CHEMICAL STUDIES ON HERRING MEAT

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The late Shigeo Sasa, a former Head and Professor Emeritus of the Hakodate College of Fisheries which has eventually become the Faculty of Fisheries of Hokkaido University, passed away in February 1949 due to old age. He was very busy in the management of the Hakodate College of Fisheries and never found opportunity to publish his life work, an investigation on the subject "Chemical Studies on Herring Meat".

The manuscript left by him is still considered of value; it is published in the form of this paper after arrangement, revision and the addition of new data by his follows, Dr. Eiichi Tanikawa, Prof. of Faculty of Fisheries (Hakodate), Hokkaido University, and Mr. Minoru Akiba, Instructor of the same Faculty.

Content

Introduction

The author (Sasa) has previously discussed and published[1] "The Food Values of Fish Meat" from the chemical, physiological and economic points of view. From the viewpoint of chemistry, general chemical constituents, elements, the distribution of nitrogen, fat, and calories of fish meat were discussed; from the physiological point of view, digestibility and absorption of fish meat in experimental animals were discussed; from the economic point of view, the amounts of the catch, and price of fish were discussed from various data in comparison with the meat of domestic animals. As a consequence, it was clarified that the food value of fish meat is as good as that of the domestic animals.

Here, the food value of herring meat, which is one of the abundant catches in Japan, is discussed on the basis of the experimental data on the general chemical constituents, amount of protein, digestibility by laboratory animals, and on the other data which have been obtained thereafter by other investigators.

I. OUTLINE OF HERRING FISHERY IN JAPAN

Herring is one of the important fishes in Japan. It is caught in Hokkaido, Saghalien, Korea. The distribution of herring was wide in Japanese waters in old times. But recently the amount of the herring catch has been decreasing in that area.

The herrings caught in Japanese waters are considered to be not all of the same family. The family lines are classified into "Japan Sea Family", "Okhotsk Sea Family", "Eastern Saghalien Family", "Pacific coast Family" and "Lakes Family".

In spring, from the end of March to early June, herrings come to the western coast of Hokkaido, viz., from Shiribeshi coast near Yoichi, Hokkaido, to Saghalien waters; to the near-by the islands of Rishiri and Rebun and to the islands Teuri and Yagishiri; to Aniwa Bay (Saghalien) and the near island, Kaiba (Saghalien), and to the whole western coast of Saghalien (See Fig. 1).

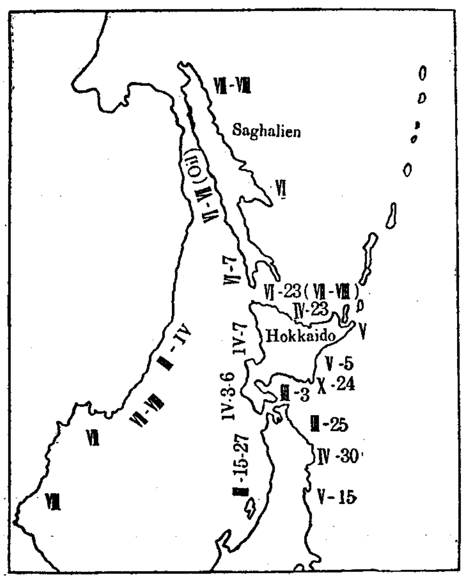


Fig. 1 Map showing the date of initial catching of herring in water of Japan Sea

Those herrings are variously called "Spring herrings" ("Haru-Nishin" in Japanese), "Fore-coming herrings" ("Hashiri-Nishin"), "Intermediate-coming herrings" ("Naka-Nishin"), "Spawning herrings" ("Sanran-Nishin"), "Crowd-coming herrings" ("Gunrai-Nishin"), "Black nose herrings" ("Hanaguro-Nishin"), "White nose herrings" ("Hanashiro-Nishin"), or "Ebisu herrings".

Among those herrings, the main shoal has large bodies, 20~40 *cm* in size, and are corpulent, rich in fat, and has matured roe and milt. They are coming to the coasts for spawning.

In summer, herrings come to the eastern coasts of Hokkaido, especially from Akkeshi to Kushiro and to both eastern and western coasts of Saghalien from early June to August or autumn. They are variously called "Foolish sardine" ("Baka-Iwashi"), "Small herrings" ("Ko-Nishin"), or "Oily herrings" ("Abura-Nishin"). Among those herrings, "Small herrings" are small, 13~20 *cm* in size, poor in fat, whilst "Oily herrings" are large and corpulent and rich in fat. Those herrings are coming to eat food, and are young being 2 or 3 years old. The milt or roe are not yet matured.

In winter, herrings (called "Winter herrings") come to several coasts of Hokkaido on the Pacific Ocean side. The bodies are of various sizes, large or small. Those herrings are said to be remains of summer herrings, therefore they are thin, poor in fat. "Winter herrings" which come to Korean northern coast line, from Seishin to Urusan, are comparatively large, but in those waters the amount is found to decrease as one goes to the south.

Among those three kinds of herrings, "Spring herrings" and "Summer herrings" are the objects for the economic fishery in nowadays. Recently from the decreasing amount of "Spring herrings", the exploitation of fishing grounds of "Oily herrings" in northern Okhotsk has been done[2]; the parental relation between the "Spring herrings" which are caught in Japan Sea and "Small herrings" ("Summer herrings") which are caught along eastern coasts of Hokkaido on the Pacific Ocean side, and the migration of "Small herrings" are under study[3]. According to the results[4] obtained, the "Small herrings" are considered to have no parental relation with "Spring herrings" which come to Japan Sea coasts.

In old times, "Small herrings" which are caught off Kushiro, in Akkeshi Bay ("Lake herring"), near Kayabe, or Lake Obuchi in Aomori Prefecture were considered to be independent families; now, however, it is considered doubtful whether that is fine.[3]

Discussing the quality of the meat, "Autumn herrings" of Saghalien are suitable for salted goods. "Spring herrings" caught off western coast of Hokkaido are spawning herrings, so the roe and milt are over-matured, the amount of fat is small, and the body loses flesh, therefore they are not suitable for salting. However, the "Spring herrings", which are caught 4 or 5 weeks before the spawning are suitable for salting. Those herrings are called especilly "Fore-coming herring" or "Snow season herring" ("Yuki-Nishin").

"Spring herring" is divided into three categories according to the catching season; the first group is from March 21st to April 15th ("Fore-coming herring" or "Snow season herring"), the second group is from April 16th to April 30th ("Intermediate-coming herring"), the third group is from May lst to June 31st ("Late-coming herring") ("Ato-Nishin"). Herrings are abundantly caught in a short period, so the catch is made into "Dried herring meat" ("Migaki-Nishin" in Japanese) which is the simplest merchandise, or fish fertilizer ("Gyokasu"). "Dried herring meat" is made from "Fore-coming herring" or from the early catch of "Intermediate-coming herring".

The "Fore-coming herring" is large, fatty and good in taste. The "Intermediate-coming herring" and "Late-coming herring" are spawned herring or young herring, so the body has lost flesh, or is small sized, therefore they are unsuitable as raw material for the dried herring meat. Especially the "Late-coming herring" has inferior quality flesh. At the catching season, temperature is becoming high, so the herring is liable to decomposition, therefore it is made into fish fertilizer. The "Spring herrings" which has not yet spawned is salted and smoked. The smoked herring made from such a material is of good quality.

The author has endeavoured to study the making of foods from herring, not the making of fish fertilizer.

II. CHEMICAL COMPOSITION OF "SPRING HERRING"

"Spring herrings" come to the whole western coasts of Hokkaido to spawn. The general chemical components of fish generally vary with season, even if the fish is the same species. Clark and Almy have observed the variation of the chemical components of the migrating fishes[5]; and they have stated that the components, especially fat and water-contents of the meat vary by catching season, age of fish, spawning, nutrition, etc.

The present author in 1925 compared the general chemical components of "Spring herrings" caught near Otaru, Hokkaido by their sex and maturity.

1. Experimental method

The weight and length of the bodies, the weight of milt or roe and the weight of the edible part of herrings which were caught at various times were estimated by comparing the age, sex and maturity. Nextly the amounts of water-content, total nitrogen, crude fat and ash of the meat muscle of the back part were estimated. Samples employed were each 10 ~ 20 fishes.

2. Experimental results

The experimental results obtained are shown as Table 1.

As seen in Table 1, the chemical components of the meat of "Spring herring" varied remarkably by the fishing period. In those experiments, the amount of water content was 67 ~ 78 %, crude protein (Total N × 6.25) was 16 ~ 21 %, crude fat was 1.5 ~ 12 %, and ash was 0.9 ~ 1.7 %. Among the variations of the chemical components, those of water content and crude fat were remarkable.

(1) Periodical variation of the weights of milt or roe and edible part

Viewing the ratios of the weight of milt or roe and edible part of the "Spring herrings" for the total weight of a fish body in Table 1, one will note that the ratios varied remarkably according to fishing period. But the ratios obtained in Table 1 do not suggest remarkable difference by ages of fishes. Therefore the variations of the ratios are drawn up by difference by sex of the fishes as shown in Figs. 2 and 3.

As seen in Fig. 2, the weight ratio of milt or roe of the "Spring herrings" became remarkably larger at the end of March, and decreased remarkably from early April to the end of April; afterwards the "Spring herrings" have disappeared from May to October, so the experiments could not be carried out. From November to February of

Table 1. General chemical composition of the meat of "Spring herrings"

Catching date	Degree of maturity	Body weight (g)	Weight of milt or roe	Weight ratios of milt or roe to the body weight (%)	Weight ratio of edible part to the body weight (%)	Body length (cm)	Sex	Ages	Water (%)	Crude protein (%)	Crude fat (%)	Ash (%)
XI. 25	Unmatured	158	15	9.5	70	24	♀	3	69.18	20.63	8.80	1.39
XII. 13	〃	95	—	—	58	—	♂	〃	69.78	21.31	7.20	1.71
〃	〃	99	—	—	58	—	♀	〃	73.23	20.94	4.39	1.44
XII. 15	〃	141	—	—	49	24	♂	〃	66.87	21.44	10.24	1.45
〃	〃	166	—	—	49	25	♀	〃	68.46	21.13	9.13	1.28
XII. 18	〃	68	—	—	47	—	♂	〃	74.08	21.25	2.91	1.76
〃	〃	71	—	—	46	—	♀	〃	74.50	21.19	2.60	1.71
II. 9	〃	90	12	13.3	67	—	♂	〃	76.62	16.81	5.44	1.13
〃	〃	90	—	—	—	23	♂	〃	76.05	16.88	5.82	1.25
〃	〃	97	9	9.3	57	24	♀	〃	75.07	16.38	7.33	1.22
〃	〃	—	—	—	—	—	♀	〃	81.61	15.75	1.62	1.02
III. 25	Full matured	215	42	19.5	65	32	♂	7	72.17	18.25	8.11	1.47
〃	〃	—	129	—	—	—	♂	5	78.46	17.63	2.49	1.42
〃	〃	—	45	—	—	—	♂	5	78.05	17.75	2.76	1.44
〃	〃	280	51	18.2	61	—	♀	5	75.32	19.50	3.67	1.51
III. 30	〃	274	45	16.4	—	28	♂	6	71.53	18.31	9.06	1.15
〃	〃	348	80	23.0	—	23	♀	〃	71.80	18.75	8.20	1.25
III. 31	〃	—	56	—	—	—	♂	7	74.64	18.75	5.29	1.32
〃	〃	—	34	—	—	—	♀	7	70.51	20.63	7.90	0.96
〃	〃	236	45	19.1	59	30	♂	6	70.86	20.41	7.37	1.36
〃	〃	—	53	—	—	—	♂	〃	75.88	18.13	4.59	1.40
〃	〃	233	144	18.9	59	32	♀	〃	70.22	20.69	7.87	1.22
〃	〃	356	101	28.4	—	32	♀	〃	71.08	18.81	8.68	1.43
IV. 3	〃	270	40	14.8	—	32	♂	〃	74.79	18.56	5.41	1.24
〃	〃	—	49	—	—	—	♂	〃	75.39	18.06	5.28	1.27
〃	〃	—	38	—	—	—	♀	〃	74.94	18.94	4.82	1.30
〃	〃	284	60	21.1	—	33	♀	〃	73.44	19.06	6.29	1.21
IV. 8	〃	—	26	—	—	—	♂	5	71.82	18.63	8.37	1.18
〃	Unmatured	161	23	14.3	47	30	♀	〃	75.68	18.34	1.88	1.10
〃	〃	—	15	—	—	—	♂	〃	77.82	18.17	2.58	1.41
〃	〃	165	26	15.7	62	31	♂	〃	75.55	18.81	4.47	1.17
IV. 11	〃	105	15	14.3	65	21	♀	3	75.90	18.75	3.95	1.40
IV. 13	Full matured	184	28	15.2	63	—	♂	5	71.22	18.88	8.46	1.44
〃	〃	179	31	17.3	61	—	♀	6	71.62	19.31	8.05	1.02
IV. 16	Spent	164	—	—	49	29	♂	〃	77.95	19.19	1.74	1.12
〃	〃	183	—	—	39	30	♀	7	78.94	17.88	1.99	1.19
IV. 26	Unmatured	188	30	16.0	70	—	♂	5	73.17	18.13	7.59	1.11
〃	Full matured	184	28	15.4	69	30	♀	4	73.16	16.75	8.91	1.18
〃	〃	147	18	12.2	—	28	♀	6	76.91	16.25	5.74	1.10
〃	〃	146	14	9.6	—	29	♀	7	76.65	16.63	5.68	1.04
V. 6	Unmatured	188	26	13.8	66	25	♀	4	72.25	17.81	8.59	1.35
V. 13	〃	146	15	10.3	67	27	♂	5	73.35	17.06	7.87	1.72
〃	〃	184	28	15.2	66	29	♀	〃	71.75	18.81	8.79	1.65
V. 24	Spent	128	—	—	47	—	♂	4	72.51	18.75	7.58	1.16
〃	〃	103	—	—	—	22	♂	〃	70.16	19.06	9.69	1.09
〃	〃	108	—	—	51	22	♀	〃	72.78	17.94	8.11	1.17
〃	Unmatured	142	36	25.3	—	29	♀	〃	71.34	18.94	8.46	1.26
V. 27	〃	—	25	—	56	—	♂	6	75.78	18.19	4.97	1.06
〃	〃	—	35	—	53	—	♀	〃	75.12	17.69	6.14	1.05
VI. 3	〃	99	19	19.2	62	—	♂	3	—	20.00	4.03	—
〃	〃	147	20	13.6	—	26	♂	4	68.51	18.50	11.95	1.04
〃	〃	146	20	13.7	57	—	♀	〃	—	18.44	5.75	—
〃	〃	135	19	14.1	—	27	♀	5	72.77	18.13	7.80	1.30

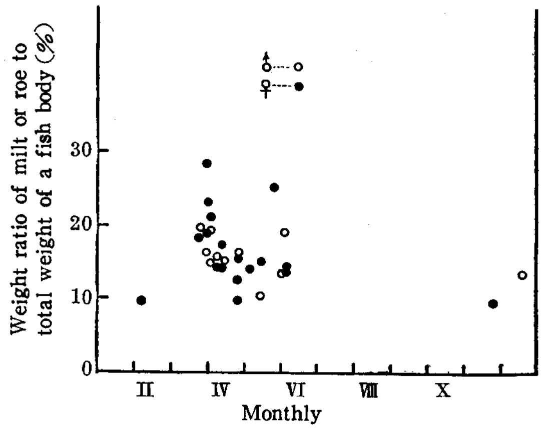


Fig. 2 Variation of the ratios of the weights of milt or roe to the total weight of a fish body by sex

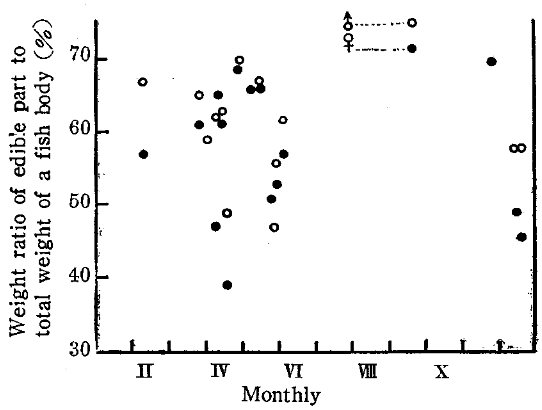


Fig.3 Variation of the ratios of the weight of the edible part to the total weight of a fish body by sex

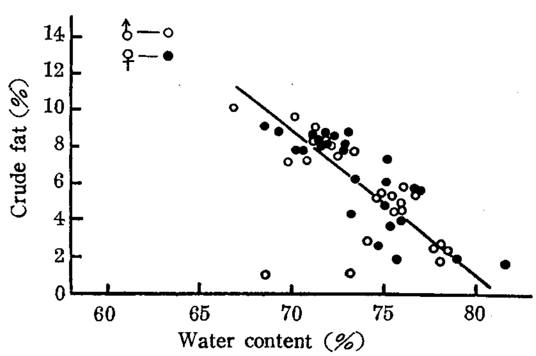


Fig. 4 Relation between the amounts of water content and fat

the next year, the "Spring herrings" were caught as unmatured fishes, so the weight ratio of milt or roe was small. At the end of March, the ratio remarkably increased. As may be noted in Fig. 1 the spawning season of the "Spring herrings" is supposed to be from the end of March to the end of April. That is to say, the weight ratio of milt or roe increased remarkably before the spawning with development toward maturity, and the ratio decreased at the end of April after the spawning.

On the contrary, as seen in Fig. 3, the ratio of the weight of the edible part of the herring showed the maximum value at the end of April. This is due to the exhaustion of milt or roe at the spawning, therefore the ratio of the weight of the edible part increased relatively.

(2) *Periodical variation of the relation between the amounts of water content and fat in the "Spring herrings"*

From Table 1, the fact that when the herrings have larger amount of water content, the amount of fat is smaller, was suggested. The relation between the amounts of water content and fat was graphed in Fig. 4 by the sexual difference of the "Spring herrings" which were caught at various times.

As seen in Fig. 4, there was no remarkable difference by sex between the relations of the amounts of water content and fat. The relations were shown as a straight line. That is to say, when the amount of water content increased in the meat of the herrings, the amount of fat decreased. This fact has been afterwards clarified by many investigators, *e.g.* in the meat of mackerel by Miyama and Saruya[6].

The periodical variations of the amounts of fat and water content differing from the sex of fishes are shown as Figs. 5 (1), (2) and Figs. 6 (1), (2).

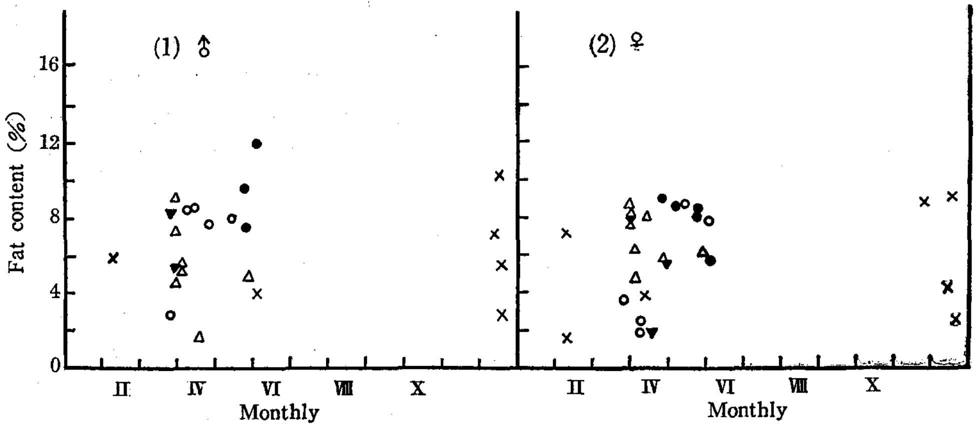


Fig. 5 Periodical variation of fat content

(1)……male, (2)……female

×…3 years old, ●…4 years old, ○…5 years old, △…6 years old, ▼…7 years old

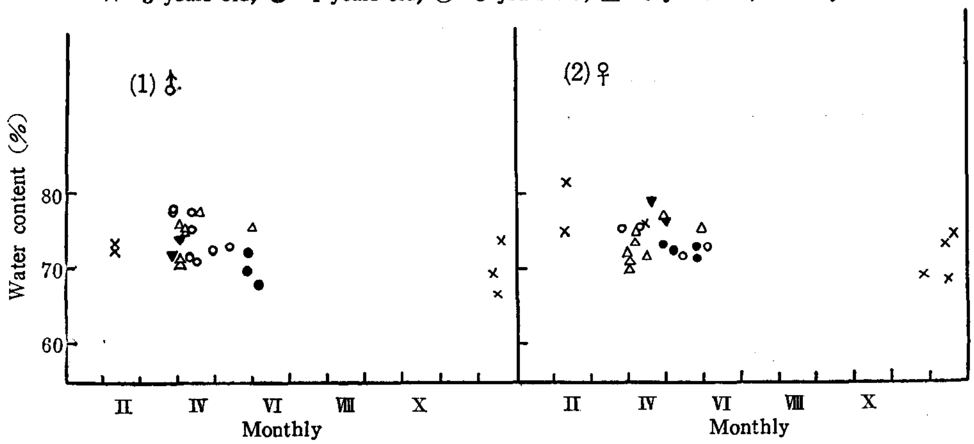


Fig. 6 Periodical variation of water content

(1)……male, (2)……female

×…3 years old, ●…4 years old, ○…5 years old, △…6 years old, ▼…7 years old

In Figs. 5 and 6, the dates, at which the herrings employed for sample by the difference of ages were caught, were irregular, to the author's regret, so the data have not been discussed in detail. But generally speaking of plots in Figs. 5 and 6, taking into account the contrary relation between the amounts of water and fat contents in the meat of the herrings, the amount of the crude fat attained larger value at the end of March, in the fishes of 3, 5, 6 and 7 years old, and decreased in the middle of May. The fishes of 4 years old showed the larger amount of crude fat at middle of May.

Considering from the results, as above mentioned, the amount of crude fat increased before the spawning, and decreased after the spawning, and then increased again with regaining of the body strength. The variations in the amounts of water content and crude fat from November to February of the next year were not clear, because the sample fish were obliged to limit to 3-year-olds and the number was small.

(3) *Periodical variation of the amounts of crude protein and ash in the meat*

From Table 1, the periodical variations of the amounts of crude protein and ash in the meat by the difference of sex are shown as Figs. 7 (1), (2) and Figs. 8 (1), (2).

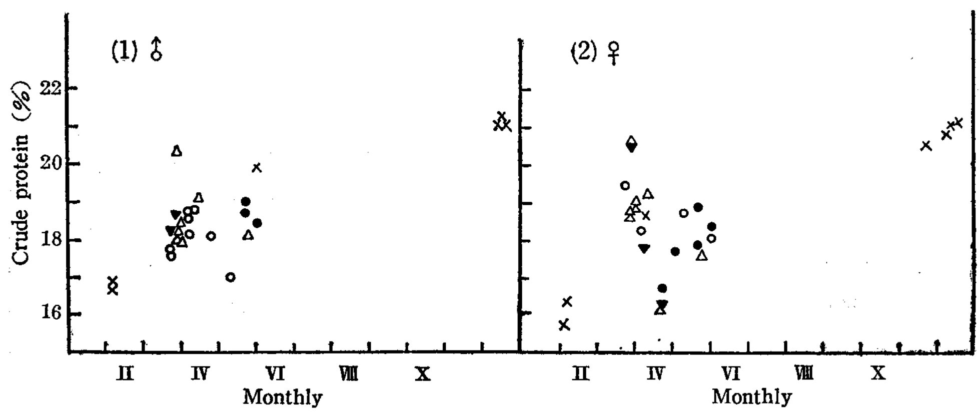


Fig. 7 Periodical variation of the amount of crude protein

(1)……male, (2)……female

×…3 years old, ●…4 years old, ○…5 years old, △…6 years old, ▼…7 years old

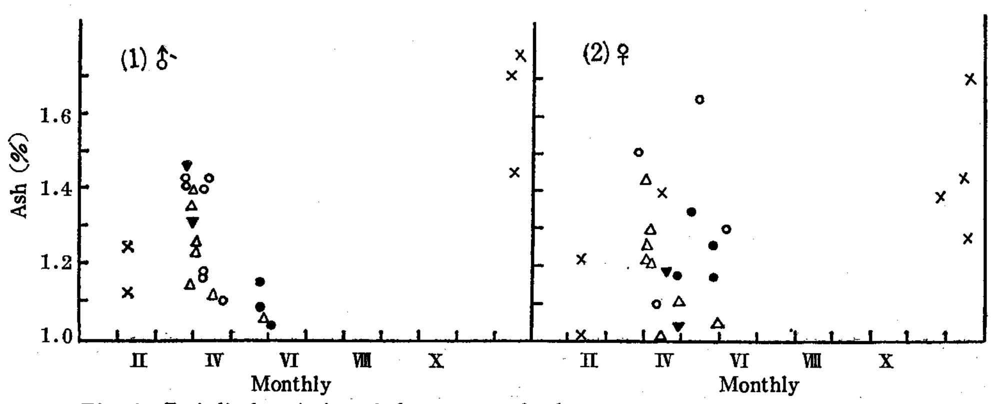


Fig. 8 Periodical variation of the amount of ash

(1)……male, (2)……female

×…3 years old, ●…4 years old, ○…5 years old, △…6 years old, ▼…7 years old

As seen in Figs. 7 and 8, the variation of the amounts of crude protein and ash in the meat of the male and female herrings was in accordance with the periodical variation of the amount of crude fat. That is to say, in fishes of 3, 5, 6 and 7 years old, the amounts of crude protein and ash showed the largest amount at the end of March, then decreased to the middle and end of April, and increased gradually in May. In fishes of 4 years old, the amounts of crude protein and ash increased from the end of April to the end of May, though the amounts in March were unknown, because no samples were obtained. But from the fact that the amounts showed comparatively larger values from November to December, it is suggested that the amounts increased from June to the winter season. The amounts are suggested to decrease again in winter to February, and to increase until March before the spawning.

3. Considerations

From the periodical variations of general chemical components of the meat of "Spring herrings", the amounts of water content and crude fat may be said to vary remarkably. Those components showed always the contrary relation; the sum of those components showed almost the same value (80 ± 3 %) through the year.

The amounts of crude fat, crude protein and ash in the meat decreased remarkably from March to April which are the spawning months judging from the variation of the weight of milt or roe. From the fact that before and after the period, the amounts show the maximum, it is judged that the components accumulate in the meat before the spawning, and decrease at the spawning, and then increase again with regaining of physical strength of the body. Miyama and Saruya[6] have observed that in mackerel meat, the amount of crude fat decreased gradually from April to May which are the spawning season, showed the minimum value from May to July, and afterwards increased reaching the maximum value at January to February of the next year. Fukuhara[7] has compared the amounts of chemical components of salmon meat before and after the spawning. He observed that the amounts of crude fat and lecithine decreased after the spawning, and the amounts of arginine and histidine in amino acids decreased, but the amount of lysine increased.

The present author has also observed the decrease of histidine and the increase of lysine after the spawning as in the results presented below (Ref. Article VIII).

According to Dill's result[8] obtaining from the estimation of the general chemical composition for the "Small herrings" caught monthly, the amounts of crude fat showed the maximum value in the period from July to September. Lovern and Wood[9] have studied the periodical variation of the chemical components of herrings in the Scotia Sea and the Shetland Islands. In those herrings the amount of the crude fat showed the minimum value from March to April, that is to say, the amount was about 5 % in the unmatured herrings (3 years old) and adult (7 years old), but the amount increased remarkably from July to August, and attained the maximum value, that is to say, about 20 %. But the amount of the fat content decreased to April of the next year. Those variations are suggested to be due to the spawning (in August). Before the spawning the amount of crude fat was larger and at the spawning, the amount decreased by the fasts. They have also observed that the amount of the crude fat depends upon the kind of plankton eaten. At the period of the increasing of the amount of the crude fat, the herrings have abundantly eaten plankton having rich fat, *Calanus finmarchicus*.

From the results obtained, the periodical variation of the amounts of crude fat, protein depends clearly on the spawning of the herrings also in Japan.

III. CHEMICAL COMPOSITION OF THE "SMALL HERRINGS"

The name "Small herrings" is applied to those herrings which are caught from Akkeshi to Kushiro of Hokkaido and both eastern and western coasts of Saghalien in summer, as above noted.

The author has determined the amount of edible part, general chemical composition and the distribution of the nitrogens of the so-called "Small herrings" which are caught off Kushiro.

(1) *The amount of edible part of the "Small herrings"*

Each 3 fishes of male and female of the "Small herrings" were used and the amount of edible part was determined. The resutls obtained are shown as Table 2.

Tabe 2. Weight ratio of edible part of the "Small herrings"

Sex	Items	Sample 1	Sample 2	Sample 3
♂	Body weight (*A*)	37.9 *g*	63.0	19.1
	Weight of edible part (*B*)	24.4 *g*	40.5	12.8
	Weight ratio of edible part ($^B/_A \times 100$)	64%	64	67
♀	Body weight (*A*)	37.1 *g*	65.3	45.8
	Weight of edible part (*B*)	22.5*g*	39.8	28.1
	Weight ratio of edible part ($^B/_A \times 100$)	61%	61	61
Remarks	Herrings used were caught in the middle of July.			

As seen in Table 2, male fish have larger amount of edible part than female. In general, the weight ratios of the edible part of fishes have been found to be 30 ~ 70%. The weight ratio of the edible part of the "Small herring" is larger than that of other fishes.

(2) *General chemical composition of "Small herrings"*

Three males and 4 females of "Small herrings" which were caught off Kushiro were used for the determination of the amounts of water-content, total nitrogen, fat and ash by usual methods. Results obtained are shown as Table 3.

Table 3. General chemical composition of the meat of "Small herrings"

Sex	Sample No.	Date of catching	Age	Water (%)	Crude protein (%)	Crude fat (%)	Ash (%)
♂	No. 1	7th, July	2 years old	59.2	20.6	18.9	1.22
	No. 2	ibid	2	75.7	19.8	3.5	1.01
	No. 3	16th, July	2	71.1	20.0	7.9	1.04
♀	No. 1	7th, July	2	73.0	19.5	6.3	1.15
	No. 2	ibid	2	61.3	20.5	17.0	1.20
	No. 3	16th, July	2	73.5	19.8	5.6	1.10
	No. 4	17th, July	3	68.9	19.4	10.6	1.18
Average on 2 years old				69.3	19.9	9.6	1.15

As seen in Table 3, the "Small herrings" have 69 % of water-content, 20 % of crude protein, 10 % of crude fat and 1 % of ash on the average. The female has a larger amount of the water-content than the male, but the former has less amount of fat than the latter. Of course, the chemical composition of the fish meat varies generally with the catching season, as above described in Article II, "Spring herrings".

According to Dill[8], small herrings of Newfoundland have the maximum amount of crude fat and the minimum amount of water content in summer, from June to September. Lovern and Wood[9] have also observed that the amount of fat in herrings of the North Sea is the minimum in April, increased remarkably from May and reached the maximum in July and to the spawning time.

"Small herring" which are caught off Kushiro and Akkeshi in early June to August are not found in other seasons. Furthermore, the parental relation between the "Small herring" of the Pacific coast side and "Spring herring" of the Japan Sea is not yet known[3]. Therefore the seasonal change of the chemical components of "Small herring" can not be known.

(3) *Nitrogen distribution of "Small herrings" meat*

"Small herrings" meat which were the same as the sample used for the determination of general chemical components was employed for the determination of the distribution of nitrogen. The meat was treated with water, alcohol, ether and the meat protein was obtained. The meat protein was hydrolyzed with sulfuric acid; the amounts of total nitrogen and nitrogens of amino acid, basic, ammonia and melanin forms were determined. The results obtained are shown as Table 4.

Table 4. Nitrogen distribution in the "Small herrings" meat protein

Items	In dried matter of sample	In ash-free dried matter	In total-N
Total-N	14.73%	15.98%	100 %
Amino-N	9.20	9.98	62.45
Basic-N	4.59	4.98	31.16
Ammonia-N	0.64	0.69	4.92
Melanin-N	0.30	0.33	2.07

As seen in Table 4, in the total amount of nitrogen of the meat protein of "Small herrings", greatest part is supplied by amino acid nitrogen and basic nitrogen.

Lately, Igarashi[10] has estimated the amounts of various nitrogens in the raw herring meat and stated that the amount of total nitrogen was 15.45 %, ammonia nitrogen was 1.42 % (9.2 % of the amount of the total nitrogen), melanin nitrogen was 0.28 % (1.8 % of the same), monoamino nitrogen was 8.46 %, (54.8 % of the same), diamino nitrogen was 5.28 % (34.2 % of the same) in the ash free anhydrous sample. Sekine[11] has also estimated the same components with 22 kinds of fishes, and found that the amount of total nitrogen was 16.22 %, amino acid nitrogen 10.09 %, basic nitrogen 4.92 % and ammonia nitrogen was 0.92 % on the average. By comparing with those data, one may see that the amounts of the nitrogenous components of the "Small herrings" meat protein are the same as those of other fishes.

IV. CHEMICAL COMPOSITION OF "OILY HERRINGS" CAUGHT AT VARIOUS PLACES

The general chemical compositions of the so called "Oily herrings" were determined by usual methods. Several fishes of male and female caught off Kabuka on Rebun Island, Wakkanai, Kitami-Esashi, Saghalien, Vladivostock and Kamchatka in the U.S.S.R., Korean coasts, Pacific side of the U.S.A. (Berkeley) were used for the determinations of water-content, total nitrogen, crude fat and ash.

1. Experimental results

(1) *Herrings caught off Rebun Island*

Each 3 fishes of male and female caught off Rebun Island on 6th June were used. Results are shown as Table 5.

(2) *Herrings caught near Wakkanai*

Each 3 fishes of male and female 6 years old caught near Wakkanai on 21st June were used. Results are shown as Table 6.

(3) *Herrings caught off Esashi, Kitami district*

Two male and three female of herrings caught off Esashi, Kitami district of Hokkaido were used. Results are shown as Table 7.

Table 5. General chemical components of "Oily herrings" caught off Rebun Island

Sex		♂			♀		
Sample No.		1	2	3	1	2	3
Water (%)		68.1	68.3	68.2	68.4	68.7	68.7
Crude protein (Total-N × 6.25) (%)		18.0	17.9	17.8	17.7	17.6	17.5
Crude fat (%)		12.6	12.5	12.7	12.4	12.3	12.4
Ash (%)		1.27	1.20	1.31	1.48	1.39	1.37
Remarks	Body length	30 *cm*	30	30	32	30	30
	Body height	8 *cm*	7	7	8	8	8
	Body weight	200 *g*	163	159	210	174	242
	Ages	7 years old	6	6	6	6	6

Table 6. Herrings caught near Wakkanai

Sex		♂			♀		
Sample No.		1	2	3	1	2	3
Water (%)		69.1	69.5	70.0	70.8	70.6	70.9
Crude protein (Total-N × 6.25)(%)		18.1	17.9	17.8	17.4	17.6	17.6
Crude fat (%)		11.3	11.2	11.0	10.5	10.3	10.2
Ash (%)		1.33	1.38	1.21	1.39	1.43	1.46
Remarks	Body length	27 *cm*	26	26	26	26	26
	Body weight	196 *g*	176	185	185	185	180

Table 7. Herrings caught off Esashi, Kitami district

Sex	♀			♂	
Sample No.	1	2	3	1	2
Water (%)	74.2	74.7	74.4	73.1	73.7
Crude protein (Total-N × 6.25) (%)	19.6	19.5	19.5	20.3	20.0
Crude fat (%)	5.1	4.5	5.0	5.2	4.9
Ash (%)	1.10	1.26	1.13	1.33	1.38
Ages	6 years old	5	5	5	5
Remarks	Caught by set net, 1st, May			Caught by gill net, 28th, May	

(4) *Herrings caught off western coast of Saghalien*

Each 3 males and females of herrings caught on 21st July and each 2 males and females caught on 22nd July were used. All these herrings were 7 years old. Results are shown as Table 8.

Table 8. Herrings caught off western coast of Saghalien

Items \ Sex		♂			♀		
Caught in 21st, July	Sample No.	1	2	3	1	2	3
	Water (%)	61.9	61.9	61.7	63.4	63.9	63.4
	Crude protein (%)	17.8	17.7	17.9	16.5	17.4	17.5
	Crude fat (%)	19.1	19.2	19.1	17.8	17.3	17.9
	Ash (%)	1.20	1.26	1.25	1.33	1.35	1.35
	Note : Body length	31 *cm*	31	30	30	30	30
	Body height	7 *cm*	7	7	7	7	7
	Body weight	255 *g*	244	263	263	251	251

Items \ Sex		♂		♀	
Caught in 22nd, July	Sample No.	1	2	1	2
	Water (%)	69.0	69.4	69.0	69.2
	Crude protein (%)	17.0	17.4	16.9	17.3
	Crude fat (%)	12.6	11.9	12.8	12.4
	Ash (%)	1.34	1.27	1.39	1.18

(5) *Herrings caught off Vladivostock*

Two males caught in the middle of February and two females caught late in March were used. Results are shown as Table 9.

Table 9. Herrings caught off Vladivostock

Sex	♂		♀	
Sample No.	1	2	1	2
Water (%)	68.4	68.5	67.8	69.2
Crude protein (Total-N × 6.25) (%)	19.2	19.1	19.3	19.0
Crude fat (%)	11.0	11.0	11.0	10.0
Ash (%)	1.40	1.41	1.84	1.75
Remarks	Taken in middle of February, male, 3 years old		Taken in end of March, female, No. 3 (6 years old) No. 4 (5 〃 〃)	

(6) *Herrings caught off western coast of Kamchatka Peninsula*

Each 3 males and females caught in August were used. Results are shown as Table 10.

Table 10. Herrings caught off western coast of Kamchatka

Sex		♂			♀		
Sample No.		1	2	3	1	2	3
Water (%)		67.5	68.1	67.6	70.1	70.3	69.8
Crude protein (Total-N × 6.25) (%)		18.1	18.0	17.9	17.8	17.8	17.6
Crude fat (%)		13.0	13.1	13.1	10.8	10.4	11.1
Ash (%)		1.35	0.83	1.38	1.40	1.48	1.44
Remarks	Body length	26 *cm*	26	26	26	26	26
	Body height	6 *cm*	5	7	5	5	5
	Body weight	109 *g*	109	138	107	109	109

(7) *Herrings caught off Korea*

Three males and 6 females of herrings caught off the northern coast of Korea in the middle of February were used. Results are shown as Table 11.

Table 11. Herrings caught off Korea

Sex	Sample	Water (%)	Crude protein(%)	Crude fat (%)	Ash (%)	Note
♀	No. 1	64.8	17.5	16.5	1.20	3 years old
	No. 2	66.5	18.5	13.6	1.45	〃
	No. 3	66.1	18.6	13.9	1.35	4 years old
	No. 4	65.0	18.3	15.4	1.37	Spent
	No. 5	61.6	18.0	18.0	1.46	〃
	No. 6	60.3	20.8	17.6	1.35	Full matured
♂	No. 1	69.4	17.9	11.3	1.46	3 years old
	No. 2	66.4	18.8	13.4	1.43	Spent
	No. 3	63.2	20.7	14.7	1.42	Full matured

(8) *Herrings caught on the Pacific coast of the U.S.A.*

Four males and 1 female of herrings of 4 years old caught off Berkeley in January were used. Those samples were salted to bring them to the author's laboratory without decomposition. On this herring, the amount of NaCl in the meat was estimated. Results are shown as Table 12.

Table 12. Herrings caught on the Pacific coast of the U. S. A.

Sex	Water (%)	Crude protein (%)	Crude fat (%)	Ash (%)	NaCl (%)
♂	53.5	21.1	16.6	15.8	14.4%
〃	53.9	21.1	16.9	16.0	14.6
〃	53.9	20.8	17.2	15.9	14.5
♀	51.8	20.6	15.9	15.3	14.0

Table 13. Average value of the the general chemical components of "Oily herrings" caught at various places

Items / Catching place	♂ Water (%)	♂ Crude protein (%)	♂ Crude fat (%)	♂ Ash (%)	♀ Water (%)	♀ Crude protein (%)	♀ Crude fat (%)	♀ Ash (%)	Remarks
Off Rebun Island	68.2	17.9	12.5	1.26	68.6	17.6	12.3	1.41	Caught in the first of June; 6 and 7 years old
Near Wakkanai	69.5	17.9	11.2	1.91	70.7	17.5	10.3	1.43	Caught in the end of June; 6 years old
Off Kitami-Esashi	74.0	19.8	4.9	1.24…(Sex was unknown)					Caught on May
Western coast of Saghalien	65.5	17.5	15.7	1.27	66.4	17.1	15.2	1.32	Caught in the end of July; 7 years old
Off Vladivostock	68.5	19.2	11.0	1.41	68.5	19.2	10.5	1.80	♂ (Caught in the middle of Feb.; 3 years old) ♀ (Caught in end of March; 5 and 6 years old)
Western coast of Kamchatka	67.7	18.0	13.1	1.19	70.1	17.7	10.8	1.44	Caught on August; 4 years old
Off Korea	67.9	18.4	12.4	1.44	64.8	18.2	15.5	1.37	Caught in the middle of Feb.; 3 and 4 years old

2. Considerations

From these data obtained with herrings caught at various places, the average value of the general chemical components are shown as Table 13.

From Table 13, in so-called "Oily herrings" meat there is above 10 % of crude fat in the fish meat excepting the herring caught off Esashi.

Comparing with "Small herrings" of which the general chemical components have been described above in Article III, the "Oily herrings" have greater amount of the crude fat. In general, the male fish have larger amount of crude fat than the female, and contrarily the former has smaller amount of water content than the latter.

V. ON THE CHEMICAL COMPOSITIONS OF THE EXTRACTIVE OF HERRINGS MEAT

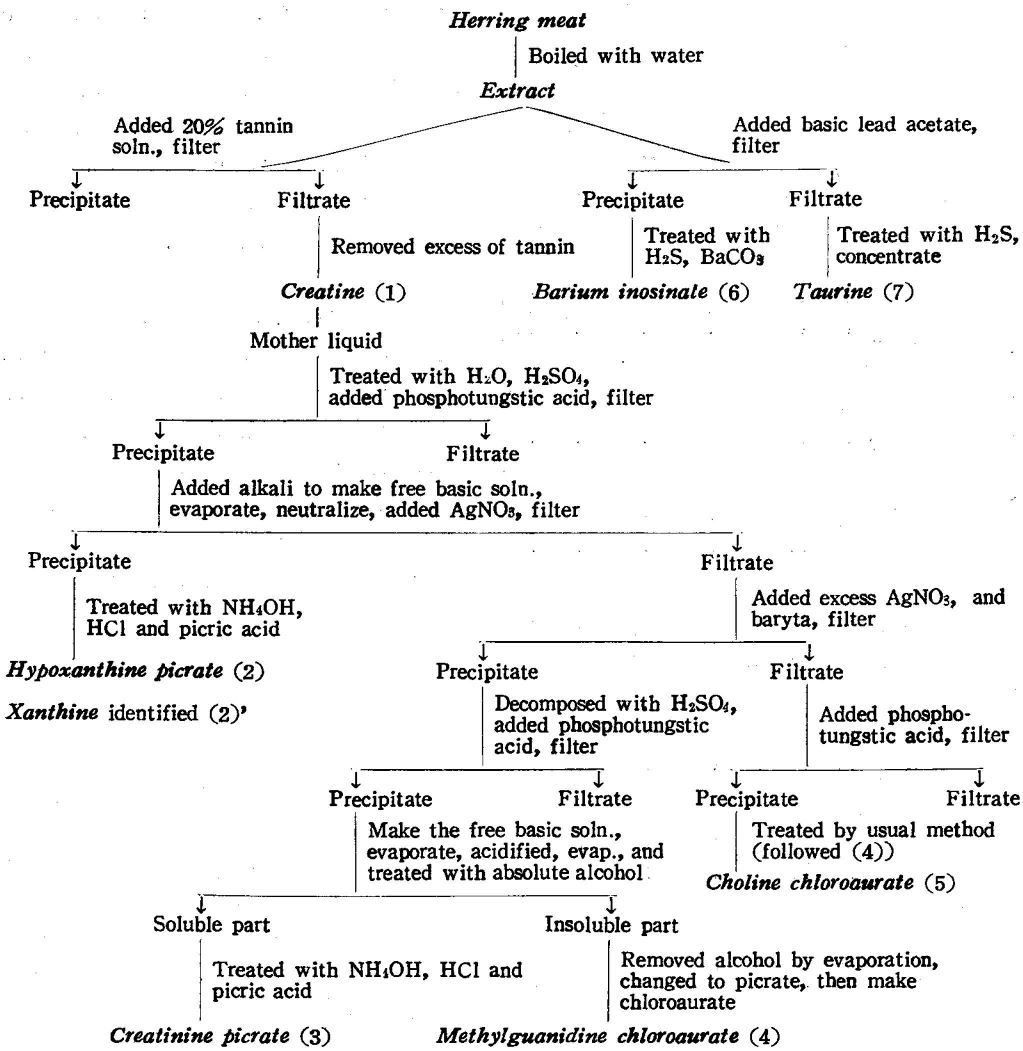
Creatine, creatinine, hypoxanthine, xanthine, methylguanidine, choline, inosinic acid and taurine were isolated from the meat extractive of herrings which were caught off Yoichi, Hokkaido, and their amounts were estimated. (See Scheme 1).

1. Experimental results

(1) Creatine

To one *kg* of the meat of the "Spring herring" (Adult, water-content 71.2 %) caught at the end of April distilled water was added, and boiled. To the total extractive from the boiled meat was added 20 % tannin solution as a protein precipitant. After the removal

Scheme 1. Isolation of various components from the extract of herring meat



of the excess tannin, 2.0110 *g* of colorless, rhumboid, columnar crystals of creatine was obtained. After the drying of the crystal, it was analyzed. From 0.2014 *g* of the sample, 0.0650 *g* of nitrogen was determined. The calculated amount of nitrogen in creatine ($C_4H_9N_3O_2$) was 32.06 %, but the experimental finding was 32.27 %.

(2) *Hypoxantine and Xanthine*

Mother liquid from which creatine had been removed was treated with water and sulfuric acid, then to it was added phosphotungstic acid. From the precipitate, free basic solution was made by usual method. The solution was concentrated by evaporation. After the neutralization of the concentrate, silver nitrate solution was added. The precipitate yielded was treated with ammonia, hydrochloric acid and picric acid by turns. Here 1.3443 *g* of picrate of hypoxanthine was obtained. At this time, the presence of xanthine was slightly observable. From 0.1908 *g* of the sample of hypoxanthine picrate, 0.0092 *g* of water of crystallization and 0.1150 *g* of picric acid were obtained. Whilst the calculated amounts of water are 4.7 % and 59.79 % for picric acid in hypoxanthine picrate ($C_5H_4N_4O \cdot C_6H_3N_3O_7 + H_2O$), the experimental amounts were 4.82 % of water, 60.27 % of picric acid. Thus 0.501 *g* of hypoxanthine was obtained from 1 *kg* of the raw meat of herring.

(3) *Creatinine*

To the filtrate from the precipitate by silver nitrate was added exess of silver nitrate and baryta. The precipitate was decomposed by sulfuric acid. After the addition of phosphotungstic acid, the precipitate yielded was treated by the usual method to make the concentrated solution of free bases. The concentrate was acidified and furthermore evaporated. The concentrate was treated with absolute alcohol and divided into two parts. From the dissolved part, 0.7712 *g* of columnar crystals of creatinine picrate was obtained, *m.p.* 214° ~ 215°C. Then the amount of nitrogen of 0.0501 *g* was estimated from 0.2031 *g* of the crystal. Compared with 24.54 % calculated amount of nitrogen in creatinine picrate ($C_4H_7N_3O \cdot C_6H_3N_3O_7$), 24.67 % nitrogen was found. Therefore, 0.2548 *g* of creatinine was obtained from 1 *kg* of the raw meat of herring.

(4) *Methylguanidine*

From the undissolved part of the material described in previous section (3), alcohol was removed by evaporation. The residue was changed to picrate, then to the complex salt of hydrochloride-chloroaurate. Thus 1.8295 *g* of methylguanidine chloroaurate was obtained. From 0.1129 *g* of the dried sample, 0.053 *g* of gold and from 0.1042 *g* of the same sample, 0.0095 *g* of nitrogen were estimated. Whilst the calculated amount of Au are 47.74 % and 10.16 % for nitrogen in methylguanidine chloroaurate ($C_2H_7N_3 \cdot HCl \cdot AuCl_3$), the experimental amount were 47.74 % of Au, 9.12 % of nitrogen. Thus 0.3381 *g* of methylguanidine was obtained from 1 *kg* of the raw meat of herring.

(5) *Choline*

To the filtrate obtained by the filtration of the precipitate yielded by the addition of silver nitrate and baryta as described in (3), was added phosphotungstic acid. The precipitate yielded was treated by usual method and 1.0051 *g* of columnar crystal of choline chloroaurate was obtained. From 0.1385 *g* of the sample, 0.617 *g* of Au in choline chloroaurate was estimated. Calc. Au in choline chloroaurate, 44.49 %; found 44.55 % experimentally. Therefore 0.3170 *g* of choline was obtained from 1 *kg* of the raw meat of herring.

(6) *Inosinic acid*

The extractive solution from 1 *kg* of raw fresh meat of herring from which reddish meat was removed was treated with basic lead acetate. The precipitate yielded was treated with sulfuretted hydrogen, and barium carbonate. Thus 0.2746 *g* of barium inosinate was obtained. From 0.2180 *g* of the sample, 0.0829 *g* of $BaSO_4$ was estimated. Calc. $BaSO_4$ in barium inosinate, 22.39 %; found 22.41 % experimentally. Therefore 0.1980 *g* of inosinic acid was obtained from 1 *kg* of the fresh meat.

(7) *Taurine*

The filtrate of the precipitate by basic lead acetate as described in (6) was treated with sulfuretted hydrogen and then concentrated. Thus 0.9025 *g* of taurine was obtained. From 0.1403 *g* of the sample, 0.0162 *g* of nitrogen was estimated. Compared with 11.55 % calculated amount of nitrogen in taurine ($C_2H_7NSO_3$), 11.20 % of nitrogen was found.

2. Considerations

The isolation of the chemical components as above described from the extract of the meat of herrings was repeated three times. The experimental results obtained are shown as Table 14.

Table 14. Chemical composition of the extract of the meat of herrings (*g/kg* fresh meat)

Components	1	2	3	Average
Creatine	2.0110 *g*	2.0974	1.9749	2.0278 *g*
Hypoxanthine	0.5010	0.5323	0.4864	0.5066
Creatinine	0.2548	0.2521	0.2627	0.2565
Methylguanidine	0.3381	0.3229	0.3335	0.3315
Choline	0.3170	0.3158	0.3184	0.3171
Inosinic acid	0.1980	—	—	0.1980
Taurine	0.9025	—	—	0.9025
Xanthine	+	+	+	+

Previously Yoshimura *et al.*[13] have isolated hypoxanthine, creatine, methylguanidine, choline, cadaverine, putrescine and ammonia from herring meal. Therefore, also in the extract of the raw meat of herring, those components are suggested to occur. The present author has isolated and estimated the components which are shown in Table 14.

The chemical components in the extract of herring meat which were estimated by the present author are compared with the components which have been determined by many investigators in the extract of the meat of other kinds of fish, as shown in Table 15.

As seen in Table 15, the amounts of creatine and creatinine contained in the extract of herring meat are less than those in other kinds of fish. But the amounts of hypoxanthine and methylguanidine contained in the former are considered to be larger

Table 15. Chemical components in the extract of the meat of various kinds of fish (*g/kg* fresh meat)

Fishes used / Components	Herring	Bonito	Mackerel	Sardine	Tuna	Salmon
Creatine	2.03	6.49[13]	4.87[13]		4.97[13]	5.60[13]
Hypoxanthine	0.51	0.08[14]		0.50[15]		0.28[16]
Creatinine	0.26	1.34[13]	0.04[13]	0.31[17]	0.64[13]	0.67[13]
Methylguanidine	0.33	0.05[14]				
Choline	0.32					
Inosinic acid	0.20	0.42[14]				
Taurine	0.90	0.80[18]				
Xanthine	+					

Note: Number in parenthesis shows the No. of literature cited.

than that in the latter. Some investigators have estimated 1.6 *g* of carnosin[19], 0.07 ~ 0.12 *g* of inositol[20], 0.192 *g* of trimethylamine oxide[21] in one *kg* of raw fish meat.

Okuda[22] has isolated purine bases and other components from the extract of the ordinary meat and reddish meat ("Chiai"-meat) of bonito. The present author has also isolated purine bases from the crude meat protein prepared from herring meat. At first, the herring meat ("Fore-coming herring") was treated with water, alcohol and ether. Then 1 *kg* of the crude meat protein thus prepared was hydrolyzed with sulfuric acid. The hydrolyzed solution was neutralized with baryta, and filtered. The filtrate was concentrated by evaporation. Thus purine bases were obtained as described previously. Then methylguanidine was isolated. From the solution from which methylguanidine was removed, xanthine and hypoxanthine were obtained.

The estimated values are as follows; (1) Methylguanidine was 0.7572 *g* from 1 *kg* of herring meat protein as the ash free anhydrous matter. In the sample obtained as methylguanidine chloroaurate, from 0.1528 *g* of the sample, 0.0728 *g* of Au (47.64 % of Au) and from 0.1642 *g* of the sample, 0.0168 *g* of N (10.23 %) were obtained. The calculated amount of Au is 47.74 % and that of N is 10.23 % in methylguanidine chloroaurate ($C_2H_7N_3 \cdot HCl \cdot AuCl_3$). (2) Hypoxanthine was 0.8439 *g* from 1 *kg* of the crude meat protein as the ash free anhydrous sample. In the sample obtained as hypoxanthine picrate, from 0.3071 *g* of it, 0.0146 *g* of H_2O (dried at 120°C) (4.82 % of H_2O) and from 0.3031 *g* of it, 0.1842 *g* of picric acid (60.78 % of picric acid) were obtained. The calculated amount of H_2O is 4.70 % and that of picric acid is 59.79 % in hypoxanthine picrate ($C_5H_4N_4O \cdot C_6H_3N_3O_7 + H_2O$). (3) Xanthine was slightly observable.

VI. INORGANIC COMPONENTS IN HERRING MEAT AND BLOOD

1. Inorganic components in the meat

(1) General inorganic components in herring meat

Fresh meat of "Fore-coming herring" was chemically analyzed, and the obtained results are as shown in the 1st column of Table 16.

Table 16. Inorganic components in herring meat and comparison with that of other fish meats (% in the dried matter of the meat)

Components \ Fishes	Herring	Tuna	Sardine	Mackerel	Bonito[22]	Cod[27]
S	0.061	1.40[23] 1.25[24]	0.97[23] 1.06[24]	1.08[24]	—	—
Ca	0.095	0.14[23]	1.48[23]	—	0.121	0.114
Fe	0.015	0.04[25]	0.04~0.05[25]	—	0.013	0.030
Mg	0.129	0.87[23]	0.70[23]	—	0.109	0.086
Na	0.299	—	—	—	0.793	1.728
K	0.837	—	—	—	0.234	0.512
P	0.532	0.03[23] 0.280[26]	0.272[26]	0.304[26]	—	—

Note: Number in parenthesis shows the No. of literature cited.

As seen in Table 16, the herring meat has comparatively abundant amounts of Na, K, P just as other fish meats. Comparing the amounts of inorganic compounds in the herring meat with the meat of other migrating fishes, recorded in columns 2 to 5, the amount of sulfur content is seen to be remarkably small, but this value is different from that of another investigator[24] who has reported 1.29% of sulfur content in the dried matter of herring meat.

As the inorganic components besides the components which are given in the Table, the amount of Cu has been stated to be 2.5 *mg/kg*[28], of fresh herrings meat, I is 2.1 *mg/kg*[29], As is 0.4~0.8 *mg/kg*[30], or 2.0 *mg/kg*[31]. According to For and Ramage[32], components, As, V, Cr, Mn, Co, Sr, Nb, Ag, Sn, Pb, were detected in the herring meal by spectrochemical analysis. According to Igarashi[10], in the air dried matter of herring meat (water content 7 ~ 8%), there are 0.67 ~ 0.72 % of sulfur, 0.03 ~ 0.28 % of phosphor, 0.28 ~ 1.15 % of calcium, 0.34 ~ 0.55 % of magnesium. He has learned that those components are more rich in the belly meat than in the back meat.

(2) *Sulfur components*

The sulfur compounds present in the fish meat are in both insoluble and soluble states. The insoluble part includes ether soluble and alcohol soluble sulfur. In this experiment the amounts of sulfur components were estimated in parts of water soluble, ether soluble, 95 % alcohol soluble, volatile, and insoluble. The results obtained are shown as in the 1st column of Table 17. (In Table 17, the numbers in parentheses show the percentage of sulfur in the total amount of sulfur.)

As seen in Table 17, about 22 % of the total sulfur in the herring meat was in water-soluble state, while the most part was in insoluble-state.

Generally speaking, the ratio of soluble sulfur to insoluble sulfur is about 1:2 ; this

Table 17. Sulfur compounds in herring meat and comparison with that of other fish meats (% of sulfur in the dried matter)

Sulfur \ Fishes	Herring	Tuna[33]	Salmon[33]
Total-S	0.061 (100%)	0.32 (100)	0.40 (100)
Water soluble-S	0.0132 (21.6)	0.12 (37.5)	0.13 (32.5)
Ether soluble-S	0.0025 (4.1)		
95% alcohol soluble-S	0.0069 (11.3)	0.20 (62.5)	0.27 (67.5)
Volatile-S	0.0102 (16.7)		
Insoluble-S	0.0282 (46.3)		

fact is observed in the tuna and salmon[33] meats as shown in Table 17.

(3) *Forms of phosphorus in the herring meat*

The greater part of phosphorus (60 ~ 75 %) in fish meat is inorganic form. The difference between the total amount of phosphorus and inorganic phosphorus is almost the same as the amount of lipoid-form, and there are only small amounts of protein form and organic phosphorus.

In this experiment, the amounts of various forms of phosphorus were estimated. The results obtained are shown in Table 18, lst column. (In Table 18, the numbers in parentheses show the percentage of various forms of phosphorus to the total amount of phosphorus in the herring meat.)

Table 18. Amounts of various forms of phosphorus in herring meat and comparison with that of other fish meat (% of P_2O_5 in the dried matter)

Phosphorus \ Fishes	Herring	Bonito[34]	Flat fish[34]
Total-phosphor	2.4402 (100%)	2.008 (100)	2.579 (100)
Alcohol ether-soluble-P	0.8146 (33.4)	0.546 (27.3)	0.639 (24.8)
Lipoid-P	0.7413 (30.4)	0.470 (23.4)	0.593 (23.0)
Water soluble-P	1.3286 (54.4)	1.302 (65.1)	1.928 (74.9)
Water insoluble-P	0.0733 (3.0)	—	—
Protein form-P	0.2970 (12.2)	0.033 (1.65)	0.065 (2.52)

As seen in Table 18, about 55% of the total amount of phosphorus in herring meat was water-soluble form phosphorus (inorganic, organic phosphorus), and other forms of phosphorus were 30 % of lipoid-phosphorus and 12 % of protein-phosphorus. When those results are compared with Takenouchi's results[34] which were obtained by the meat of bonito and flat fish, the herring meat is seen to contain a larger amount of protein-phosphorus than bonito or flat fish.

As the protein-phosphorus is present in the reddish meat ("Chiai") more abundantly than in ordinary meat[35], this fact obtained above, is probably due to the abundant amount of reddish meat in the herring bodies.

2. Inorganic components in the blood

Blood was taken from 10 specimens of "Spring herrings" which were caught in early April (adult) (body length 29 *cm*, weight 177 *g* on the average). Twenty five *cc* of the isolated blood was analyzed for the amounts of inorganic components. The results obtained are shown in Table 19.

Table 19. Amounts of inorganic components in the blood of herring

Components	*g*/25*cc* Sample 1	*g*/25*cc* Sample 2	*g*/25*cc* Average	*g*/1000*cc* Average
K_2O	0.0070	0.0078	0.0074	0.296
Na_2O	0.0849	0.0855	0.0852	3.408
Cl	0.0751	0.0761	0.0756	3.024
CaO	0.0020	0.0024	0.0022	0.088
MgO	0.0009	0.0017	0.0013	0.052
P_2O_5	0.0177	0.0187	0.0182	0.728
Fe_2O_3	0.0160	0.0170	0.0165	0.660

As seen in Table 19, among the inorganic components in the herrings blood, NaCl is the principal. Other components were present in only small amounts.

VII. CHANGES OF THE AMOUNTS OF VOLATILE BASIC NITROGEN AND pH VALUE DURING THE STORING OF RAW HERRINGS MEAT

1. Amount of volatile basic nitrogen (V.B.-N) and pH value in fresh herring meat

The amount of V.B.-N and pH value were determined by employing the meat of fresh herring ("Fore-coming herring" caught off Yoichi). Those herrings were used immediately after catching for the determination. Back meat was taken from the herring bodies, and crushed through a chopper. To the crushed meat was added dist. water of 5 times amount of the meat, agitated thoroughly, and then filtered through the cotton. pH value of the filtrate was colorimetrically determined. The amount of V.B.-N was estimated by usual method (aeration method). Results obtained are shown in Table 20.

Table 20. pH value and amount of volatile basic nitrogen in fresh herrings meat

Sex	Body length	Body weight	pH	V. B.-N
♂	25 *cm*	123 *g*	6.8	7.15 *mg%*
♂	25	120	6.8	7.15
♂	25	120	6.8	7.15
♀	25	119	6.8	7.01
♀	25	119	6.8	7.01
♀	25	118	6.8	6.94

As seen in Table 20, there was no difference of pH value and amount of V.B.-N between male and female fish. pH value was 6.8 and the amount of V.B.-N was 7 *mg%*.

2. Changes of pH value and the amounts of V.B.-N in the herring meat during storing

(1) *Change of pH value of the meat stored in a closed vessel*

Twenty specimens of "Spring herrings" (adult) were caught, from which the back meat was taken and crushed. The crushed meat was stored in closed vessels in which the storing temperatures of 3° ± 2°C, 15° ± 2°C and 18° ± 2°C respectively. At definite intervals during the storing, samples of the meat stored was taken. pH value was determined by the same method as above described. The results are shown in Table 21 and Fig. 9.

Table 21. Change of pH value of the herring meat stored in closed vessels

Time (days) \ Temp.	3° ± 2°C	15° ± 2°C	18° ± 2°C
After catching	6.8	6.8	6.8
1/8 days	6.8	—	—
1/4	6.5	—	—
1	(in rigor mortis) 6.5	—	6.4
1¼	(softened) —	—	6.2
2	6.5	6.6	6.8
3	6.4	6.8	(bad smell) 7.0
4	6.4	(bad smell) 7.2	7.0
4½	6.0	—	—
5	6.4	7.2	6.9
6	—	7.2	6.9
6¼	—	—	7.4
7	—	6.8	7.6
7¼	—	—	7.8
8	—	7.0	8.0
9	—	7.6	8.0
10	—	8.2	8.2
11	—	8.2	8.2

As seen in Table 21 and Fig. 9, the pH value of meat changed gradually from 6.8 to 6.2 ~ 6.4 in 3 ~ 4 days stored at 3°C, or in one day stored at 15°C or 18°C. Afrerwards the pH value increased to alkaline side. With ascending of the storing temperature, the pH value showed larger. According to organoleptic observation, in the course of increasing of pH value, at pH 6.8, it has already smelled putrefactive odors. Therefore the limit of pH value of the herrıng meat which is edible was considered to

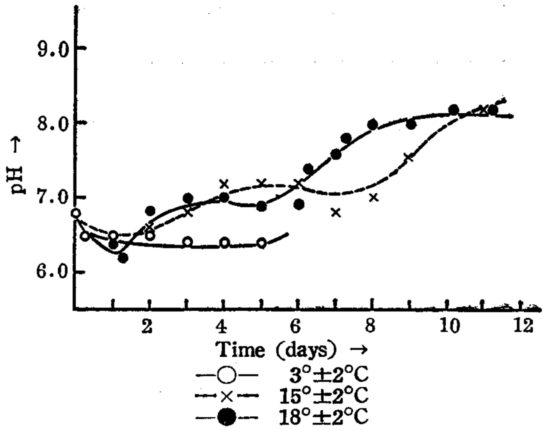


Fig. 9 Change of pH value of the herring meat stored in closed vessels

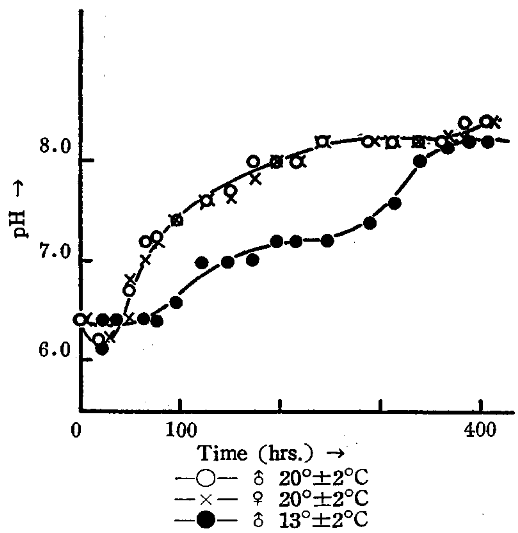


Fig. 10 Change of pH value during the storing of herring in open place

be below 6.5.

The results obtained above showed that lactic acid was produced in the herring meat by autolysis after the death, and thereby the pH value decreased at first; the pH value showed the minimum when the produced amount of lactic acid reached to the maximum. In the succeeding of bacterial decomposion, the amount of V.B.-N increased, and the pH value increased. Those results agreed with Macpheron's[36]. Yamamura[37] has estimated the relation between pH value and the amount of V.B.-N for 22 kinds of fish, and observed that the pH value was 6.5 at the incipient putrefaction of fish meat.

(2) *Change of the pH vlaue in the herring meat stored in open place*

Two specimens of male of "Spring herrings" (adult, 32 *cm* in length, 283*g* weight, 7 years old) which were caught off Yoichi and 2 females (31.5 *cm* in length, 311 *g* weight, 8 years old) were stored at 13° ± 2°C and 20° ± 2°C separatealy in round bodies. At definite intervals of the storing, the back meat was taken and the pH value was estimated by the same method as above described. The results obtained are shown in Table 22 and Fig. 10.

As seen in Table 22 and Fig. 10, there was no difference of the pH values between the male and female. Until the end of the initial 24 hours' storing, the pH value decreased, and afterwards the value increased comparatively rapidly with ascending of the temperature, in agreement with the observations reported in previous section (1). When the pH value showed 6.6 ~ 6.8 at the increasing period of pH value, the fresh bodies

Table 22. Change of pH value during the storing of herring in open place

Time \ Temp. / Sex	20° ± 2°C		13° ± 2°C
	♂	♀	♂
0 hrs.	6.4	6.4	6.4
18	6.2	6.2	6.2
24	6.2	6.2	6.4
42	6.4	6.4	6.4
48	6.7 (bad smell)	6.8 (bad smell)	6.4
65	7.2	7.0	6.4
77	7.2	7.2	6.4
96	7.4	7.4	6.6 (bad smell)
123	7.6	7.6	7.0
147	7.7	7.6	7.0
171	8.0	7.8	7.0
196	8.0	8.0	7.2
216	8.0	8.0	7.2
240	8.2	8.2	7.2
288	8.2	8.2	7.4
312	8.2	8.2	7.6
336	8.2	8.2	8.0
360	8.2	8.2	8.2
384	8.4	8.2	8.2
408	8.4	8.4	8.2

have smelled and became unedible.

(3) *Changes of pH value and the amount of V.B.-N in various parts of the stored herring body*

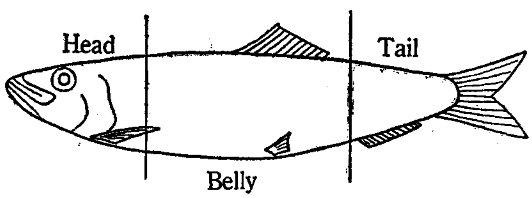


Fig. 11 Position of taking samples

From 5 male fish (248 *cm* in average length, 123.2 *g* weight, 6 years old) and 5 females (24.6 *cm* length, 117.6 *g* weight, 6 years old) of "Spring herrings",, head- belly- and tail-part meat were taken as shown in Fig.11. Meat taken from those parts was crushed and stored at 16° ± 3°C.

At definite intervals of the storing, samples from the various parts meat were estimated for the determination of pH value and the amount of V.B.-N. The results obtained are shown in Table 23.

There was no difference in the changes of pH value and V.B.-N between male and female. Therefore, those changes of male fish only are graphed as shown in Figs. 12 and 13.

Table 23. Changes of pH value and the amount of volatile basic nitrogen in various parts of the body of stored herring

Items / Time (hrs.)	Head-part				Belly-part				Tail-part			
	♂		♀		♂		♀		♂		♀	
	pH	V.B.-N (*mg%*)	pH	V.B.-N (*mg%*)	pH	V.B.-N (*mg%*)	pH	V.B.-N (*mg%*)	pH	V.B.-N (*mg%*)	pH	V.B.-N (*mg%*)
0	6.5	7.20	6.5	7.20	6.5	7.15	6.5	7.20	6.5	7.10	6.5	7.15
19	6.1	8.91	6.1	8.90	6.0	8.40	6.1	8.03	6.1	8.03	6.1	8.03
41	6.1	—	6.1	—	6.0	—	6.0	8.25	5.9	7.30	5.9	7.30
67	6.8	37.9	6.8	37.9	6.6	32.0	6.6	32.0	6.2	9.50	6.2	9.50
89	7.2	46.7	7.2	46.5	6.8	37.9	6.8	37.9	6.4	12.8	6.4	12.4
113	7.4	47.8	7.2	46.7	7.2	46.7	7.1	45.8	7.4	47.8	7.2	46.5
137	7.4	—	7.4	47.7	7.2	—	7.2	46.5	7.4	—	7.4	47.6
161	7.4	—	7.4	—	7.2	—	7.2	—	7.4	—	7.4	—
185	7.6	52.0	7.6	51.5	7.6	50.7	7.5	49.7	7.6	52.0	7.6	51.8
209	7.6	—	7.6	—	7.6	52.0	7.5	—	7.6	—	7.9	—
233	7.8	53.7	7.8	53.8	7.7	52.5	7.7	52.4	7.8	53.7	7.8	53.7
257	7.8	—	7.8	—	7.7	—	7.7	—	7.8	—	7.8	—
281	8.2	64.4	8.2	64.0	8.2	64.2	8.2	64.3	7.8	—	7.8	—
305	8.2	—	8.2	—	8.2	—	8.2	—	8.2	64.4	8.2	64.4
329	8.4	65.4	8.4	65.4	8.4	65.3	8.3	65.3	8.4	65.5	8.2	—
353	8.4	—	8.4	—	8.4	—	8.4	65.4	8.4	—	8.4	65.4
377	8.4	—	8.4	—	8.4	—	8.4	—	8.4	—	8.4	—
401	8.4	65.5	8.4	65.6	8.4	65.4	8.4	65.4	8.4	65.2	8.4	65.4

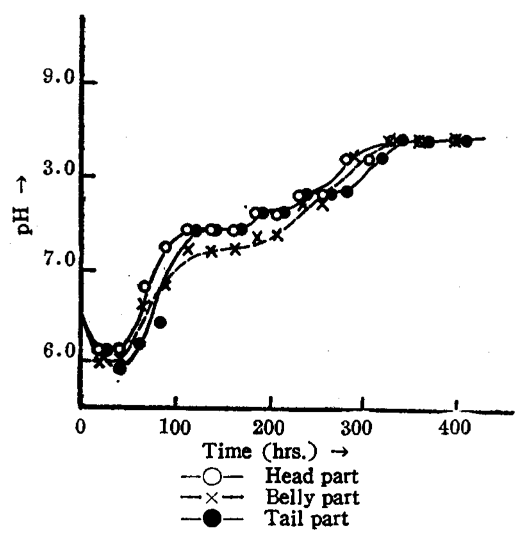


Fig. 12 Change of pH value in various parts of the stored herring body (16°±3°C)

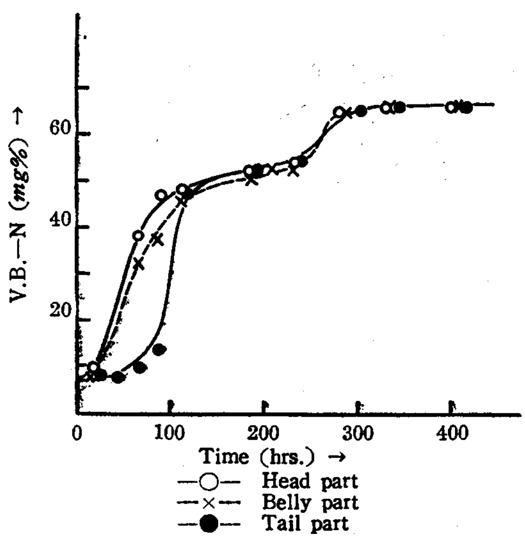


Fig. 13 Change of the amount of volatile basic nitrogen in various parts of the stored herring body (16°±3°C)

As seen in Fig. 12, the pH values of meat samples from various parts decreased once, and afterwards reached to about 6.0 in 24 ~ 48 hours; thereafter the pH values increased rapidly. After 100 hours' storing, the pH value became above 7.0. Afterwards the pH values gradually increased. To the initial increasing period of pH value, head, belly and tail parts reached slowly in order of time. There were remarkable differences of the pH value among the various parts of the meat, but after 100 hours' storing there was no difference.

The changes of the amount of V.B.-N shown in Fig. 13 indicate the relative relation with the change of pH value. The increasing of the amount of V.B.-N occurred late in order of head, belly and tail parts. From those results, the tail part meat is considered to be less decomposable than the head and belly parts meat. It is not yet known whether or not the difference of decomposable rate is due to the difference of chemical components. When the amount of V.B.-N reached 30 *mg%* in the meat at which point the incipient putrefaction begins, the pH value showed about 6.5. Those results agreed with the organoleptic results noted in the previous experiment.

3. Considerations

From the results obtained in this experiment, the pH value of the fresh herring meat was 6.8, and the amount of V.B.-N was about 7 *mg%*. When the raw herring meat is stored at various temperatures, with the lapse of time, the pH value decreased in the initial stage, and afterwards increased, while the amouns of V.B.-N increased. No difference of those changes showed between male and female fishes of herrings. Remrkable difference in those changes were observed between the places of the meat taken. The tail part meat of herring body was less decomposable than head and belly parts.

From these present experiments, the author could not determine the decomposability of herrings meat in comparison with other kinds of fish. But it has been said that herring meat is less decomposable. Prof. Tanikawa, is trying to verify the truth of that opinion by detailed experiments now, so he will report his results in future.

(The literature cited will be listed in continued paper of this series.)