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STUDIES ON THE MANUFACTURE OF CANNED CRAB

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The history of manufacture of canned crab is old in Japan; as long ago as about 1892-1893 canned crab was being manufactured in the neighbourhood of Otaru in Hokkaido. It has been said that experimental studies on the improvement of the quality of canned crab had already been made by Mr. Shigeo SASA (later President of the Fisheries College of Hakodate, Hokkaido) who was a technologist of the Hokkaido Fisheries Experimental Station, at Kunashiri Island. Those studies were carried out under the presumption that it was a hopeful enterprise to make canned food with crab meat. At that time the crab meat was prepared in dried form only.

The results of Mr. SASA's experiments in those days showed that the freshness of crab meat influences the quality of the canned crab, and the catastrophe of the canned crab meat (eg. especially blackened crab meat) can be prevented by treatment with acetic acid or by covering with parchment paper. Afterward the number of makers of canned crab increased, but the quality of the goods was never good. In 1917 Tsutsumi Co. Ltd. (present Nichiro Gyogyo Co. Ltd.) first manufactured comparatively good quality canned crab, and then the quantity for export increased. Afterward in 1924 the Association of Packers of Canned Crab of Japan (Nippon Kani Kanzumegyo Suisan Kumiai Rengokai) was established to control the quality of the canned product; then the regulations for inspection the quality of canned crab were strengthened. By such means the quality of the canned crab was improved while the output was increased. It was worthy note in those days that the Association sponsored studies on the improvement of crab and inspector belonging to the Association assumed the leadership the packers. The quality of the canned crab became famous the world round.

In spite of the decrease in the catching of crab resultant from the losing of Saghalien and the Chishima Islands after the recent War, the number of canneries in operation in various parts of Hokkaido has increased. On account of the decrease in the catch it has become impossible to pack good crab meat selected from a larger amount of material as well as could be done in the old times. As the case stands at present the packers pack a small quantity of material leaving nothing over.

Such an abnormal packing causes deterioration in the quality of the canned crab and spoiled cans occur frequently. On account of this deteriorating, there are many packers who have been suffering a loss. It is unreasonable to expect to pack cans of good quality if unfresh crab meat is used as well as fresh meat. In recent years, experimental studies on canned crab have been thought to be so extensive as to leave nothing more. However there now arise some intricate points regarding canned crab differing from the old time,

and there are also pending questions.

In order to solve those questions the present authors have made various experiments on crab meat [*Erimacrus isenbeckii* (Brandt) and *Paralithodes camtschatica* (Til)] which are in commerce and wish to offer the results of those experiments for the use of the canning industry.

PART I. ON THE MANUFACTURE OF CANNED CRAB
FROM *Erimacrus isenbeckii* (Brandt)

Report 1. THE RELATION BETWEEN THE FRESHNESS OF RAW CRAB MEAT
MATERIAL AND THE QUALITY OF THE CANNED PRODUCT

1. ON THE VELOCITY OF AUTOLYTIC DECOMPOSITION OF
MEAT OF *Erimacrus isenbeckii*

Eiichi TANIKAWA, Minoru AKIBA and Morihisa KIMURA

The muscle fiber of *Erimacrus isenbeckii* is more fine than that of *Paralithodes camtschatica*; the taste of the former is plain. The velocity of loss in freshness is also high. It is impossible to pack good quality cans with crab meat which has become unfresh. On the velocity of autolytic reaction of crab meat, ŌYA⁽¹⁾ has studied with the suspension of the meat of a kind of crab, *Chionoecetes opilio* (*O. Fabricus*); he has found that the value of the reaction velocity constant is almost the same until 5 days at 37°C. Thereafter the value of the constant decreases gradually. There is no study on the velocity of autolytic reaction of the meat of *Erimacrus isenbeckii* and *Paralithodes camtschatica*.

The authors have determined the amount of amino acid nitrogen when the meat is left at various temperatures and they have calculated the reaction velocity constant, temperature constant and temperature coefficient.

1. Sample and Experimental method.

Several number of merus of the ambulatory leg of *Erimacrus isenbeckii* (sloughed, male, 2 hours after catching) which was caught at the shore of Oshamambe, Hokkaido was wrenched from the body; the meat was taken off from the crust and put in toluene. The samples were brought to the laboratory as soon as possible. Then the samples were separated into three groups, and these samples were put into fresh toluene and stored aerobically at 4°±1°C, 25°±1°C and 35°±1°C. At definite intervals, those samples respectively were taken for the determination of the amount of amino acid nitrogen by Pope-Steven's method. In sampling about 30 gm of the respective samples were taken on the dried filter paper. After the toluene had dripped from the meat, a definite amount of the sample was taken without pressing it. As control some pieces of merus of the ambulatory leg were brought to the laboratory without pressing. As control some pieces of merus of the ambulatory leg was brought to the laboratory without antiseptizing with toluene; they were aerobically stored at 25°±1°C.

At definite intervals these samples were quantitatively analyzed for the amount of amino acid nitrogen and volatile base nitrogen. The moisture content of the raw sample was

74.32%; the total nitrogen was 3.2%, that is to say 20% of protein; and the amino acid nitrogen produced by hydrolysis of the protein with hydrochloric acid was 2.184%.

In the autolytic decomposition of the meat muscle, the autodigestion velocity constant may be calculated from a monomolecular chemical reaction by use of the following equation (1)

$$K = k \times 0.4343 = 1/t \log a/a-x \dots\dots\dots (1)$$

In equation (1), K (or $k \times 0.4343$) is the autodigestion velocity, "t" is time until which the amount of amino acid nitrogen in the meat was determined, "a" is the total amount of amino acid nitrogen which was produced from the original substrate by the hydrolysis with hydrochloric acid, "x" is the increasing amount of amino acid nitrogen at every time of determination. The temperatures of the determination were 4°C, 25°C and 35°C, so temperature constant and temperature coefficient (Q_{10}) in the autolysis of crab meat could be calculated. For calculating temperature constant and temperature coefficient, Arrhenius' equation was employed after the manner of ŌYA's experiment as follows:

$$K_2/K_1 = e^{\frac{A}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)} \dots\dots\dots (2)$$

In equation (2), K_1 and K_2 are autodigestion velocity constants which were calculated respectively at the temperatures of determination, T_1 and T_2 °K after a definite time, R is gas constant (1.985 kcal), A is temperature constant.

2. Experimental Results and Discussion.

Results obtained are given in Table 1. In the Table the time of determination is shown by the time elapsed since the catching. The relation between the amounts of amino acid nitrogen or volatile base nitrogen and the time elapsed is shown in Fig. 1.

Table 1. Changes of the amounts of amino acid nitrogen and volatile base nitrogen in the autolytic decomposition of the meat of *Erimacrus isenbeckii*.

| Samples | The meat antiseptized with toluene. | | | Control (The meat without antiseptized with toluene) | | |
|--------------|-------------------------------------|--------------|--------------|--|--------------|-----------------|
| | Temp. | 4° ± 1°C | 25° ± 1°C | 35° ± 1°C | 25° ± 1°C | |
| Time elapsed | Com- ponents | Amino acid-N | Amino acid-N | Amino acid-N | Amino acid-N | Volatile base-N |
| 7 (hrs.) | | 223mg% | 223mg% | 223mg% | 223mg% | 15mg% |
| 10 | | 225 | 240 | 246 | 263 | 20 |
| 15 | | 227 | 253 | 295 | 281 | 24 |
| 20 | | 229 | 265 | 329 | 316 | 34 |
| 25 | | 233 | 274 | 338 | 349 | 55 |
| 30 | | 238 | 279 | 341 | 388 | 74 |
| 40 | | 252 | 286 | 344 | 490 | 140 |
| 50 | | 268 | 290 | 347 | 393 | 224 |
| 60 | | 281 | 293 | 348 | 394 | 236 |
| 70 | | 289 | 296 | 349 | 382 | 240 |
| 80 | | 294 | 298 | 350 | — | — |
| 90 | | 294 | 298 | 350 | — | — |

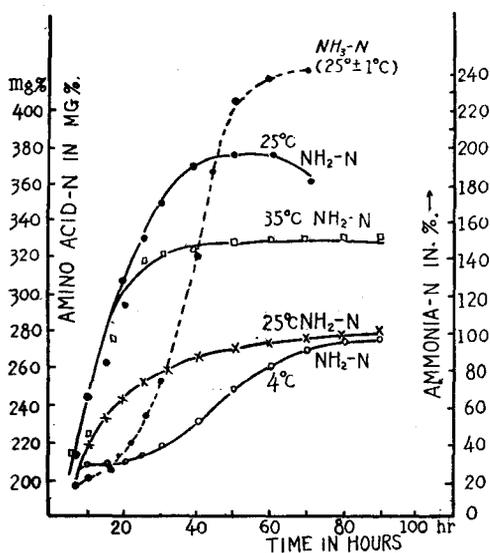


Fig. 1 Change of the amounts of Amino acid-N and Ammonia-N during Auto-catalytic decomposition.

— The meat antiseptized with toluene.
 The meat without antiseptized with toluene.

From Table 1 where are shown the auto-digestion velocity constants, by means of the amount of amino acid nitrogen, the values of $K \times 10^6$ ($k \times 10^6 \times 0.4843$) and of " $\log a/a-x$ " for antiseptized sample with toluene at every time of determination, " t ", can be calculated. They are shown as in Table 2.

From the results obtained for the control sample which was without antiseptizing with toluene, autolytic reaction velocity constant is not calculated, because those results are applicable to the monomolecular autocatalytic reaction rather than to the monomolecular chemical reaction.

As clearly shown in Table 1 and Fig. 1 where are given the increasing amounts of amino acid nitrogen, the autodigestion velocity of the meat of *Erimacrus isenbeckii* increased with the rising of the temperature, and the maximum value of the velocity is

Table 2. Changes of the autodigestion velocity constants ($K \times 10^6$) and of " $\log a/a-x$ " by the changes of temperature and time (hours) at the determination (the amount of total nitrogen 3.2%, $a=2184\text{mg}\%$).

| Time | 4° ± 1°C | | 25° ± 1°C | | 35° ± 1°C | |
|----------|--------------|-----------------|--------------|-----------------|--------------|-----------------|
| | $\log a/a-x$ | $K \times 10^6$ | $\log a/a-x$ | $K \times 10^6$ | $\log a/a-x$ | $K \times 10^6$ |
| 10(hrs.) | 0.0003 | 30 | 0.0034 | 340 | 0.0045 | 450 |
| 20 | 0.0013 | 65 | 0.0084 | 420 | 0.0216 | 1,080 |
| 30 | 0.0029 | 97 | 0.0112 | 373 | 0.0240 | 800 |
| 40 | 0.0057 | 142 | 0.0126 | 315 | 0.0247 | 617 |
| 50 | 0.0090 | 180 | 0.0135 | 270 | 0.0258 | 506 |
| 60 | 0.0096 | 160 | 0.0141 | 235 | 0.0256 | 427 |
| 70 | 0.0133 | 190 | 0.0145 | 207 | 0.0259 | 370 |
| 80 | 0.0142 | 178 | 0.0152 | 190 | 0.0260 | 325 |
| 90 | 0.0142 | 160 | 0.0152 | 170 | 0.0260 | 290 |

obtained after 70~80 hours' storage at 4°C, 40 hours' storage at 25°C, 20 hours' storage at 35°C. With the passage of time beyond that which shows the maximum values the values attained equilibrium. On the other hand, the produced amount of volatile base nitrogen attained to about 30 mg% after 80 hours when the meat was stored at 35°C. This fact shows that antiseptics with toluene may be in vain. The increase in amount of volatile base nitrogen is slight when the meat is stored at 25°C or 4°C.

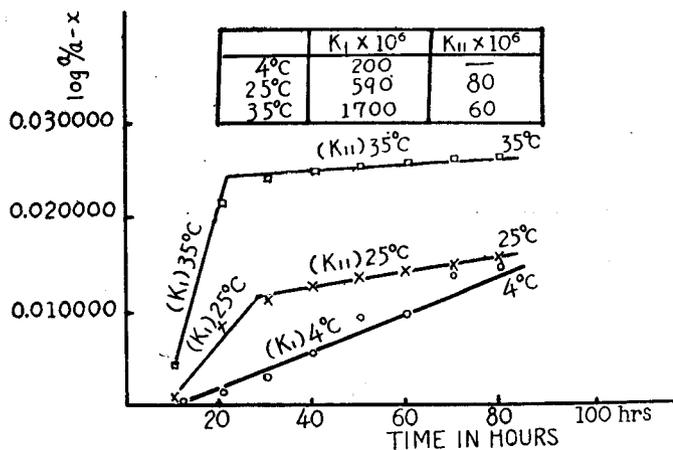


Fig. 2 Relation between the value of "log a/a-x" and time "t"

velocity constant, K , is manifested by a measure of inclination of the straight line. The line is straight at 4°C, and it is divided into two stages at 25°C and 35°C respectively.

If the autodigestion velocity constant of the first stage is K_1 and that of the second stage is K_2 , the values of K_1 and K_2 are calculated as are given in Table 3.

Table 3. Relation between temperature and the autodigestion velocity constant.

| Temp. | $K \times 10^6$ | $K_1 \times 10^6$ | $K_2 \times 10^6$ |
|-------|-----------------|-------------------|-------------------|
| 4°C | | 200 | — |
| 25°C | | 590 | 80 |
| 35°C | | 1,700 | 60 |

As seen in Table 3 and Fig. 2, the value of $K_1 \times 10^6$ is 200 at 4°C in the sphere between 10~80 hours. The value of $K_1 \times 10^6$ is 590 at 25°C until about 30 hours, then the value becomes 80 after 30 hours, that is to say the autodigestion velocity decreases very much. At a higher temperature, e.g. at 35°C, the value of $K_1 \times 10^6$ becomes 1,700 in 20 hours, then the value of $K_2 \times 10^6$ decreases to 60. That is to say, the initial autodigestion velocity increases with the rising of the temperature and reaches rapidly to equilibrium. This fact agrees with the properties of every line drawn in Fig. 1. In calculating of the temperature constant and the temperature coefficient of *Erimacrus isenbeckii*, as clearly shown in Fig. 2, the required time in which the initial autodigestion reaction constant ($K_1 \times 10^6$) reaches to equilibrium at 35°C is 20 hours. So the values of the autodigestion velocity constant at 20 hours were set as standard for every temperature of determination.

When equation (2) was changed to

But the increase in amounts of volatile base nitrogen and amino acid nitrogen is remarkable and the meat came to the state of incipient putrefaction after 10 hours when the unantiseptized meat was stored at 25°C.*

The relation between time, "t," and the value "log a/a-x" which is obtained from the data given in Table 2, is linear as shown in Fig. 2. And from this fact equation (1) is admitted right. In this case the value of autodigestion

* The authors know that the incipient stage of putrefaction of the meat of *Erimacrus isenbeckii* is 20 mg of volatile base nitrogen per 100 gm of the meat. This chemical reason will be described later. The limit of freshness for raw meat of *Erimacrus isenbeckii* for canned crab is 20 mg% of volatile base nitrogen.

$$K_2 e^{\frac{A}{R} \cdot \frac{1}{T_2}} = K_1 e^{\frac{A}{R} \cdot \frac{1}{T_1}}$$

then the above equation becomes

$$K e^{\frac{A}{R} \cdot \frac{1}{T}} = \text{constant}$$

$$\log K + \frac{A}{R} \log e \frac{1}{T} = \text{constant} \dots\dots\dots (3)$$

The relation between the reciprocal of temperature, $1/T$, and the value of logarithms of the autodigestion velocity constant, K , shows linear, and the measure of inclination of the straight line is shown as " $A/R \log e$;" then the value of temperature coefficient, Q_{10} , is given as follows in the sphere in which the values of " $\log K$ " and " $1/T$ " are linear.

$$Q_{10} = \frac{kt+10}{kt} = e^{\frac{A}{R} \left(\frac{1}{T} - \frac{1}{T+10} \right)}$$

Therefore the value of " Q_{10} " will be given from the following equation. (4)

$$\log Q_{10} = A/R \log e (1/T - 1/T + 10) \dots\dots\dots (4)$$

Table 4. Relation between $\frac{1}{T}$ and $\log K \times 10^6$

| Temp. (t) | $\frac{1}{T}$ | $\log K \times 10^6$ |
|-----------|---------------|----------------------|
| 4°C | 0.00361 | 1.8129 |
| 25°C | 0.00336 | 2.6138 |
| 35°C | 0.00325 | 3.0338 |

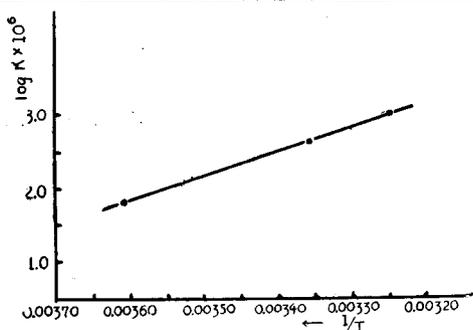


Fig. 3. Relation between the value of " $\log K \times 10^6$ " and time " t "

The relation between the value of " $1/T$ " and " $\log(K \times 10^6)$ " at every temperature at 20 hours is shown in Table 4 and Fig. 3. From Fig. 3 the value of " $A/R \log e$ " which is a measure of inclination of the straight line is 3,350. Therefore the value of the temperature constant, A , in the case of autodigestion of *Erimacrus isenbeckii* is 15,311 at 4~35°C, and then the value of Q_{10} becomes 2.34. When Q_{10} is calculated from $K \times 10^6$ at 25°C and 35°C at 20 hours, the value of Q_{10} is given 2.57 from Table 2 and 2.88 from Table 3. The value of Q_{10} may then be given as about 2.6 on the average.

3. Summary

(1) In order to autodigest crab meat (*Erimacrus isenbeckii*), the meat was aerobically stored in toluene at about 4°C, 25°C and 35°C. The amount of amino acid nitrogen of

the stored meat was estimated at certain definite intervals, and the change of the autodigestion velocity constant ($K \times 10^6$) by storing temperature and storing time, was observed.

(2) The values of $K \times 10^6$ are given as 200 at 4°C in the sphere of 10~80 hours, 590 at 25°C in 10~40 hours, 1,700 at 35°C in 10~25 hours. Thereafter the value of K decreased and attained equilibrium with the lapse of the storing time.

(3) The initial autodigestion velocity of the crab meat increased with the rising of temperature until 35°C, and reached rapidly to equilibrium.

(4) The value of temperature constant, A, in the autolysis of the crab meat was 15,311.

(5) The value of temperature coefficient, Q_{10} , in the autolysis of the crab meat was about 2.6 in the sphere of 0°C~35°C.

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II. VELOCITY OF BACTERIAL DECOMPOSITION OF THE MEAT OF

Erimacrus isenbeckii

Eiichi TANIKAWA, Minoru AKIBA and Terushige MOTOHIRO

As stated in the previous part of this report autodigestion is influenced by the increase in the storing temperature up to a certain limit of the temperature. To prevent the autodigestion of the crab meat, it is customarily boiled as soon as it is brought into the cannery after being landed from the fishing boat. In fishing boat the crabs are removed from the nets and the carapaces removed together with the liver in which active protease is contained. Therefore, the deterioration of the crab meat in the cannery is dependent upon the action of bacteria which contaminates the meat after the boiling.

KANEKO⁽¹⁾ has stored the boiled crab meat and calculated the temperature coefficient in the bacterial decomposition of the meat by estimating the incipient spoilage not by quantitative determination of the chemical products in the decomposed meat, but by organoleptic detection.

The authors have aerobically or anaerobically stored the boiled crab meat and control meat (unboiled leg meat and shoulder meat) with and without crust at 4°C, 25°C and 35°C, and estimated quantitatively the volatile base nitrogen at certain definite intervals. Canned crab meat was also employed in another lot of samples. From the change of the amount of volatile base nitrogen, the bacterial decomposition velocity constant was calculated. Values of temperature coefficient and temperature constant at different storing temperatures were also calculated. Thus the relation between bacterial decomposition of crab meat and storing temperature was ascertained.

1. Experimental samples.

In this experiment the crab meat (*Erimacrus isenbeckii*) was treated in the form of 16 kinds of sample as follows;

- (1) Samples of raw meat, removed from the crust and ground.

Sample-A Raw meat (shoulder and leg meat), ground and stored aerobically at 4° ± 1°C.