(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.

Literature cited

(1) T. ŌYA (1928) ; Suisan Gaku Kaiho, Vol. 5, No. 1

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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 decompostion 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;

(i) 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.

Sample-B ………… Treated as above and stored aerobically at 24° ± 2°C.
Sample-C ………… Treated as above and stored aerobically at 35° ± 2°C.
Sample-D ………… Treated as above and stored anaerobically at 24° ± 2°C.

(ii) Samples of boiled meat removed from the crust (shoulder and leg meat)

Sample-E ………… Boiled meat, stored aerobieally at 4° ± 1°C.
Sample-F ………… Boiled meat, stored aerobically at 24° ± 2°C.
Sample-G ………… Boiled meat, stored aerobically at 35° ± 2°C.
Sample-H ………… Boiled meat, stored anaerobically at 24° ± 2°C.

(iii) Çanned meat (shoulder and leg meat from which meat juice had been removed)

Sample I ………… Canned meat taken out of cans, stored aerobically at 22°C ± 2°C.
Sample-J ………… The same material, stored anaerobically at 24° ± 2°C.

(iv) Samples of raw meat with crust.

Sample K ………… Round body meat without removal of carapace, stored aerobically at 23° ± 1°C, shoulder meat only was used.
Sample L ………… Treated as above, stored aerobically at 23° ± 1°C, leg meat only used.
Sample M ………… After removal of carapace, stored aerobically at 23° ± 1°C without washing, shoulder meat only used.
Sample O ………… Round body meat without removal of carapace, stored aerobically at 35° ± 1°C, both shoulder and leg meat used.
Sample P ………… After removal of carapace, boiled and stored aerobically at 35° ± 1°C with crust, both shoulder and leg meat were used.

For the sample materials, *Erimacrus isenbeckii* was caught off the shores of Abuta and Oshamambe, Hokkaido several times between the end of July and early September 1952. The freshness of the crab meat was good.

Samples of groups (i) and (ii) were immediately removed from carapace and viscera at landing field, and brought to the laboratory in ice within 4 hours. At the laboratory the shoulder and leg meat were washed with sterilized water. The meat was stored as raw meat or as boiled meat. The samples which were stored aerobically were put flat on the dish and placed at the respective temperatures. The samples which were stored anaerobically were put in large test tube in 50 gm portions and sealed by melted vaselin on the meat, thus being cut off from the air; then the test tube was plugged with gum. The sample of canned meat sample (iii) was packed as raw crab meat and processed as usual.

2. Method of Experiment.

The amount of volatile base nitrogen in raw samples was quantitatively determined at certain definite intervals from the time of catching as the starting point in the raw sample, from the time of boiling in the boiled sample and from the time of opening of can in the canned meat.

3. Results of Experiments.

To calculate the bacterial decomposition velocity constant (the volatile base producing velocity constant), equation (5) of the monomolecular autocatalytic chemical reaction to volatile base accumulation was applied after KIMATA[2] and YAMAMURA[3]

$$\log y/A\text{-}y \; = Kt + C \cdots\cdots\cdots\cdots\cdots\cdots (5)$$

In equation (5), "y" is the increasing amount of volatile base, "A" is the maximum amount of volatile base produced, "t" is time from the starting point until the estimation of the amount of volatile base (hrs.), "K" is volatile base producing velocity constant. "C" is a constant.

From equation (5) the relation between the value of "log y/A-y" and time, "t," is manifested by a straight line, and from the measure of inclination of the line the value of "K" is determined. If "t_1" is time at which the reaction is half completed, then "t_1" is obtained by the following equation (6)

$$\log y/A\text{-}y \; = K(t\text{-}t_1) \cdots\cdots\cdots\cdots\cdots\cdots (6)$$

The temperature constant "A", and the temperature coefficient "Q_{10}" in the bacterial decomposition of the meat of *Erimacrus isenbeckii* were obtained by equation (3), (4) derived from Arrhenius' equation (2) as in the previous Report from the data which were estimated at various storage temperatures for the same samples.

In equation (2) K_1 and K_2 is the volatile base producing velocity constant respectively at T_1 and at T_2. R is gas constant (1.985 Kcal). A is temperature constant.

For every sample, the amounts of volatile base nitrogen were estimated at certain intervals; the obtained experimental data are shown in Table 1.

From Table 1 the relation among the amount of volatile base nitrogen produced, storing temperatures and storing time in the aerobic bacterial decomposition for the raw crab meat (A-, B- and C- sample) and boiled crab meat (Samples E, F and G) are shown in Fig. 1. In Fig. 2 are shown the differences of the amounts of volatile base nitrogen produced at almost the same temperatures as in above experiments for raw crab meat (Samples B and D) and boiled crab meat (Samples F and H) under aerobic and anaerobic storing conditions. Fig. 3 exhibits the data from crab meat with crust (Samples K, L, M, N, O and P).

In the same Fig. the curves for Samples B, C and G are also shown as control.

By applying equations (5), (4) and (3) to experimental results, the writers obtained the bacterial decomposition velocity constant "$K \times 10^3$", the temperature coefficient "Q_{10}", and the temperature constant "A" in the bacterial decomposition were calculated. Besides those data, time, "t_1," at which the reaction is half completed, and time, "t_{20}," at which the amount of volatile base nitrogen produced in crab meat reached to 20 mg%, are shown in Table 2.

The reason for evaluating "t_{20}" is that 20 mg% of the amount of volatile base nitrogen produced in crab meat (*Erimacrus isenbeckii*) is the approvable limit of freshness as raw material for canned crab meat as later stated.

4. Discussion

(1) Difference of values of bacterial decomposition velocity as caused by different storage temperatures.

Table 1. The changes in the amount of volatile base nitrogen (mg%) when samples were stored under different conditions.

Samples / Time (hrs.)	Samples of raw meat, removed from the crust and ground (Shoulder and leg meat).				Samples of boiled meat, removed from the crust (Shoulder and leg meat).				Canned meat (Shoulder and leg meat).		Samples of raw meat with crust.					
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
0	6	12	6	12	9	10	8	6	17	5	—	—	—	—	—	—
5	—	—	—	—	—	—	11	—	—	—	—	—	—	—	2	7
10	7	17	22	—	—	—	—	12	20	7	10	4	8	6	9	11
15	—	24	69	—	—	—	45	29	—	11	18	7	13	10	47	18
20	11	34	122	24	10	15	102	49	22	—	32	10	19	15	84	25
25	—	50	172	33	—	57	—	109	44	24	—	—	—	—	90	38
30	18	74	220	51	—	127	172	140	94	46	64	24	33	24	—	57
35	—	103	234	75	—	—	186	—	132	71	—	—	—	—	—	—
40	32	140	242	104	13	137	207	147	154	89	78	49	53	37	—	114
45	80	193	245	134	—	—	207	—	162	94	—	—	—	—	—	128
50	103	224	246	159	—	142	—	149	163	95	86	65	82	60	—	130
55	—	234	—	174	—	—	—	151	—	—	—	—	—	—	—	—
60	103	236	—	182	17	144	—	159	—	98	90	76	126	95	—	—
65	—	—	—	184	—	—	—	174	—	—	—	—	—	—	—	—
70	—	240	—	186	—	145	—	189	—	92	92	84	150	144	—	—
80	—	—	—	—	23	—	—	—	—	—	93	90	170	159	—	—
100	—	—	—	—	30	—	—	—	—	—	—	—	—	—	—	—
120	—	—	—	—	47	—	—	—	—	—	—	—	—	—	—	—
135	—	—	—	—	75	—	—	—	—	—	—	—	—	—	—	—
150	—	—	—	—	90	—	—	—	—	—	—	—	—	—	—	—

Remarks

Components of the sample.

Sample No.	Water content %	Total nitrogen %
A, D	78.4	3.0
B, C	77.2	3.0
I	80.5	2.8
J	80.6	2.8
K	77.7	3.3
L	77.7	2.8
M	75.9	3.7
N	74.3	2.5

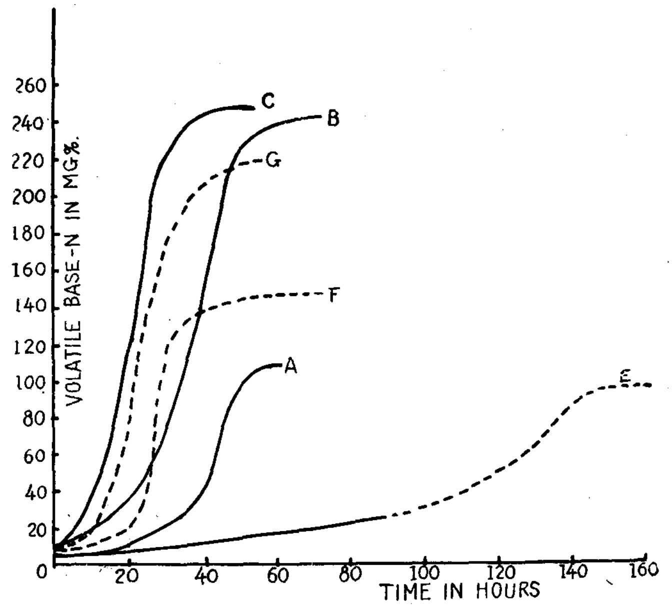

Fig. 1 Changes in the amount of volatile base nitrogen produced from raw and boiled crab meat at various storage temperature.

As shown in Fig. 1 and Table 2, the velocity of bacterial decomposition of *Erimacrus isenbeckii* is rapid with the rising of temperature within the definite limit of temperatures, therefore the amount of chemical products (volatile base) from the sample becomes larger and the value of the bacterial decomposition velocity constant ($K \times 10^3$) also becomes larger with the increase of temperature. On the contrary, the values of "t_1" and "t_{30}" not much influenced by the rising of temperature, that is to say, the progress of the decomposition is clearly rapid, in a short time, in the case of higher temperature.

(2) Difference of values of bacterial decomposition velocity found in samples stored under aerobic and anaerobic conditions.

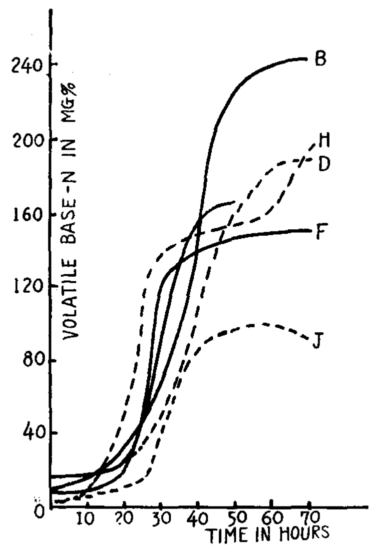

Fig. 2 Changes of the amount of volatile base nitrogen produced in various samples under different storage conditions (aerobically and anaerobically.)

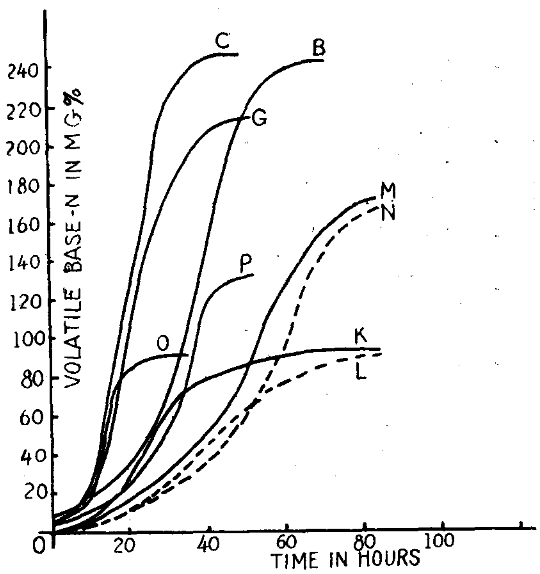

Fig. 3 Changes in the amount of volatile base nitrogen in the course of bacterial decomposition of crab meat with crust.

Table 2. Bacterial decomposition velocity constant, temperature coefficient, temperature constant at various storage conditions.

Kinds of samples and putrefactive conditions.	Storing temperature. (°C)	$K \times 10^3$	t_1 (1)	t_{20} (2)	Temperature coefficient* (Q_{10})* and temperature constant *A.*
A. Raw meat, shoulder and leg meat, aerobically	4+1°C	53	48	30	Raw crab meat.
B. Treated as above and stored aerobically.	24±2°C	74	373	12	4~35°C
C. Treated as above and stored aerobically.	35±2°C	91	20	5.5	Q_{10}=1.2, A=2,910
D. Treated as above and stored anaerobically.	24±2°C	71	39	15	
E. Boiled meat, stored aerobically.	4±1°C	55	88	70	Boiled crab meat.
F. Boiled meat, stored aerobically.	24±2°C	108	26	20	At the range of temp. 4~25°C
G. Boiled meat, stored aerobically.	35±2°C	103	22.5	9	Q_{10}=1.4, A=6,000
H. Boiled meat, stored anaerobically.	25±2°C	99	21.6	12	
I. Canned meat taken out of cans, stored aerobically.	22±2°C	111	30	20	
J. The same material, stored anaerobically.	24±2°C	91	30.9	26.5	
K. Round body meat without removal of carapace, stored aerobically, shoulder meat only was used.	23±1°C	55	28.3	16	When the sample which round body meat without removal of carapace was used.
L. Treated as above, stored aerobically, leg meat only used.	〃 〃	44	41.7	27	
M. After removal of carapace, stored aerobically without washing, shoulder meat only.	〃 〃	43	48.4	21	Q_{10}=1.8, A=11,050
N. Treated as sample-M, leg meat only used.	〃 〃	41	55.1	25	
O. Round body meat without removal of carapace, both shoulder and leg meat.	35±1°C	105	148	11.5	
P. After removal of carapace, boiled and stored aerobically, both soulder and leg meat.	〃 〃	74	28.2	17.5	

Note : (1) The time at which the reaction is half completed.
(2) The time at which the amount of volatile base nitrogen of sample meat reached to 20 mg %.

As shown in Fig. 2 the progress of decomposition in the case of aerobic decomposition of raw meat and canned meat is more rapid than in the case of anaerobic decomposition, and the amount of decomposed products of the former is much greater than that of the latter.

There is little difference however between the values of bacterial decomposition velocity constant of aerobic storing and anaerobic storing.

(3) Difference of values of bacterial decomposition velocity as caused by different treatments of the meat (raw, boiled and canned crab meat): In aerobic storing condition, boiled meat decomposed later than does raw meat, but when the bacterial decomposition reacted to the lag period of the decomposition, the boiled meat decomposed more rapidly than the raw. For example, in the samples stored at 35°±2°C the value of "$K \times 10^3$" of the raw meat was 91 and of boiled meat 103; the value of "t_1 (or t_{20})" for raw meat was 20 hours (or 5.5 hours) and that for boiled meat was 22.5 hours (or 9 hours). The aerobic or anaerobic bacterial decomposition velocity constant "$K \times 10^3$" of canned crab meat were together large; this meat is decomposable more rapid than raw meat of boiled meat. Therefore canned crab meat must be eaten immediately after the opening of the can. In anaerobic storing the value of the bacterial decomposition velocity constant of boiled meat is larger than that of raw meat, and the former attained more rapidly the lag period of the decomposition than the latter.

(4) Difference of bacterial decomposition velocity as influenced by storing of sample with or without crust: As shown in Fig. 3 and Table 2 the leg meat with crust decomposed later than the meat which is removed from the crust in storage. This is the reason why the former is little contaminated by bacteria. Therefore in the canning of crab meat the boiled meat must be prepared immediately after the removing from the crust. When the shoulder meat and leg meat were compared, the former decomposed more rapidly than the latter in the storing with or without crust. The reason why this is true is that the shoulder meat is close to the liver which is in the carapace, so the liver enzyme may act upon the shoulder meat. The boiled shoulder and leg meat decomposed later than the raw shoulder and leg meat, but when the bacterial decomposition of the boiled meat began, the progress of the decomposition was more rapid than that of the raw meat. In this case the shoulder meat decomposed more rapidly than the leg meat.

(5) Temperature coefficient and temperature constant in the bacterial decomposition of sample meat.

The value of temperature coefficient, "Q_{10}," of raw ground crab meat was 1.2 and the value of temperature constant, "A," was 2,910 in the limit of temperature 4°~35°C; for boiled crab meat "Q_{10}" was 1.4 and "A" was 6,000. The value of "t_{20}" of boiled meat was larger than those of the raw meat at various temperatures, that is to say, the boiled meat decomposes later than the raw meat, but when the bacterial decomposition of the boiled meat has once begun, the progress of the decomposition is more rapid than that of the raw meat. In case of the storage of raw crab meat with crust, the value of "Q_{10}" was 1.8 and the value of "A" was 11,050. In this case the value of "t_{20}" of boiled meat was larger than the raw meat, that is to say, the boiled meat took a longer time than raw meat to reach the incipient spoilage stage, but when the boiled meat began the bacterial decomposition, the progrss of the decomposition was rapid.

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.

Literature cited

(1) KANEKO (1952) : The Canners Journal. (Kanzume Jiho), Vol. 31, No. 7. p. 78

(2) KIMATA (1941) : J. Imp. Fish. Inst., Vol. 34, No. 2, p. 116

(3) YAMAMURA (1937) : Bull. Jap. Soc. Sci. Fish., Vol. 6, No. 3, p. 141

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

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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.