times10^7$ | 7.5 | ++ | ++ | 60 | 120 | — | $2.2\times10^8$ | — | ++ | ++ |
| 60 | 126 | 63 | 1.41 | $6.0\times10^8$ | — | ++ | ++ | 95 | — | — | — | — | / | / |
| 70 | 150 | — | — | — | — | / | / | 144 | — | — | — | — | / | / |
| 80 | 170 | 58 | 0.84 | — | — | / | / | 159 | 63 | 1.54 | — | — | / | / |

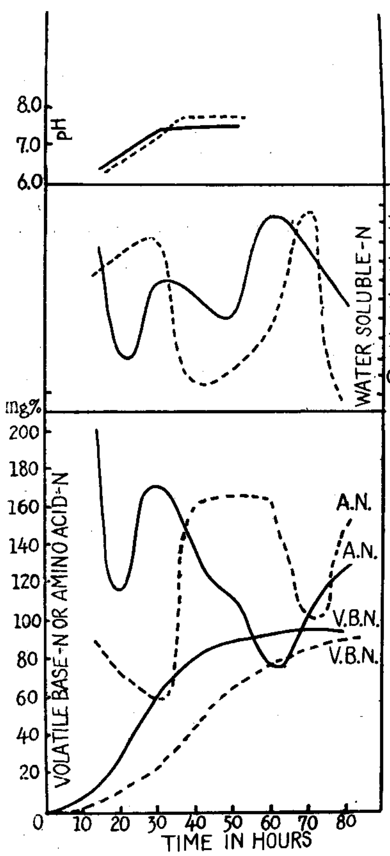



Fig. 4 The chemical changes of shoulder and leg parts of round crab body stored at 23°±1°C.
——Shoulder meat, ……Leg meat.
A.N.=Amino acid nitrogen, V.B.N=Volatile base nitrogen.

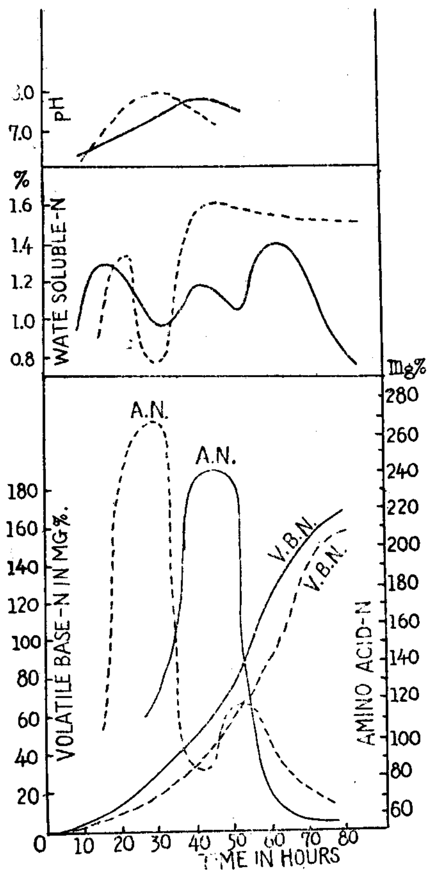



Fig. 5 The chemical changes of shoulder and leg meat with crust after removing carapace.
——Shoulder meat, ……Leg meat.
A.N.=Amino acid nitrogen, V.B.N.=Volatile base nitrogen.

and the organoleptic examination by the colour and smell of raw meat, when the amount of volatile base nitrogen reached to 20~25 mg%, the smell was noticeable; when the amount reached to 30 mg%, the spoilage smell was clearly realized, and the colour of the surface skin of the meat changed from pink to dark brown.

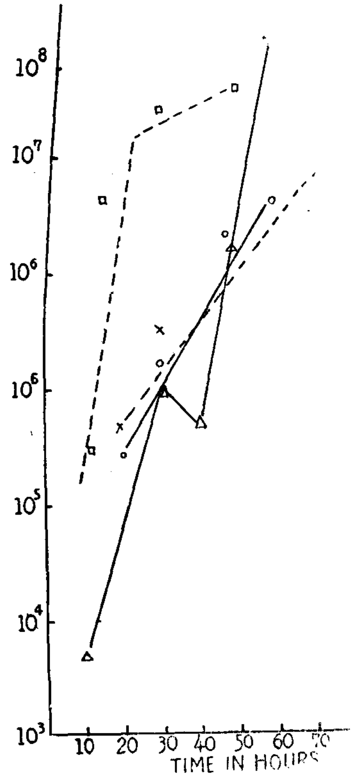
Table 3 shows the chemical change of shoulder and leg meat of round crab body stored at 23°±1°C.

Table 4 shows the chemical change of shoulder and leg meat which were removed from the crust after removing carapace.

From the data in Tables 3 and 4, the changes of the amount of volatile base nitrogen, amino acid nitrogen, water soluble matter nitrogen and values of pH are graphed in Figs. 4 and 5. The change of bacterial number is shown in Fig.6.

As seen in Figs. 4 and 5, both samples showed almost the same change, that is to say, the amount of volatile base nitrogen increased comparatively irregularly, and then attained apparent equilibrium. In this case, the shoulder meat obviously decomposed is admitted to decompose more rapidly than the leg meat.

The changes of the amount of amino acid nitrogen and water soluble matter nitrogen were complex, and indicated irregular increase and decrease. This is perphps due to non-uniform sampling of the part of crab body or to individual differences. Glycolytic action may also be one of the causes of irregular changes. But these causes are not all. Those irregular changes may not be useful as a method for estimating the freshness of raw crab meat. The change of value of pH increased gradually from the initial storage and showed in the range of 6.0~8.0.




○——○ Shoulder meat of round body.
×······× Leg meat of round body.
△——△ Shoulder meat stored after carapace removed.
□······□ Leg meat stored after carapace removed.

Fig. 6 The change of bacterial number of shoulder and leg meat of round crab body of those with sheath from which the carapace had been removed.

As seen from Fig. 6 the bacterial number in the shoulder and leg meat of round body which was stored at 23° ± 1°C increased logarithmically until 60 hours storage when the amount of volatile base nitrogen reached equilibrium. The bacterial number in the shoulder meat stored with crust which was removed from the carapace increased logarithmically during the period from the initial decomposition to 20~30 hours, when the bacterial number once decreased and then increased logarithmically again. This is perhaps due to the fact that the change of bacterial number of the leg meat increased logarithmically up to 25 hours storage and then reached apparent equilibrium.

As seen in Tables 3 and 4, the detecting result using W-reaction indicated conflictingly that even the fresh sample was unfresh, so that this reaction is not useful for the detecting of the freshness of crab meat.

Judging from the results obtained with many chemical and organoleptic methods for detecting the freshness of crab meat, the method of estimation of volatile base nitrogen is the best, because the results obtained by this method agree with the organoleptic test and bacterial count.

**3. Summary**

As methods for detecting the freshness of crab meat which is raw material for canned crab, practical methods such as the estimation of the amounts of volatile base nitrogen, amino acid nitrogen, water soluble nitrogen and value of pH, by the bacterial count, by determination of W-reaction and Eber's reaction and by estimation of turbidity were discussed in comparison with organoleptic determination.

The results obtained may be summarized as follows;

(1) The changes of the amount of amino acid nitrogen and water soluble matter nitrogen showed irregular increase and decrease. There was no remarkable value in such estimations for detecting the freshness of crab meat particularly in the stage of incipient spoilage.

(2) The change of the value of pH showed gradual increase, and reached to equilibrium with the lapse of time of decomposition. Therefore, it was difficult to detect the freshness of crab meat in the stage of incipient decomposition.

(3) The bacterial number in the raw crab meat increased logarithmically and reached equilibrium in the later period of spoilage; therefore it is difficult to detect the freshness of crab meat by the bacterial count in a short time.

(4) W-reaction was positive which indicates unfreshness even though the crab meat was known to be fresh. Therefore it is also unsuitable to detect the freshness of crab meat.

(5) The comment on Eber's reaction is as same as for W-reaction.

(6) The determination of turbidity was not very clear for detecting of freshness of crab meat.

(7) As a method for detecting freshness of crab meat, the estimation of the amount of volatile base nitrogen is the best. When the freshness of crab meat drops to incipient spoilage, the amount of volatile base nitrogen becomes 20 mg%, differing from the 30 mg% in the case of fish meat. This amount of volatile base nitrogen agrees with the result by organoleptic test, that is to say, when 20～25 mg% of the amount of volatile base nitrogen produced in crab meat, abnormal smell is noticeable, and when 30 mg% of the amount of volatile base nitrogen was estimated, the tainted smell was strong, the viscosity increased, and the color of the meat became dark brown.

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## IV. STUDIES ON THE INFLUENCES OF THE FRESHNESS OF RAW CRAB MEAT AND DURATION OF STORAGE AFTER BOILING UPON THE QUALITY OF CANNED CRAB MEAT

Eiichi TANIKAWA, Yasunosuke INOUE and Minoru AKIBA

The freshness of raw crab meat varies by fishing methods, such as catching by gill net, catching by basket, catching by a type of dredge net. Even if the carapace was removed from the crab body, and the crab leg and shoulder meat were immediately boiled, it sometimes happens that the boiled meat cannot be taken off from the crust and packed in cans because of the faulty management of the factory. In such cases, storing time and temperature after boiling influence the reduction in the freshness of meat. It is very important to know the limit of freshness of raw meat and boiled meat as raw material of canned crab meat. KANEKO[1] has detected organoleptically the smell of shoulder and joint meat as a means to learn a standard of limit of freshness; he considered the time from boiling to the incipient spoilage which is in inverse proportion to the bacterial decomposition velocity