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Technological and chemical characteristics of commercial fish in the Pacific Basin

by I. V. Kizevetter

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The Technological and Chemical Characteristics of Commercial Fish of the Pacific Basin.

By: I.V. Kizevetter; Doctor of Technical Sciences, Professor.

<u>Thunniformes.</u> *259

This suborder comprises a large number of species of the <u>Thunnidae</u> family which are valuable commercial fish.

If we generalize the results of investigations performed at TINRO, and data from foreign authors, the following description of individual tuna species can be given.

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* Numbers in the right-hand margin indicate the corresponding pages in the original.

Auxis (Auxis thazard) or King mackerel has a body length of 30-40 cm and weighs 800-2000 gm. Filleting gives /260
a high meat yield (62.3-66.7% of the body weight). The meat is tender and tasty.

Based on the data in the literature, the composition of the meat is (%): Moisture 71-74.7%, fat 4-6.2, protein 17.9-19.2 and ash 1.1-1.3.

M. Ionaze (1956) found Vitamin B_6 (470-570γ%) in the raw meat of Auxis. The liver contains 630-1600γ% Vitamin B_2 and the pyloric appendages contain 630-680γ% B_2 and 1-1.5γ% B_{12}.

Auxis is a valuable table fish.

Skipjack tuna or Katsuwo (Katsuwonus pelamis) has a body length of 40-100 cm (usually 50-70 cm); the weight is 900-25000 gm (usually 1500-5000 gm).

The studies of A. Myaksha, K. Mershina and V. Kushelevskii show clearly that skipjack tuna is a valuable meaty fish but that the weight ratios between the parts of the body (in % of the weight of the body) vary over a wide range: head 11-26.5 (including gills at 3.3); viscera 6.6-21.6 (including liver at 0.9-3.5); trunk 68.4-86 (including tail and fins at 1.5-2.5); spine and bones 8.1-11.1; meat with the skin 60.8-66.

The time of the beginning of rigor mortis and its duration in skipjack tuna depend on the temperature of the surrounding air, the size of the fish and the character of the ante-mortem agony. Thus, in a skipjack tuna of 5-6 kg at an air temperature of +11-15° C, rigor mortis sets in 70-75 min. after removal from the water and it is completed after 20 hours. However, at 20-23° C it sets in after 50-55 min. and it is completed after 14 hours.

The meat of skipjack tuna is dense, dark in colour, and rather dry. It has a slightly acidic taste.

Based on the analyses by G. Fil'e, K. Mershina and others, and based on the data in the literature, the chemical composition of skipjack tuna meat obtained in the February-August period varies in a wide range (%): moisture 64.8-75.4, fat 0.4-13.4, protein 18.3-26.3 and ash 0.9-2.8. According to the data in the literature (Kondo, 1936; Miyama, 1940; and others) a low moisture content (65.7-66.5%) and a low fat content (6.6-8.8%) are characteristic of skipjack tuna, while the protein content is very high (24.6-27.2%).

The meat of skipjack tuna contains 2.8-3.1 parts of water per part of protein (by weight). This makes the meat dry and crumbly. The meat has a non-uniform fat content, dependent on the season of fishing, on the weight of the fish, and on the distribution of the meat on the body.

Based on the results of our analyses, the average fat content in the meat of a 2.5-3 kg fish is 1.7% in February, 8.8% in August, 7.5% in September, and 2.9% in November.

The fat content is highest in the meat of the abdomen. Generally, the fat content increases with the increase of the weight of the fish. Thus, in February a fish of 3 kg has 0.4-0.8% fat in the meat of the back and 1-1.5% of fat in the meat of the abdomen. A larger fish (weight 8 kg) has correspondingly 1.6-2.3 and 2.9-4.3% fat.

Even greater differences in the fat content were found in the muscles of the skipjack tuna by Y. Miyama and K. Saruya (1938-1940). Based on their data, the amount of fat in the meat of the dorsal part varied in the range of 1.8-8.8% and in the abdomen 17.6-29.8%.

The fat of the skipjack tuna has a high iodine number value (189-209) and it is therefore very unstable toward oxidation. The fat has a d_4^{15} of 0.9293-0.9361, a η_d^{20} of 1.4820-1.4845 and a saponification number of 182-191.

Based on the data of T. Mori, S. Konosu (1957), S. Muroyama (1957), H. Higashi (1959) and other authors, and also based on the results of the analyses by M. Syromyatnikova and A. Teplitskaya, one can conclude that /261 the dark meat of the skipjack tuna as compared to the white meat contains far more vitamins of the B group and that the niacin content is far less (table 366).

A variety of water-soluble vitamins were found in the tissues of the pyloric appendages (γ% based on the raw material) by D. Kakimoto (1957): B_1 - 300, B_2 - 750-780, B_c - 50, B_{12} - 6.3-7.5, biotin - 16 and pantothenic acid - 740.

Таблица 366

Части тела	Пределы содержания (γ%) в сыром веществе				
	B_{12}	B_2	Вс	PP	B_1
Мясо светлое	2,5—7,5	40—300	300—450	9000—12 200	60
Мясо темное	16,5—23,5	930—2500	200—400	13 000—24 500	260
Печень	40—90	1300—2500	500—1300	10 000—25 000	—

Table 366.
1 - Parts of the body
2 - Range of the contents (γ%) in the raw material
3 - White meat
4 - Dark meat
5 - Liver

Bluefin or Eastern tuna (Thunnus thynnus) is the largest tuna, reaching a length of 300 cm (usually 150-180 cm) and a weight of 370 kg (usually 9-90 kg).

The relative weight of the body parts of bluefin tuna are not different from other tuna species. Filleting gives a high meat yield.

The relative weight of the body parts of the bluefin tuna varies in the following range (in % of the body weight): head 16.1-17.5 (including gills at 3.8-4.2), viscera 5.1-8.8 (including liver at 1), trunk 75.1 (including the skin at 4.6-5.4), tail and fins 1.4-1.6, spine and bones 7-9.3, meat 60.1-63.1.

According to the data in the literature (Mannan, Fraser, 1961; Dill, Vinogradov and others) and based on the results of the analyses by G. Fil'e, the chemical composition of eastern tuna varies in a rather wide range (%): moisture 65-75, fat 1-34.5, protein 15.4-26.3 and ash 1.1-2.7.

The hydration index of the proteins in the meat of the eastern tuna is somewhat higher than in the case of the meat of the skipjack tuna (3.3-3.8). This is the reason why the meat of the eastern tuna is more juicy.

As in the case of the skipjack tuna, the highest fat content in the eastern tuna is in the meat of the abdomen (table 367).

Таблица 367

(1) Состав мяса различных частей тушки восточного тунца

(2) Мясо	(3) Состав	(4) Пределы содержания, %	
		(5) по данным ТИНРО	(6) по данным литературы
(7) Спины	(8) Влага	71,0—72,5	65,0—74,0
	(9) Жир	2,6—3,6	1,0—10,0
	(10) Белок	22,1—22,5	23,7—26,5
(11) Хвостовой части	(8) Влага	68,5—70,5	—
	(9) Жир	1,1—2,9	—
	(10) Белок	25,3—25,7	—
(12) Брюшка	(8) Влага	67,1—69,5	46,8—47,1
	(9) Жир	6,4—14,8	20,0—34,5
	(10) Белок	15,4—21,0	18,0—18,6

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Table 367.
1 - The composition of the meat in various parts of the trunk of the eastern tuna
2 - Meat of
3 - Composition
4 - Range of contents, %
5 - Data of TINRO
6 - Data from the literature
7 - Back
8 - Moisture

9 - Fat
10 - Protein
11 - Tail part
12 - Abdomen

The physicochemical constants of the fat vary in the following ranges: d_4^{15} - 0.9240-0.9449, n_d^{20} - 1.4800-1.4837, saponification number 177.0-186.4, iodine number 164.2-194.6. The content of unsaponifiable matter is 1.4 to 1.9%. The fat contains 68 to 70% unsaturated fatty acids, including 30-32% highly unsaturated fatty acids (the iodine number of the fatty acids is 360-365). /262

The high percentage of highly unsaturated fatty acids in the fat makes it very unstable towards oxidation. This is noticeable in the preservation of frozen tuna.

Albacore (Germo alalunga). The length of the body is 50-130 cm (usually 80-100 cm), the weight is 3.5-45 kg (usually 5.5-15 kg).

Filleting of albacore yields 54-58% meat. This tuna has a small head (10.2-13.5%). However, the fins and the bones are massive (26.3-29.4%).

The chemical composition of albacore meat (Fil'e and Novozhilova) varies in the following ranges (%): moisture 55.8-64.3, fat 1.6-23, protein 17.5-25.5 and ash 0.9-2.6.

As in the case of the other species, albacore has the highest fat content in the abdomen (up to 23%). The fat content in the meat of the back and in the tail part does not exceed 10.7%. The meat of albacore is light in colour and palatable. The main value of this type of tuna is for the preparation of canned fish.

A. Teplitskaya and M. Syromyatnikova found high contents of the vitamins B_{12} and PP (γ%) in the dark meat of this tuna species (table 368).

Таблица 368

(1) Ткани	(2) Пределы содержания (γ%) в сыром веществе			
	B_{12}	B_2	Bc	PP
(3) Мясо светлое	2—3,5	200	300—500	900—1300
(4) Мясо темное	25—50	1500	200—350	11 500—15 000
(5) Печень	450—650	1500	1000—1300	13 000—25 000

Table 368.
1 - Tissues
2 - Range of the contents (γ%) in the raw material
3 - White meat
4 - Dark meat
5 - Liver

Yellowfin tuna (Neothunnus albacora) usually has a body length of 100-180 cm (up to 300 cm) and a weight of 20-45 kg (up to 200 kg).

Based on the data of V. Zhbanova, filleting of the yellowfin tuna yields the following body parts under industrial conditions (in % based on the weight of the fish): head 16.4-17.5, the pectoral girdle 1.9-2.3, the area between the first pair of fins and cuttings of gills 1.7-1.8, tail, fins, and cuttings 1.4-1.5, viscera 3.9-4.8 (including the milt and the roe at 0.7-0.9 and the liver at 0.4), scale and skin 0.9-1.1, bones and cartilages 8.4-9.2, dark meat 2.2-3.1, white meat 60-64% of the weight of the fish. Based on the data of A. Myaksha, the relative weights of the body parts of the yellowfin tuna are on the average: head and gills 20.2%, viscera 6.1% (including the liver at 1.1%), trunk 71.1% (including the skin at 1.5%), fins 1.1%, spine and bones 6.1% and meat 62.4% based on the weight of the body of the fish.

According to the analyses by A. Novozhilova and G. Fil'e, the meat of the yellowfin tuna has the following chemical composition: moisture 67.8-73.3%, fat 1.9-6%, protein 22.3-24.7% and ash 1.2-2.2%.

Data in the literature (Mannan, 1961; Sakaguchi, 1964 and others) show that the percentage of fat in the meat of this species of tuna varies in a wider range (0.9-12.9) and the amount of protein, 23.3-26.7.

In yellowfin tuna (Fil'e) the highest fat content /263 is found in the meat of the abdomen (6%) and the lowest amount is found in the back part (1.9-2.9%). The fat of this fish has a high iodine number (133-181) and it oxidizes readily.

M. Sakaguchi and co-workers (1964) found a high content of non-protein nitrogen (730-740 mg%) in the meat of the yellowfin tuna. A large amount of histidine (up to 880 mg% based on the weight of the raw meat) and creatine (556-560 mg%) was found in the composition of the non-protein extractives. Relative to the total amount of extractive nitrogen, the histidine nitrogen amounts to nearly 22% and the creatine nitrogen is 26%. The high content of non-protein nitrogen, histidine and creatine is a biochemical characteristic of the meat of all species of tuna.

The analyses of M. Syromyatnikova and A. Teplitskaya and the data in the literature (Kisaka, 1958) show that the meat and the tissues of the other body parts of yellowfin tuna contain a rich complex of water-soluble vitamins (table 369).

The fat of the yellowfin tuna has a high iodine number (133-181) and it is unstable to oxidation.

G. Dolbish found in the liver of the yellowfin tuna 3.1-4.7% fat and 450-510 IU of Vitamin A (1 gm of liver fat contains 8100-10320 IU of Vitamin A).

Таблица 369

(1) Части тела	(2) Пределы содержания (γ%) в сыром веществе					
	B_2	Bc	B_6	B_{12}	PP	(3) пантотеновая кислота
(4) Мясо светлое	100—700	100—200	610—1290	4—25	7000—13000	140—270
(5) Мясо темное	1500	240—600	—	60—140	—	—
(6) Внутренности без печени	500—700	—	—	30—50	4000—9000	—
(7) Печень	500—1700	1200	—	150—250	7000—25000	—

Table 369.
1 - Parts of the body
2 - Range of contents (γ%) in the raw material
3 - Pantothenic acid
4 - White meat
5 - Dark meat
6 - Viscera without liver
7 - Liver

Bigeye tuna (Parathunnus olesus) has a length of 70-200 cm (most commonly 80-120 cm) and a weight of 4-85 kg (usually 8-14 kg).

The data of V. Zhbanova show that filleting of bigeye tuna yields under industrial conditions 38.4-42.3% of waste byproducts (in %): head 18-20.2, pectoral girdle 1.6-2.1, the area between the first pair of fins and cuttings of gills 1.9-2.1, tail, fins, and cuttings 1.5-1.7, viscera 2.9-4.9 (including milt and roe at 0.7-1 and liver at 0.5), scale and skin 1.1-1.4, tails and cartilages 8.3-8.8, dark meat 2.9-3.6. The white meat yield ranges between 58% and 62% based on the weight of the fish body.

The chemical composition of the meat of bigeye tuna is as follows: moisture 68.4-71.4%, fat 0.9-8.4%, protein 21.6-24.3% and ash 1.6-1.8%.

The meat of bigeye tuna contains a large amount of histidine from which, in the posthumous period, histamine is formed due to the action of some species of Proteus (Kawabata, Ishigaka, 1956). The meat of the tuna becomes poisonous when the histamine content exceeds 110-120 mg%.

In bigeye tuna (Mori, 1957; Higashi, 1959 and other authors) the brown muscles contain considerably more vitamins of the B group than the light coloured muscles (table 370).

The fat of the bigeye tuna also has high iodine number values (172-196) and it is unstable to oxidation.

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Таблица 370

(1) Витамины	(2) Пределы содержания (γ%) в сыром веществе	
	(3) светлое мясо	(4) бурое мясо
B_1	50—60	250—260
B_2	60	260
PP	1430	730
B_{12}	0,5	6,2
(5) Холин	30—40	100—500

Table 370.
1 - Vitamins
2 - Range of contents (γ%) in the raw material
3 - White meat
4 - Dark meat
5 - Choline

The results of the investigations of individual species of tuna and the data available in the literature allow us to list a number of common technological characteristics.

The body of all species of tuna is covered with a dense skin with a layer of fatty cellular tissue underneath. All species of tuna are fleshy and they yield in filleting 60-65% meat relative to the weight of the fish. The meat obtained is differentiated in structure and colour into two groups: white and brown.

The brown meat is unevely distributed along the center line of the body: the heaviest layer of brown meat is located in the center of the body; it is thinner towards the head and the tail.

The ratio between the weight of white and brown meat depends on the tuna species. The yellowfin tuna has the least brown meat-5.8%-and the skipjack tuna has 10-13% brown meat relative to the weight of the total meat.

The white meat of individual species is distinguished by its consistency, colour and taste. The meat of albacore is the lightest in colour and it has the greatest palatability; the meat of skipjack tuna is darker in colour and is less tasty.

In all species of tuna, the highest fat content in the meat is in the abdomen. The tissue fat in tuna has high iodine numbers (133-209), causing instability of the fats to oxidation. The tissues of tuna contain active hydrolases which cause tissue fat hydrolysis in the posthumous period. For this reason, frozen tuna is unstable in preservation. Therefore, thorough glazing and preservation of frozen tuna at a temperature not in excess of - 25° C are compulsory technological requirements to secure a long term preservation.

The organoleptic properties of the meat of tuna make it a valuable base stock for the manufacture of canned foods of the type "meat in its own juice" as well as "blanched meat in oil". There is a general trend towards the manufacturing of canned tuna. The data of K. Mershina showed that canned tuna meat is characterized by a high protein content (table 371).

Таблица 371

(1) Наименование консервов	(2) Пределы содержания, %			
	(3) влага	(4) жир	(5) белок	(6) зола
(7) Бланшированное мясо, в масле (мясо со спины и хвостовой части)	57,0—62,5	8,5—12,7	21,9—29,9	1,2—2,4
(8) То же (мясо брюшной части)	41,6—48,5	11,9—21,7	27,6—36,6	1,5—2,8
(9) Копченое мясо, в масле	59,6—69,7	8,9—14,6	21,7—28,4	1,4—2,9
(10) Бланшированное мясо, в томатном соусе	68,9—73,3	2,1—3,0	18,5—21,9	1,9—2,4

Table 371.
1 - Description of canned food
2 - Range of contents
3 - Moisture
4 - Fat
5 - Protein
6 - Ash
7 - Blanched meat in oil (meat from the back and the tail part)
8 - Ditto (meat from the abdominal part)
9 - Smoked meat, in oil
10 - Blanched meat, in tomato sauce

Tuna is also used for freezing for subsequent culinary usage. /265

The meat of tuna is a valuable source of minerals.

According to the data in the literature (Dontcheff, 1938; Coulson, 1935; Kisaka, 1958; Nilson, 1939; and others) and based on the analyses by K. Mershina, A. Krasnitskaya, N. Khalina and E. Nasedkina, the following elements have been found (in mg%) in the minerals in the meat of tuna: iron 8-18, phosphorus 190-700, zinc 20-80, aluminum 1.2-1.5, manganese 90-110, copper up to 100, potassium 260-360, magnesium 90-110, calcium 10-40, cobalt 6-7, molybdenum 4-8 and iodine

30-115.

The brown meat which is separated in the preparation of canned food, is perfectly edible and it has a good taste in culinary products, resembling the taste of venison. However, it is not blended with the white meat in the preparation of canned food. Canned brown meat is of much lesser value in the world market.

The chemical composition of the inedible body parts of the investigated tuna species are described in table 372 based on the analyses by G. Fil'e, V. Rudakova, G. Dolbish and others.

Таблица 372

Химический состав несъедобных частей тела тунцов

(1) Части тела	(2) Пределы содержания, %			
	(3) влага	(4) жир	(5) белок	(6) зола
(7) Голова, жабры, плавники, хвост, позвоночник	59,3 / 76,3	1,6 / 12,6	14,3 / 21,0	4,6 / 15,9
(8) Кожа	54,0	22,5	—	—
(9) Желудок, кишечник	73,4 / 78,1	1,6 / 6,5	16,8 / 21,0	1,1 / 2,4
(10) Печень	71,4 / 72,6	5,5 / 35,6	—	—

~~Результаты исследований Г. Долбиш и Г. Филье показали, что печень тунцов содержит много витамина А (табл. 373).~~

Table 372.
The chemical composition of the inedible body parts of tuna.

1 - Body parts
2 - Range of contents, %
3 - Moisture
4 - Fat
5 - Protein
6 - Ash
7 - Head, gills, fins, tail, spine
8 - Skin
9 - Stomach, intestines
10 - Liver

The results of the investigations by G. Dolbish and G. Fil'e have shown that the liver of tuna contains a large amount of Vitamin A (table 373).

Таблица 373

Содержание витамина А

(1) Части тела	(2) Содержание жира, %	(3) Пределы содержания витамина А, и. е. на 1 г	
		(4) вещества	(5) тканевого жира
(6) Печень	2,1 / 35,6	300 / 10700	10320 / 197410
(7) Молоки	3,9 / 6,7	350 / 1000	7080 / 18200
(8) Кишечник и желудок	1,6 / 3,3	50 / 390	2600 / 16080

Table 373.
Vitamin A contents.
1 - Body parts
2 - Fat content, %
3 - Range of Vitamin A content in IU per 1 gm
4 - Tissue
5 - Tissue fat
6 - Liver
7 - Milt
8 - Intestines and stomach

The tissues of the inner organs of tuna, especially the liver, contain a rich complex of vitamins of the B group. The range of contents of individual water-soluble vitamins is (γ%): B_{12} - 6-250 (the maximum occurs in the liver), B_1 - 150-300 (the maximum is found in the heart), B_2 - 500-2500 (maximum in the liver), B_c - 500-1300 (maximum in the liver), pantothenic acid - 600-3960 (maximum in the liver and in the roe), PP - 7000-25000 (maximum in the liver).

Flatfishes (Pleuronectiformes). /266

The family of flounders (Pleuronectidae). Numerous species of flounder (over 30) are widely distributed in all the seas of the Northern Pacific. The flounder, a typical ground fish, migrates considerably during the annual cycle, either to the spawning site or in search of food. The spawning period of the various species of flounder is rather wide and depends on the species, the age of the flounder, the region of their habitat and the hydrological conditions. Spawning takes place at different times: from the end of the winter to the end of the summer. As a result of this extended span of the spawning period, both meager fish (which ceased feeding and started to spawn) and well-fed fish (which finished spawning and started to feed) are found simultaneously in the catch.

Among the multiform species of flounder, the following species were investigated (table 374).

Таблица 374

(1) Род	(2) Вид камбалы	(3) Русское название
Limanda	Limanda aspera	(4) Желтоперая камбала
	Limanda punctatissima	(5) Длиннорылая камбала
	Limanda herzensteini	(6) Желтополосая камбала
	Limanda yokohama	(7) Японская камбала
(8) Лиопсетты (Liopsetta)	Liopsetta pinnifasciata	(9) Полосатая камбала
	Liopsetta obscura	(10) Темная камбала
	Lipidopsetta bilineata	(11) Двухлинейная камбала
Pleuronectes	Pleuronectes quadrituberculatus	(12) Желтобрюхая, или четырехбугорчатая камбала
Cleisthenes	Cleisthenes herzensteini	(13) Остроголовая камбала
Glyptocephalus	Glyptocephalus stelleri	(14) Малоротая камбала
Hippoglossoides	Hippoglossoides elassodon	(15) Палтусовидная камбала
	Platichthys stellatus	(16) Звездчатая камбала
	Clidoderma asperimosa	(17) Бородавчатая камбала

Table 374.

1 - Genus
2 - Species of flounder
3 - Russian name
4 - Yellowfin sole
5 - Longsnout flounder
6 - Yellow-striped flounder
7 - Japan Sea flounder
8 - Liopsetta
9 - Banded flounder
10 - Black flounder
11 - Rock sole
12 - Alaska plaice
13 - Sohachi flounder
14 - Slime flounder
15 - Flathead sole
16 - Starry flounder
17 - Roughscale sole

The data of P. Moiseev, M. Krivobok, M. Demidova, M. Tychkova, E. Polutov, A. Fadeev, A. Medveditsyna and others show that the dimensions and the weight of various species of flounder in commercial fishing are characterized by great variability (table 375).

Таблица 375

Пределы изменения размеров и веса различных видов камбал

(1) Вид камбал	(2) Длина AB тела, см		(3) Вес рыбы, г	
	(4) пределы	(5) преобладают	(6) пределы	(7) преобладают
(8) Желтоперая	21,0—50,0	22—35	100—1300	250—720
(9) Длинперылая	19,8—40,0	24—28	90—500	150—320
(10) Желтополосая	27,1—51,2	28—32	240—1800	320—530
(11) Японская	22,0—44,6	28—32	150—690	200—380
(12) Двухлинейная	21,0—56,7	26—38	115—2350	320—810
(13) Желтобрюхая	25,0—75,0	28—40	160—3000	420—720
(14) Малоротая	30,0—50,0	—	150—650	270—450
(15) Палтусовидная	21,0—49,0	24—39	85—1350	260—620
(16) Звездчатая	60,0	—	2500	—
(17) Камбала Надежного	35,0	—	65—350	180—450
(18) Остроголовая	20,0—45,6	—	180—650	280—450

Table 375.
The range of differences in dimension and weight of various flounder species.

1 - Species of flounder
2 - Length AB body, cm
3 - Weight of fish, gm
4 - Range
5 - Predominant
6 - Range
7 - Predominant
8 - Yellowfin sole
9 - Longsnout flounder
10 - Yellow-striped flounder
11 - Japan Sea flounder
12 - Rock sole
13 - Alaska plaice
14 - Slime flounder
15 - Flathead sole
16 - Starry flounder
17 - Nadezhnyi flounder
18 - Sohachi flounder

These variances are due to the influence of numerous factors of a biological nature: the age distribution of the fish aggregates, differences in the rate of growth of one and the same species in various regions of /267 habitat, the ratio between males and females, etc.

In individual species of flounder there is an evident relationship between the weight and the length of the body. V. Tikhonov established this relation between the weight (P gm) and the total length (L cm) for yellowfin sole which dwells on the western coast of Kamchatka; for males: $P = 0.01016\ L^{3.0588}$ and for females $P = 0.007952\ L^{3.1503}$.

The specific gravity of the uncut flounder varies from 1.045 to 1.11 and for the decapitated flounder from 1.091 to 1.183.

The bulk density of the uncut flounder depends both on the compactness of packing of the fish and also on its size (table 376).

Таблица 376

Насыпной вес камбал

(1) Камбала	(2) Гравитационная загрузка	(3) Заполнение на вибраторе	(4) Штучная укладка
(5) Мелкая (80—150 г)	0,878—1,02	0,901—1,04	0,908—1,06
(6) Средняя (250—400 г)	0,825—0,915	—	0,890—0,910
(7) Крупная (более 500 г)	0,806—0,900	0,869—0,998	0,900—0,980

Table 376.
The bulk density of flounder.
1 - Flounder
2 - Charging by gravity
3 - Charging by vibrator
4 - Packing by the piece
5 - Small
6 - Medium
7 - Large

The fleshiness ratio in flounder increases with the increase of the dimensions of the fish. Therefore, the large specimens of flounder have a considerable technological value (table 377).

Таблица 377

Изменение коэффициента мясистости (г/см) в зависимости от длины тела камбал

(1) Вид	(2) Длина тела, см							
	18—20	24—26	30—32	34—36	38—40	46—48	50—52	54—56
(3) Двухлинейная камбала	5,7	6,6—8,2	10,1	14,3	18,3	25,0	29,0	30,0
(4) Желтоперая камбала	6,0	7,0—8,0	9,5—12,0	13,0—16,0	18,0—19,0	—	—	—
(5) Желтополосая камбала	4,8	8,8—8,9	10,0—12,0	12,0—15,0	17,0—19,0	—	—	—
(6) Палтусовидная камбала	—	6,0	9,0	14,0	17,0	—	—	—
(7) Остроголовая камбала	4,0	5,6	9,2	10,7	15,0	—	—	—

Table 377.
The change in the fleshiness ratio (gm/cm) in relation to the length of the flounder body.

1 - Species
2 - Length of the body, cm
3 - Rock sole
4 - Yellowfin sole
5 - Yellow-striped flounder
6 - Flathead sole
7 - Sohachi flounder

The abundant excretion of slime in the preservation of the fish must be considered as a technological feature of flounder: under industrial circumstances, the loss of weight during transportation or preservation of the raw material varies from 2.5 to 19.5%.

The amount of slime formed in the posthumous period depends on the species of flounder. Under similar conditions of preservation, the highest degree of slime excretion can be observed in flathead sole, slime flounder and Alaska plaice and the lowest excretion is observed in yellowfin sole, starry flounder, black flounder and yellow-striped flounder.

Regardless of the species composition of the raw material, the amount of excreted slime depends on the temperature of the fish body, the depth of the layer and the duration of preservation (table 378).

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Таблица 378

Потери веса при хранении камбал

(1) Температура тела рыбы	(2) Высота слоя рыбы, см	(3) Пределы потерь веса в %		
		(4) 2 часа	(5) 4 часа	(6) 8 часов
18—23°	60—65	2,7—3,8	—	5,1—19,6
	30—22	1,5—2,5	2,8—3,5	3,5—6,2
2— 6°	60—65	1,8—3,0	—	4,0—6,1
	20—22	0,8—1,0	1,8—2,4	2,3—3,4

Table 378.
Weight loss during preservation of flounder.
1 - Body temperature of the fish
2 - Depth of the layer, cm
3 - Range of weight loss in %
4 - 2 hours
5 - 4 hours
6 - 8 hours

When flounder is preserved in boxes, the increasing weight loss is reduced in long term storage (fig. 45).

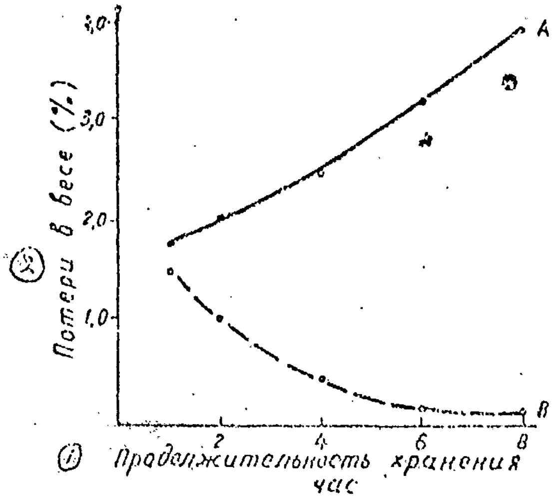

Рис. 45. Изменения потерь веса по периодам хранения камбал в ящиках (нетто 20—25 кг) без льда при температуре воздуха 18—20°. А — общие потери, В — потери веса за каждый час

Fig. 45.
The changes in weight loss during various periods of storage of flounder in boxes (net weight 20-25 kg) without ice at an air temperature of 18-20°.
A - total loss, B - weight loss per hour.
1 - Duration of storage, in hours
2 - Weight loss (%)

Numerous investigations have been carried out by P. Kantemirov, E. Kleie, V. Petrochenko and L. Konysheva concerning the determination of the weight interrelations of the body parts in various species of flounder obtained in different commercial regions (Peter The Great Bay, Tatar Strait, the west coast of Kamchatka, the Bering Sea, etc.). The results of these investigations show that all species of flounder have a small head and that the relative weight of the fins, the spine and the large bones is very substantial. The relative weight of the viscera was found to be very variable and this instability is related to the weight of the sexual glands (table 379).

The highest yield from trunks (64-75%) is obtained in slime flounder, yellow-striped flounder, Japan Sea flounder and rock sole. The following species give a somewhat lower yield (53-75%): the banded flounder, the black flounder, the sohachi flounder, and the yellowfin sole; next comes the flathead sole, the longsnout flounder and the starry flounder (50-73) and, finally, the Alaska plaice (44-70%). The highest relative weight of meat with skin is found for slime flounder (60-63%) and the lowest weight is obtained in Alaska plaice (32-55%).

It might be useful to point out that the relative weight of the fish trunk of the same species and sex, caught in the same region and in the same month of the year, decreases as the weight of the fish increases. For instance, in a flounder weighing 150-250 gm, the relative weight of the trunk is 61.1-64.6% of the body weight, while in a large mature fish of 410-760 gm, the relative weight of the trunk is 40.8-56.8%.

The weight interrelations between the parts of the body of the flounder change particularly drastically dependent on the stage of maturity of the sex gland. A good example of this is the female Alaska plaice, caught at the end of August in the Tatar strait (table 380).

The highest yield from a flounder trunk can be obtained right after spawning. Since the period of spawning for the various species of flounder is rather extended, we were not able to detect any regularity in the seasonal changes of the yield of trunks in the filleting of fish of commercial catches. The yield of trunks varied in January-February in the range of 59.6-68.1%, in April-May between 69.6 and 73.1%, in June-July between 54.4 and 73.2%, in August-September between 50.2 and 73% and November between 66 and 73.4%.

Text continues on page 27.

Таблица 379

Весовые соотношения частей тела

Вид камбалы	Период лова	Вес рыбы, г	В % к весу рыбы: голова	внутренности	в т. ч.: печень	в т. ч.: половые железы	плавники	тушки	позвоночник и кости	мясо с кожей
Род лиманд										
Желтоперая	Апрель—ноябрь	200 800	10,6 20,6	5,7 25,6	1,1 2,6	1,3 19,8	3,3 8,9	54,4 70,8	10,5 18,3	43,1 54,5
Длиннорылая	Январь—сентябрь	270 620	11,7 20,1	4,9 17,2	—	—	3,1 5,2	50,0 73,4	—	—
Желтополосая	Апрель—ноябрь	160 280	18,4 19,0	—	—	—	—	65,2 70,9	—	—
Японская	Апрель—сентябрь	170 390	13,2 19,7	10,8 28,7	—	6,3 19,8	3,3 4,6	65,0 71,1	—	59,2 59,8
Род лиопсетт										
Полосатая	Январь—ноябрь	80 685	11,7 23,9	6,2 30,4	1,6 2,6	1,5 25,4	3,1 6,0	53,5 75,5	9,6 12,3	45,6 60,1
Темная	Февраль—август	80 320	13,0 16,7	6,7 22,6	1,2 2,6	6,2 16,8	4,3 5,3	58,6 73,2	—	—
Двухлинейная	Май—август	300 1600	13,4 15,0	8,6 17,8	3,9	1,0 10,6	5,1 8,7	64,4 71,4	13,0 20,0	44,6 55,3
Разные виды										
Желтобрюхая	Июль—сентябрь	290 2300	10,8 24,1	11,4 56,2	0,7 13,4	0,7 32,8	4,3 13,8	42,1 69,7	10,4 12,9	31,8 55,4
Остроголовая	Май—ноябрь	260 520	11,9 20,3	7,8 17,3	—	5,1 8,3	3,8 4,7	58,6 69,6	—	—
Малоротая	Январь—август	560	9,7 10,6	4,8 13,2	—	5,8 8,7	4,0 4,3	67,8 75,4	7,2 9,6	60,3 61,8
Палтусовидная	Март—сентябрь	230 680	14,0 24,0	6,5 21,4	0,6 3,1	0,7 6,8	2,5 4,8	50,2 69,3	10,5 18,0	37,8 52,7
Звездчатая	Сентябрь	1570	16,6	21,3	4,3	10,0	10,0	56,1 65,4	14,6	36,6
Бородавчатая	Май	1020 1430	16,0	14,8	2,6	—	3,7	65,2	10,2	52,7

Table 379.

The weight relations between the parts of the body.

1 - Flounder species
2 - Fishing period
3 - Weight of the fish, gm
4 - In % of the weight of the fish
5 - Head
6 - Viscera
7 - Including
8 - Liver
9 - Sex glands
10 - Fins
11 - Trunks
12 - Spine and bones
13 - Meat with skin
14 - Genus Limanda
15 - Yellowfin sole
16 - Longsnout flounder
17 - Yellow-striped flounder
18 - Japan Sea flounder
19 - Genus Liopsetta
20 - Banded flounder
21 - Black flounder
22 - Rock sole
23 - Various species
24 - Alaska plaice
25 - Sohachi flounder
26 - Slime flounder
27 - Flathead sole
28 - Starry flounder
29 - Roughscale sole
30 - April-November
31 - January-September
32 - April-November
33 - April-September
34 - January-November
35 - February-August
36 - May-August
37 - July-September
38 - May-November
39 - January-August
40 - March-September
41 - September
42 - May

Таблица 380

① Вес рыбы, г	② Стадия зрелости половых желез	③ В % к весу тела самок	
		④ ястыков	⑤ тушек
150—280	I—II	0,7	61,1
380—470	II—III	1,8	64,1
580—930	IV—V	25,6	40,8
1080—1650	IV—V	32,7	28,5

Table 380.
1 - Weight of the fish, gm
2 - Stage of maturity of the sexual glands
3 - In % of the female body weight
4 - Ovaries plus their membranes
5 - Trunks

Depending on the species and on the biological condition of the flounder, the relative weight of the meat with skin varies in the range of 32-36% for the Alaska plaice and for the starry flounder and it reaches up to 63% in the case of the slime flounder. The weight of the skin varies in a range of 4.7-14.2% relative to the weight of the fish, depending on the character of the integument and on the precision with which the skin is separated from the meat cuts. The yellowfin sole and the sohachi flounder have the most "light-weight" skin and the starry flounder has the most "heavy" skin (related to the thickness of the skin and the presence of many mineralized excrescenses).

In the slicing of fillet of flounder meat, the yield of pure meat under industrial conditions amounts to 30.7-40.1% and the yield of meat crumbles amounts to 2.1-3.6%, both relative to the weight of the fish.

To ease the removal of the skin, the trunk is scalded (30-45 sec.) in boiling water, and in that case the meat yield does not exceed 34-36%.

Thus, the flounder should be placed in the category of fish from which a small yield of pure meat is obtained in filleting.

V. Adistanova, A. Burii, N. Gavrilenko, V. Gotovets, L. Konysheva, E. Kleie, E. Lagovskaya, K. Mershina, N. Nikonova, N. Novozhilova, O. Omel'yanenko, V. Petrochenko, V. Rudakova, N. Skorobogatova and others performed analyses of numerous samples of meat of the various species of flounder obtained in different regions and at different periods of time. The summary of the results of these investigations (table 381) shows that the chemical composition of the meat of the various species of flounder is changing constantly and that this is due equally to the variability of the moisture content (65-87.1%), the fat content (0.2-12.3%) and the protein content (12.5-21.5%).

The highest moisture content (up to 84%) was found in the meat of the Alaska plaice, the flathead sole, the rock sole and the yellowfin sole. The meat of the starry flounder, the Japan Sea flounder and the black flounder have the least variable moisture content (75-80%).

Apparently, there is an inverse relation between the moisture content and the fat content in the meat of the various species of flounder. Thus, the meat with 84-77% of moisture contains 0.3-5.4% fat, with a moisture content of 76.9-71% the fat content is 1.4-7.1% and with a moisture content of 70.9-65% the fat content is 4.4-12.3%. However, this general trend does not always apply to the individual species.

The largest amount of fat has been found in the meat of the sohachi flounder (9.9%) and in the meat of the slime flounder (up to 7%). The fat content in the meat of the sohachi flounder fluctuates from 0.8 to 9.9% and it ranges between 3.3 and 7% in the case of the slime flounder. Among Limanda the highest average fat content in the meat is found for the yellowfin sole (on the average 3.2%), followed by the Japan Sea flounder (1.9%), the yellow-striped flounder (1.2%) and the longsnout flounder (0.7%). Among Liopsetta, the black flounder has an increased fat content. Based on the range of the fat content in the meat, the majority of the flounder species can be classified as medium-fat or low-fat fish.

Таблица 381

Химический состав мяса различных видов камбал

(1) Вид камбал	(2) Период лова	(3) Вес рыбы, г	(4) Пределы содержания, %			
			(5) влага	(6) жир	(7) белок	(8) зола
(9) Род лиманд						
(10) Желтоперая	(26) Январь — ноябрь	150 / 805	72,9 / 83,7	1,0 / 5,0	11,6 / 19,6	1,0 / 3,3
(11) Длиннорылая	(27) Июль — ноябрь	170 / 350	77,5 / 80,9	0,7 / 2,3	16,5 / 18,2	1,7 / 2,4
(12) Желтополосая	(28) Январь — ноябрь	160 / 260	76,4 / 80,4	0,6 / 3,0	16,6 / 19,1	0,6 / 2,5
(13) Японская	(29) Апрель — октябрь	170 / 550	75,5 / 79,0	0,6 / 4,4	15,2 / 19,7	0,6 / 2,7
(14) Род лиопсетт						
(15) Полосатая	(30) Февраль — октябрь	80 / 680	74,6 / 80,6	0,3 / 3,5	16,4 / 19,3	1,1 / 3,2
(16) Темная	(31) Февраль — август	80 / 320	75,0 / 78,9	1,2 / 4,2	17,3 / 19,6	1,4 / 2,7
(17) Двухлинейная	(32) Февраль — август	165 / 1600	72,7 / 84,2	0,2 / 3,5	13,1 / 18,2	0,9 / 1,7
(18) Разные виды						
(19) Желтобрюхая	(33) Февраль — сентябрь	370 / 2300	77,7 / 84,1	0,2 / 5,6	13,0 / 18,1	1,3 / 2,8
(20) Остроголовая	(34) Май — сентябрь	280 / 520	74,4 / 82,3	0,8 / 9,9	14,7 / 18,1	1,4 / 2,9
(21) Малоротая	(35) Январь — август	300 / 560	73,2 / 80,3	3,3 / 7,0	15,8 / 17,3	1,3 / 1,8
(22) Палтусовидная	(36) Январь — сентябрь	110 / 830	77,7 / 84,2	0,8 / 3,6	13,3 / 18,9	1,0 / 2,7
(23) Звездчатая	(37) Май — сентябрь	480 / 1500	76,6 / 79,5	2,7 / 3,1	13,1 / 14,8	1,2 / 1,7
(24) Камбала Надежного	(38) Май — июль	270 / 940	77,8 / 82,7	1,8 / 4,6	12,5 / 20,6	1,0 / 2,4
(25) Бородавчатая	(39) Май	1020 / 1430	65,0	12,3	21,5	1,2

Table 381.
The chemical composition of the meat for various species of flounder.

1 - Species of flounder
2 - Period of fishing
3 - Weight of the fish, gm
4 - Range of contents, %
5 - Moisture
6 - Fat
7 - Protein

8 - Ash
9 - Genus Limanda
10 - Yellowfin sole
11 - Longsnout flounder
12 - Yellow-striped flounder
13 - Japan Sea flounder
14 - Genus Liopsetta
15 - Banded flounder
16 - Black flounder
17 - Rock sole
18 - Various species
19 - Alaska plaice
20 - Sohachi flounder
21 - Slime flounder
22 - Flathead flounder
23 - Starry flounder
24 - Nadezhnyi flounder
25 - Roughscale sole
26 - January-November
27 - July-November
28 - January-November
29 - April-October
30 - February-October
31 - February-August
32 - February-August
33 - February-September
34 - May-September
35 - January-August
36 - January-September
37 - May-September
38 - May-July
39 - May

For the majority of flounder species, an increased percentage of fat in the meat can be observed in the summer-fall period. However, the increased amount of fat in the meat occurred in the first half of the year in the case of the flathead flounder and the slime flounder. These changes in the fat content are related to the periods of spawning and foraging: in the pre-spawning period (winter) and in the post-spawning period (spring) the fat contents reach their minimum and the accumulation of fat in the meat is the highest for all species of flounder in the period of foraging. Due to the fact that the spawning period is very prolonged for the various species and for the various age groups of the mature flounder, it is very difficult to establish when the best condition prevails for the flounder catch or when it is most emaciated.

No relation at all could be observed between the fat content in the meat and the weight of a certain species of flounder and in many cases small specimens of actively feeding immature fish have a fatter meat than the large fish after spawning.

For example, the immature yellowfin sole (weight /272 200-300 gm) has a fat content in the meat varying in the range of 1.7-5% whereas for a mature fish (weight 700-800 gm) in the spawning period the fat content is 2.8-3.5%. On the other hand the fat content in the meat is the same (0.8-1.3%) in a flathead sole of 200-300 gm and one of 600-700 gm.

Apparently, the age factor, which has a distinct affect on the fat content in the meat of numerous species of fish, is not of crucial importance in the case of the flounder.

The deposits of fat in the organism of the fully "conditioned" flounder (Wilson, 1939) are concentrated at the base of the fins and around the bones and the spine. When the spawning time approaches, the fat reserve decreases and these fat deposits become hardly noticeable immediately after the flounder has spawned (fig. 46).

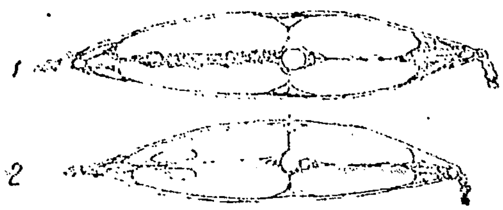

Рис. 46. Расположение отложений жира в теле камбалы в период нагула (1) и после нереста (2) (по Д. Вильсону)

Fig. 46.
The distribution of the fat deposits in the body of the flounder in the period of foraging (1) and after spawning (2) after D. Wilson.

Based on the results of our analyses we conclude that the fattest meat is found in the flounder in the head area and that the least amount of fat is found in the tail area.

The amount of proteins in the meat of the different flounder species varies in the range of 11.6-21.5%. However, the widest range of protein content variation (11.6 to 20.6%) is found in the yellowfin sole and in the Nadezhnyi flounder (translator's note: name transliterated). The most stable and also high (17.3-19.6%) protein content is found in the meat of the black flounder and the least content (13.2-14.8%) is found in the meat of the starry flounder.

It is a characteristic that the hydration index of the meat proteins fluctuates widely due to the instability of the moisture content and the protein content in the individual species. All the species investigated by us can be listed in an ascending order (table 382).

Таблица 382

(1) Вид камбалы	(2) Степень гидратации белков мяса		
	(3) от	(4) до	(5) среднее
(6) Темная	3,9	4,6	4,2
(7) Полосатая	3,9	4,6	4,3
(8) Японская	3,6	4,8	4,4
(9) Длиннорылая (10) и желтополосая	4,0	5,0	4,5
(11) Остроголовая (12) и желтоперая	4,2	5,3	4,7
(13) Двухлинейная	4,6	5,8	4,8
(14) Палтусовидная, (15) Надежного, (16) малоротая	4,1	6,2	5,0
(17) Желтобрюхая, (18) звездчатая	4,8	6,5	5,3

Table 382.
1 - Flounder species
2 - Degree of hydration of the meat proteins
3 - From
4 - To
5 - Average
6 - Black flounder
7 - Banded flounder
8 - Japan Sea flounder
9 - Longsnout flounder
10 - and yellow-striped flounder
11 - Sohachi flounder
12 - and yellowfin sole
13 - Rock sole
14 - Flathead sole
15 - Nadezhnyi flounder
16 - Slime flounder
17 - Alaska plaice
18 - Starry flounder

The data in the literature (Jarvis, 1926; Nilson, 1939; Coulson, 1939 and others) and the results of the analyses by K. Mershina, N. Krasnitskaya, N. Khalina and others show that the following macro- and micro-elements form part of the composition of the minerals in flounder meat (in mg%): calcium 90-240, phosphorous 140-280, iron 0.4-5, magnesium 6-26, potassium 190-270 (γ%), iodine 40-70, cobalt 0.4-0.5, zinc 16-40, molybdenum 0.2-0.24, manganese 40-50.

There is a noticeable difference in the organoleptic properties of the meat of specific species of flounder. /273
A good taste, a tender consistency and a white colour are characteristic of the yellowfin sole, the black flounder, the yellow-striped flounder and the Japan Sea flounder. The meat of the longsnout flounder, the rock sole and the starry flounder has a satisfactory palatibility. The latter species features the presence of hard scutes on the skin. These are resistant to heat and they should be removed in the preparation of canned food. The meat of the flathead sole, the Alaska plaice, the banded flounder, the slime flounder and the Nadezhny flounder is flabby and watery and is not very palatable. The meat of the sohachi flounder has a specific unpleasant "oozy" taste.

The palatability of the meat of the specific species of flounder appears to be related to the specificity of the composition of the nitrous extractives. For instance, in the meat of the flathead sole, which has a poor palatability, M. Sakaguchi and M. Hujita (1964) found a relatively high content of extractive non-protein nitrogen (up to 290 mg%).

As compared to the meat of other sea fish, the content of creatine (150-170 mg%) and creatinine (50-58 mg%) in flat-head sole is lower and the trimethyl-amino oxide content is rather high (150-160 mg%). However, in the meat of the soha-chi flounder, which has unpleasant organoleptic properties, V. Rudakova found 780 mg% of extractive nitrogen (including 75-90 mg% of volatile basic compounds).

The meat of the flounder is rather rich in free amino acids (150-170 mg%), mainly in the form of replaceable amino acids (90-100 mg%). The composition of the irre-placeable amino acids shows very little histidine (9-10 mg%) and methionine (up to 1 mg%0). However, the amount of ly-sine is large 30-35 mg%) and there is a fair amount of threonine. The replaceable amino acids contain a large amount of taurine (60-65 mg%), aspartic acid (15-16 mg%) and glycine (7 mg%).

The palatability and the whiteness of flounder meat are directly related to the basic volatile nitrogen compounds (ALO) and the methylamine content. For instance, if the ALO content in the meat is not more than 30-35 mg%, then it has an entirely white colour and there is no un-pleasant taste at all. However, if the basic volatile ni-trogen compound content in the meat is in excess of 50 mg%, then it becomes cream-coloured and it has a distinct and unpleasant taste.

The rate of accumulation of basic volatile nitrogen compounds in the meat of the flounder is directly related to the temperature. For instance, when the meat is preserved at 0° C one finds after four days a basic volatile nitrogen compound content of 45-30%. This is in the same range as what is found at a preservation temperature of 10-12° C after two days and at 16-20° C after 24-36 hours. When flounder is preserved in cold sea water (minus 1-1.8° C), then a content of 45-50 mg% of basic volatile nitrogen compounds appears after six or eight days. However, the meat of the fish begins to swell already after four days (the weight increases by 8-10%).

To obtain white and tasty meat in canned foods and in culinary products, the processing of flounder should be performed in the stage of rigor mortis. The subsidence of rigor mortis and the transition to autolysis is accompanied by a decline in the organoleptic properties of the meat. The fish should therefore be cooled after it is lifted from the water so that the rigor mortis stage of the flounder is prolonged.

The inedible body parts of all the species of flounder investigated by us have a rather monotonous chemical composition (table 383).

Only the liver tissues of the flounder show a rather substantial accumulation of fat (up to 26%). The highest fat content in the inedible part of the flounder body is found during the foraging period.

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Таблица 383

Химический состав частей тела камбал

(1) Части тела	(2) Пределы содержания, %			
	(3) влага	(4) жир	(5) белковые вещества	(6) зола
(7) Голова	74,9 / 85,5	1,3 / 6,7	8,6 / 14,1	3,2 / 8,2
(8) Плавники и хвост	65,3 / 75,2	0,8 / 5,8	12,7 / 20,8	9,8 / 12,9
(9) Позвоночник и крупные кости	61,5 / 73,8	4,1 / 9,7	14,0 / 20,4	8,2 / 10,9
(10) Внутренности (без печени и половых желез)	71,2 / 85,1	0,7 / 8,4	11,8 / 20,0	1,3 / 2,7
(11) Печень	74,0 / 81,1	2,0 / 26,4	10,4 / 16,6	1,3 / 1,9
(12) Икра	76,3 / 79,6	0,5 / 1,2	15,7 / 18,3	1,6 / 2,1
(13) Кожа	70,0 / 73,7	1,7 / 8,3	19,6 / 23,3	1,9 / 3,8

Table 383.
The chemical composition of the body parts of the flounder.
1 - Parts of the body
2 - Range of contents, %
3 - Moisture
4 - Fat
5 - Proteins
6 - Ash
7 - Head
8 - Fins and tail
9 - Spine and large bones
10 - Viscera (without liver and without sexual glands)
11 - Liver
12 - Roe
13 - Skin

The phosphorus content of the inedible parts of the body varies in the various species of flounder in the following range (% of the raw meat weight): head 1-1.3, bones and fins 1.3-1.8, viscera 0.9-1.3, roe 1-1.3.

E. Lagovskaya and G. Dolbish investigated numerous specimens of flounder liver. Their analyses show that the content of fat and of Vitamin A in the liver is very unstable (table 384).

All species of flounder are characterized by a distinct increase of the fat content in the liver from the beginning of the year to the summer and the fall (20-30%). However, the amount of Vitamin A in the liver fat reaches its maximum values in the period when the fat content of the liver is at its minimum. The highest Vitamin A content (27000-61000 IU) was found in the liver fat of starry flounder and of yellowfin sole, and the lowest Vitamin A content (up to 1370-2220 IU per 1 gm of fat) was found in the liver of the Japan Sea flounder and the black flounder.

The ability to accumulate Vitamin A in the liver increases with the age of the fish and also with the higher geographical latitude of the habitat of a given species. It has been established that cold-loving species of flounder accumulate considerably more Vitamin A in their organism than the warmth-loving species.

The tissues of the stomach and of the intestines of the flounder show a noticeably lesser degree of fat accumulation than in the liver, even in the summertime. However, in individual species the concentration of Vitamin A in the tissue fat reaches high values (table 385). Thus, the liver of the flounder is undoubtedly of considerable interest as a raw material for Vitamin A and this also applies, but to a lesser degree, to the tissues of the stomach and the intestines.

The data in the literature and the results of the analyses performed by us show that the fat obtained from the liver of the flounder has a dark colour and the following values for the physico-chemical constants: d^{15}_{4} - 0.9178-0.9280, saponification number 179.0-198.6, iodine number 118-131, and a rather large content of unsaponifiables (7.0-12.6%).

Таблица 384

Пределы содержания жира и витамина А в печени камбал

Вид камбал	Район лова	Период лова	Вес рыбы, г	% к весу рыбы	Содержание жира	Содержание витамина А в *и. е.*	
						в 1 г тканей	тканевого жира
Желтоперая	Зал. Петра Великого, Южный Сахалин, восточное побережье Камчатки, Берингово море	Май—сентябрь	130 / 1160	1,3 / 3,0	2,3 / 27,0	10 / 510	110 / 57400
Длиннорылая	Зал. Петра Великого	Май—декабрь	80 / 250	1,3 / 2,8	4,8 / 7,4	50 / 630	790 / 10920
Желтополосая	Зал. Петра Великого, Южно-Курильские о-ва	Март—ноябрь	110 / 590	1,1 / 4,4	4,7 / 26,4	10 / 340	120 / 2240
Японская	Зал. Петра Великого, Южный Сахалин	Июль—ноябрь	100 / 840	1,5 / 4,3	5,2 / 21,2	30 / 170	100 / 1370
Темная	Зал. Петра Великого	Февраль—август	110 / 520	0,9 / 2,3	1,5 / 29,4	10 / 7730	90 / 61000
Двухлинейная	Берингово море, Южный Сахалин	Август—сентябрь	340 / 1600	1,2 / 2,8	7,7 / 18,9	90 / 250	810 / 3460
Полосатая	Зал. Петра Великого	Февраль—октябрь	100 / 710	1,5 / 2,8	3,6 / 16,1	10 / 480	70 / 9250
Палтусовидная	Южный Сахалин, Камчатка	Июль—сентябрь	—	1,5 / 2,3	2,3 / 21,8	20 / 570	100 / 9200
Звездчатая	Берингово море, Камчатка, Сахалин	Июль—сентябрь	250 / 1500	2,1 / 4,3	5,5 / 29,2	30 / 2400	210 / 61000
Желтобрюхая	Сахалин, Камчатка	Сентябрь—ноябрь	860 / 3070	2,4 / 5,4	7,6 / 11,8	40 / 180	620 / 1840
Остроголовая	Приморье, Сахалин	Май—декабрь	100 / 510	1,2 / 2,3	5,0 / 20,7	50 / 390	670 / 6300
Малоротая	Приморье, Сахалин	Июль—декабрь	130 / 1320	0,7 / 2,7	6,1 / 30,7	20 / 2660	120 / 21610

Table 384.
The range of the fat and Vitamin A content in the liver of the flounder.

1 - Flounder species
2 - Region of fishing
3 - Period of fishing
4 - Weight of fish, gm
5 - % of the fish weight

6 - Fat content
7 - Vitamin A content in IU
8 - In 1 gm of tissue
9 - Tissue fat
10 - Yellowfin sole
11 - Longsnout flounder
12 - Yellow-striped flounder
13 - Japan Sea flounder
14 - Black flounder
15 - Rock sole
16 - Banded flounder
17 - Flathead sole
18 - Starry flounder
19 - Alaska plaice
20 - Sohachi flounder
21 - Slime flounder
22 - Peter The Great Bay, Southern Sakhalin, east coast of Kamchatka, Bering Sea
23 - Peter The Great Bay
24 - Peter The Great Bay, Southern Kuril islands
25 - Peter The Great Bay, Souther Sakhalin
26 - Peter The Great Bay
27 - Bering Sea, Southern Sakhalin
28 - Peter The Great Bay
29 - Southern Sakhalin, Kamchatka
30 - Bering Sea, Kamchatka, Sakhalin
31 - Sakhalin, Kamchatka
32 - Primor'e, Sakhalin
33 - Primor'e, Sakhalin
34 - May-September
35 - May-December
36 - March-November
37 - July-November
38 - February-August
39 - August-September
40 - February-October
41 - July-September
42 - July-September
43 - September-November
44 - May-December
45 - July-December

The results of the analyses by M. Syromyatnikova and A. Teplitskaya and the data in the literature (Sautier, 1946; Higashi, Murayama, Ionaze, 1959 and others), show that the tissues of the inedible parts of the body of various species of flounder contain noticeably more water-soluble vitamins than the meat (table 386).

The highest Vitamin B_{12} content has been found in the liver of the black flounder (Liopsetta obscura)(300-490 γ%) and of Limanda aspera (248γ%).

Therefore, the waste obtained in filleting has considerable value as a raw material for the manufacture of feed products.

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Таблица 385

Пределы содержания жира и витамина А в тканях желудка и кишечника

Вид камбал	Район лова	Период лова	Вес рыбы, г	% к весу рыбы	Содержание жира, %	Содержание витамина А в 1 г: тканей	Содержание витамина А в 1 г: тканевого жира
Желтоперая	Зал. Петра Великого, Камчатка, Берингово море	Июль—август	380/1160	4,1/5,9	1,3/4,8	30/1530	1190/119400
Темная	Зал. Петра Великого	Февраль—август	180/520	2,4/7,2	1,6/3,5	следы/120	следы/3530
Полосатая	Зал. Петра Великого	Февраль—август	140/460	2,0/5,5	1,3/2,0	следы/70	следы/5500
Остроголовая	Зал. Петра Великого	Июль—август	200/510	3,3/15,0	0,8/2,1	10/50	1880/2600
Малоротая	Зал. Петра Великого	Июль—август	130/1320	1,1/3,2	1,3/2,1	следы/80	следы/5500
Двухлинейная	Берингово море	Август	1600	4,2	3,0	615	20870
Желтобрюхая	»	Сентябрь	1510/2300	3,3/3,8	2,0/2,5	50/85	5000/7890

Table 385.
The range of the fat and Vitamin A content in the stomach and intestinal tissues.

1 - Species of flounder
2 - Region of fishing

3 - Period of fishing
4 - Weight of the fish in gm
5 - % of the fish weight
6 - Fat content, %
7 - Vitamin A content in 1 gm
8 - Tissues
9 - Tissue fat
10 - Yellowfin sole
11 - Black flounder
12 - Banded flounder
13 - Sohachi flounder
14 - Slime flounder
15 - Rock sole
16 - Alaska plaice
17 - Peter The Great Bay, Kamchatka, Bering Sea
18 - Peter The Great Bay
19 - Peter The Great Bay
20 - Peter The Great Bay
21 - Peter The Great Bay
22 - Bering Sea
23 - July-August
24 - February-August
25 - February-August
26 - July-August
27 - July-August
28 - August
29 - September
30 - Traces

Таблица 386

Содержание витаминов группы В

(1) Витамин	(2) Пределы содержания (γ%) в сыром веществе				
	(3) мясо	(4) печень	(5) кишечник, желудок	(6) голова, позвоночник, плавники	(7) половые железы
B_1	40—65	120—140	400	—	—
B_2	100—500	200—3000	700	—	—
Bc	3—200	200—700	—	—	—
PP	1200—3000	2000—8000	—	—	—
B_{12}	1,3—8	5—490	1,5—4,8	0—0,6	1,5—7,5
(8) Пантотеновая кислота	1000—1700	370—420	—	—	—

Table 386.
The Vitamin B group content.
1 - Vitamin
2 - Range of content (γ%) in the raw material
3 - Meat
4 - Liver

5 - Intestines, stomach
6 - Head, spine, fins
7 - Sexual glands
8 - Pantothenic acid

The characteristics of the chemical composition of the food and feed products prepared from the Far East flounder is illustrated in table 387, based on the analyses by E. Kaletina, L. Khorynskaya, L. Vakulyuk, L. Ertel, and others.

The canned flounder of the type "fish in its own juice", prepared from raw fish in tomato juice or in oil and salted flounder have an unsatisfactory palatibility.

The following elements are present in the minerals contained in feeding meal obtained from the waste products of flounder (%): calcium (1.3-4.3), magnesium (0.24-0.42), phosphorus (2.5-4.2) and, as microelements (mg%): manganese (0.17-3.4), iron 8.8-132.8), copper (0.36-1.10), iodine (0.02-0.09).

Halibut. Four species of halibut are widely distributed in the northern part of the Pacific. The (true) halibut (Hippoglossus spp.) is the largest among them (table 388).

Таблица 387

(1) Наименование	(2) Пределы содержания, %			
	(3) влага	(4) жир	(5) белок	(6) зола
(7) Консервы				
(8) «Камбала обжаренная, в томатном соусе»	51,3 / 61,2	16,3 / 20,1	17,3 / 21,1	2,4 / 4,6
(9) «Камбала обжаренная, в белом соусе»	60,4 / 64,8	8,9 / 13,7	11,4 / 15,9	2,4 / 3,2
(10) «Камбала обжаренная, в масле»	45,4 / 49,7	25,8 / 31,4	17,3 / 19,9	2,6 / 3,8
(11) «Копченая камбала, в масле»	44,3 / 50,6	23,0 / 28,0	19,1 / 24,3	1,3 / 3,2
(12) «Камбала в собственном соку»	72,0 / 77,1	1,9 / 4,6	13,9 / 16,9	1,9 / 4,8
(13) «Фрикадели, в томатном соусе»	65,6 / 67,8	3,3 / 4,7	23,8 / 27,7	3,0 / 3,8
(14) «Котлеты, в томатном соусе»	62,3 / 67,2	6,3 / 8,5	20,0 / 26,2	3,2 / 3,5
(15) Фарш из вареного мяса, с маслом	57,6	13,2	24,0	5,1
(16) Мясо крепкосоленых камбал	51,3 / 60,7	2,3 / 5,4	20,8 / 26,0	15,0 / 19,9
(17) Соленая икра	57,9	1,7	25,7	12,6
(18) Пищевая мука из вареного мяса	2,9—9,7	7,6—16,5	74,4—81,0	5,7—10,8
(19) Кормовая мука из отходов, получаемых при разделке камбал для изготовления консервов	6,7 / 9,8	6,3 / 10,2	50,9 / 65,6	15,5 / 27,6
(20) Кормовая мука из мелкой неразделанной рыбы	4,4 / 11,2	5,8 / 10,8	61,7 / 68,8	16,2 / 11,6

Table 387.

1 - Name
2 - Range of contents in %
3 - Moisture
4 - Fat
5 - Protein
6 - Ash
7 - Canned food
8 - "Seared flounder in tomato sauce"
9 - "Seared flounder in white sauce"
10 - "Seared flounder in oil"
11 - "Smoked flounder in oil"
12 - "Flounder in its own juice"
13 - "Fricassee, in tomato sauce"
14 - "Cutlets in tomato sauce"
15 - Stuffing from cooked meat with oil
16 - Meat of strongly salted flounder
17 - Salted roe

18 - Feeding meal from cooked meat
19 - Feeding meal from waste, obtained from flounder filleting in the manufacture of canned food
20 - Feeding meal from small nonfilleted fish

Таблица 388

(1) Русское название	(2) Латинское название	(3) Длина тела, см		(4) Вес рыбы, кг	
		(5) обычно	(6) наибольший	(7) обычно	(8) наибольший
(9) Белокорый	Hippoglossus hippoglossus stenolepis	70—90	200	5—9	100,0
(10) Черный, или синекорый	Reinhardtius hippoglossoides mathsurae	50—70	100	1,0—3,5	14,0
(11) Стрелозубый американский	Atheresthes stomias	40—60	86	0,8—2,5	7,5
(12) Стрелозубый азиатский	Atheresthes evermanni	35—55	90	0,9—2,0	6,0

Table 388.
1 - Russian name
2 - Latin name
3 - Length of the body, cm
4 - Weight of the fish, kg
5 - Usually
6 - Maximum
7 - Usually
8 - Maximum
9 - (True) halibut
10 - Greenland halibut
11 - Arrow-toothed halibut, American
12 - Arrow-toothed halibut, Asiatic

The average dimensions and the weight of halibut in industrial catches vary considerably depending on the region, the period of fishing and also on the method of fishing. If halibut is fished with a set-line, the average size and weight of the fish in the catch is bigger than in trawl fishing. Larger specimens are obtained at considerable depths. The females are bigger than the males of the same age.

The results of studies performed by M. Vernidub, V. Nevzorova, E. Kleie and N. Novikov showed that there is a direct relation between the length of the body and the weight (table 389).

Таблица 389 /278

Зависимость между длиной и весом тела палтусов

(1) Длина тела АД, см	(2) Вес рыбы, кг		
	(3) черный палтус	(4) белокорый палтус	(5) стрелозубые палтусы
30,0—40,0	0,5—0,6	3,5—4,0	0,4—0,8
40,1—50,0	0,6—2,1	—	0,9—1,4
50,1—60,0	2,5—3,2	4,8—9,0	1,5—2,5
60,1—70,0	3,5—4,65	9,0—11,0	3,0—4,5
70,1—80,0	4,8—6,5	—	—
80,1—90,0	5,0—7,5	13,0—18,0	—
90,1—100,0	13,6	14,0—20,0	—
110,1—125,0	—	18,2—24,8	—

Table 389.
The relation between the length and the weight of the halibut body.
1 - Length of the body AD (translit.), cm
2 - Weight of the fish, kg
3 - Greenland halibut
4 - (True) halibut
5 - Arrow-toothed halibut

The halibut is a fleshy fish. The highest yield was obtained for the American arrow-toothed halibut (table 390).

Таблица 390

Весовые соотношения частей тела у палтусов

Части тела	Виды палтусов			
	черный палтус	белокорый палтус	стрелозубые палтусы	
			азиатский	американский
	Январь—сентябрь	Январь—октябрь	Март—сентябрь	Март—октябрь
Вес рыбы, кг	0,53—6,1	2,88—55,0	0,6—4,65	0,63—3,6
В % к весу рыбы				
Голова	13,5—27,3	11,5—22,1	17,6—24,7	17,7—20,0
Внутренности,	4,5—20,9	8,6—14,4	4,4—18,7	6,3—10,1
в т. ч. половые железы	0,3—8,0	1,0—8,3	0,1—1,5	0,5
печень	1,5—5,1	0,9—3,0	1,2—4,3	0,9—2,5
Тушка,	54,1—65,6	68,0—74,1	60,9—74,4	64,9—74,5
в т. ч. плавники и позвоночник	4,9—17,2	7,6—18,5	8,8—15,0	6,9—13,2
мясо с кожей	48,5—60,0	48,3—67,7	46,9—65,9	59,0—67,6

Table 390.
The weight relations between the parts of the body of the halibut.

1 - Part of the body
2 - Species of halibut
3 - Greenland halibut
4 - (True) halibut
5 - Arrow-toothed halibut
6 - Asiatic
7 - American
8 - Weight of the fish, kg in % of the body weight
9 - Head
10 - Viscera, including sexual glands
11 - Liver
12 - Trunk, including fins and spine
13 - Meat with skin
14 - January-September
15 - January-October
16 - March-September
17 - March-October

The results of experiments performed by E. Kleie, P. Kantemirov, A. Levoi and others show that there is no distinct relation between the yield of meat and the weight or the sex of the halibut. However, in all cases a distinct decrease in the yield of meat can be observed in the period from the summer to the fall (table 391). This is due to the considerable increase of the relative mass of the viscera.

Таблица 391

(1) Вид палтуса	(2) Выход мяса, %		
	(3) июль	(4) август	(5) сентябрь
(6) Черный	49,8—56,0	—	45,8—51,5
(7) Белокорый	—	54,1—57,7	48,3—50,0
(8) Стрелозубый азиатский	49,2—59,4	45,9—51,9	—
(9) Стрелозубый американский	67,6	60,4—61,1	—

Table 391.
1 - Halibut species
2 - Yield of meat in %
3 - July
4 - August
5 - September
6 - Greenland halibut
7 - (True) halibut
8 - Asiatic arrow-toothed halibut
9 - American arrow-toothed halibut

The results of the analyses by E. Kleie, V. Petrochenko, R. Velichanskaya, N. Rublevskaya and others show that the chemical composition of the meat in the different species of halibut varies in a rather wide range (table 392).

Таблица 392

Химический состав мяса палтусов

(1) Вид палтуса	(2) Период наблюдений	(3) Вес рыбы, г	(4) Пределы содержания, %			
			(5) влага	(6) жир	(7) белок	(8) зола
(9) Черный	(13) Январь—сентябрь	1790/9660	67,8/85,6	5,4/18,6	9,7/15,5	0,9/1,1
(10) Белокорый	(14) Январь—октябрь	1900/26300	73,6/81,4	0,2/9,8	14,8/22,9	1,0/1,6
(11) Стрелозубый азиатский	(15) Март—сентябрь	720/8400	64,1/77,6	5,0/21,3	10,8/17,5	0,1/1,4
(12) Стрелозубый американский	(16) Март—октябрь	530/3600	66,1/81,3	1,0/21,2	14,6/16,5	1,0/1,3

Table 392.
The chemical composition of halibut meat.

1 - Halibut species
2 - Observation period
3 - Weight of the fish, gm
4 - Range of contents, %
5 - Moisture
6 - Fat
7 - Protein
8 - Ash
9 - Greenland halibut
10 - (True) halibut
11 - Asiatic arrow-toothed halibut
12 - American arrow-toothed halibut
13 - January-September
14 - January-October
15 - March-September
16 - March-October

Based on data in the literature (Reay, 1943; Vinogradov, Mattisen, 1950; Suoston, 1961; Mannan, 1961 and others), the chemical composition of the meat of the halibut Hippogl. hippogl. varies in the following range (%): moisture 68-79, fat 0.5-9.6, protein 18-22.9 and ash 1-1.5. The meat of the halibut is less fat in the summer than in the spring (the fat content in July is 0.9-3% and in April 1.2-9.3%). The meat consists of white-coloured and brown muscles.

According to the data given by A. Mannan (1961) and other authors, the dark muscles of the (true) halibut are distinguished from the light-coloured muscles by their chemical composition and by their TMA* content (table 393).

Таблица 393

(1) Состав	(2) Пределы содержания, %	
	(3) светлая мускулатура	(4) темная мускулатура
(5) Влага	77,2—79,0	71,7—76,9
(6) Жир	0,7—1,1	3,9—8,5
(7) Белок	19,0—20,1	18,8—19,0
(8) TMA (мг%)	0,2	1,3—2,6

Table 393.
1 - Composition
2 - Range of content, %
3 - Light-coloured muscles
4 - Dark muscles
5 - Moisture
6 - Fat
7 - Protein
8 - TMA (translit.)(mg%)

As compared with the meat of other species of halibut, the meat of the (true) halibut has the lowest fat content but it has the highest content of proteins. The Greenland halibut and the arrow-toothed American halibut have a low protein content and a high hydration index value for the meat proteins. It should be pointed out that the hydration index of the meat proteins varies in a rather wide range for each species of halibut: in the arrow-toothed Asiatic

* Revisor's note. No suitable expansion is available for this abbreviation, which has been taken directly from the original Russian text.

halibut from 4 to 6.5, in the (true) halibut from 3 to 4.3, in the arrow-toothed American halibut from 4.5 to 7 and in the Greenland halibut from 4.3 to 8.4.

These fluctuations in the hydration index values of the proteins can be expected to correspond to variations in the technological properties of the meat of the individual species of halibut. In fact, among the Pacific species of halibut, the (true) halibut has the most compact meat. The meat of the Greenland halibut has a more tender consistency, however in fish with a low fat content it becomes somewhat watery since the hydration index of the proteins reaches 7 to 7.5%.

The meat of the arrow-toothed halibut has a number of specific features. When common methods of cooking, searing and smoking with heat are applied, the meat of the defrosted halibut is unstable. The fat easily separates out from the meat, a large amount of freely liberating coagulate is formed, the meat exfoliates, the pieces break up, etc.

When arrow-toothed halibut is salted, the meat /280
tightens up in the beginning. However, when the fish is left in the brine it swells considerably, becomes jelly-like, peels off the bones and a large amount of fat is excreted. V. Myasoedova pointed out that the meat of the arrow-toothed halibut as compared to, for instance, the meat of the Greenland halibut contains much less nitrogen, elastin, and collagen

(2.2 and 4.7% nitrogen respectively). It is possible that the low connective tissue protein content in the meat of the arrow-toothed halibut causes its instability in heat processing and in brine preservation of salted fish. The analyses by L. Ertel and Z. Repina showed that a complex of extremely active proteolytic ferments is present in the meat of arrow-toothed halibut. Judging by the rate of accumulation of the products of proteolysis, the muscle ferments of the arrow-toothed halibut are 20 times more active at pH 4.5 and 100 times more active at pH 6.5 than the muscular ferments of the Greenland halibut. This biochemical characteristic of the halibut meat certainly promotes the hydrolysis of the connective tissue in the posthumous period and thereby reduces the stability of the tissues. It is very probable that the presence of highly active proteolytic ferments is connected with an infestation of the tissues by some species of Microsporidia.

As compared to the (true) halibut, the meat of which is normal in structure, consistency and organoleptic properties, the arrow-toothed halibut contains much less free amino acids (on the average 190 mg% and 65 mg% respectively) according to E. Nasedkina. Moreover, although the ratio between the individual free amino acid groups in the meat of the species in question is practically equal, the predominance of monoamino acids as compared to other amino acid groups may be recognized (table 394).

Таблица 394

Группа аминокислот	Соотношение групп САК в мясе	
	белокорого палтуса	стрелозубого палтуса
Моноаминокислоты	1	1
Диаминокислоты	0,62	0,58
Сульфоаминокислоты	0,33	0,31
Циклические аминокислоты	0,20	0,15

Table 394.
1 - Amino acid group
2 - Ratio between SAK (free amino acid) groups in the meat
3 - (True) halibut
4 - Arrow-toothed halibut
5 - Monoamino acids
6 - Diamino acids
7 - Sulfamino acids
8 - Cyclic amino acids

The meat of the (true) halibut and of the arrow-toothed halibut differs slightly in the interrelation of the individual amino acids in the composition of the proteins. According to the data in the literature (Rideel, Brocklesby, 1937; Thurston, 1960 and others) and based on the results of the analyses by E. Nasedkina, the meat proteins of the arrow-toothed halibut contain somewhat more irreplaceable amino acids and somewhat less glycine, alanine, serine and arginine (table 395).

M. Syromyatnikova and A. Teplitskaya showed that halibut meat contains 0.6-8γ% Vitamin B_{12}. Its content is highest (3.5-8γ%) in the meat of the arrow-toothed halibut. The Vitamin B_2 content in halibut meat ranges from 40 to

200γ%, and the highest content of this vitamin was found in the meat of the (true) halibut. The Vitamin B_c and Vitamin PP contents are not in excess of 100γ% and 1200γ% respectively.

P. Sautier (1946) found 30-80 % thiamine and up to 90γ% riboflavin in the meat of the arrow-toothed halibut.

Kh. Khiroze and his co-workers (1959) showed that the meat and the liver of the Greenland halibut, as compared to the (true) halibut, contains more folic acid and more pantothenic acid (table 396).

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Таблица 395

Группа аминокислот	Незаменимые аминокислоты	Белокорый палтус	Стрелозубый палтус	Заменимые аминокислоты	Белокорый палтус	Стрелозубый палтус
Моноаминокислоты						
монокарбоновые	Валин	8,6	15,1	Глицин	6,2	4,9
	Лейцин	15,2	16,1	Аланин	7,1	4,5
	Треонин	4,2	3,4	Серин	4,0	2,4
		28,0	34,6		17,3	11,8
дикарбоновые	—	—	—	Аспарагиновая кислота	7,5	8,4
				Глютаминовая кислота	12,9	11,6
					20,4	20,0
серусодержащие	Метионин	—	—	—	—	—
Диаминокислоты						
монокарбоновые	Лизин	13,2	13,1	Аргинин	8,1	6,5
дикарбоновые, серусодержащие	—	—	—	Цистин	3,5	4,2
Циклические аминокислоты	Фенилаланин	5,4	7,6	Пролин	—	—
	Гистидин	+	+	Тирозин	4,0	5,3
	Триптофан	—	—			
		5,4	7,6		4,0	5,3
		46,6	55,3		55,3	47,8

Table 395.
1 - Amino acid groups
2 - Irreplaceable amino acids
3 - (true) halibut
4 - Arrow-toothed halibut
5 - Replaceable amino acids
6 - (True) halibut
7 - Arrow-toothed halibut
8 - Monoamino acids
9 - Monocarboxylic
10 - Dicarboxylic
11 - Sulfur-containing
12 - Diamino acids
13 - Monocarboxylic
14 - Dicarboxylic
15 - Sulfur-containing
16 - Cyclic amino acids
17 - Valine
18 - Leucine
19 - Threonine
20 - Methionine
21 - Lysine
22 - Phenylalanine
23 - Histidine
24 - Tryptophan
25 - Glycine
26 - Alanine
27 - Serine
28 - Aspartic acid
29 - Glutamic acid
30 - Arginine
31 - Cystine
32 - Proline
33 - Tyrosine

Таблица 396

Вид палтуса	Части тела	Пределы содержания (γ%) в сыром веществе	
		фолиевая кислота	пантотеновая кислота
Белокорый	Мясо	80—230	2,2—3,0
	Печень	140—210	13—15
Черный	Мясо	280—890	2,5—3,2
	Печень	80—30	35—39

Table 396.
1 - Halibut species
2 - Parts of the body
3 - Range of content (%) in the raw material
4 - Folic acid

5 - Pantothenic acid
6 - (True) halibut
7 - Greenland halibut
8 - Meat
9 - Liver
10 - Meat
11 - Liver

There is a distinct inverse correlation between the moisture content and the fat content in the meat of the halibut. For the same moisture content in the meat, the level of fat accumulation depends on the halibut species (table 397).

Таблица 397

Корреляция между содержанием влаги и жира в мясе палтусов

(1) Пределы содержания влаги в мясе	(2) Пределы содержания жира, %, в мясе палтусов			
	(3) черного	(4) белокорого	(5) стрелозубого американского	(6) стрелозубого азиатского
65,1—67,0	—	—	21,2	18,3—21,4
67,1—69,0	14,3—18,6	—	18,1	—
69,1—71,0	16,4—18,1	—	15,6	14,6
71,1—73,0	9,7—15,5	—	9,9—13,5	10,9
73,1—75,0	10,4—14,5	3,2—9,8	9,3—10,0	8,1—11,0
75,1—77,0	9,1	2,3—8,5	9,0	6,5
77,1—79,0	—	1,0—1,5	5,1	—
79,1—61,0	5,4—9,2	0,2—1,3	1,0—5,5	—

Table 397.
The interrelation between the moisture content and the fat content in the meat of the halibut.
1 - Range of moisture content in the meat
2 - Range of fat content, % in the meat of the halibut
3 - Greenland halibut
4 - (True) halibut
5 - Arrow-toothed American halibut
6 - Arrow-toothed Asian halibut

The fat content in the meat of the various hali- /282
but species usually increases with the age and the weight of the fish. However, large fish often can contain less

fat than smaller fish. This may be illustrated by the results of analyses of halibut meat caught in the month of August in the Bering Sea and in Alaska Bay (table 398).

Таблица 398

(1) Средний вес рыбы, кг	(2) Пределы содержания жира в мясе, %			
	(3) черный палтус	(4) белокорый палтус	(5) стрелозубые палтусы	
			(6) американские	(7) азиатские
0,5	—	—	1,0	—
0,9	—	—	—	8,7
1,1	—	—	—	10,2
1,4	—	—	9,9	—
2,1	—	—	—	18,3
2,5	9,9—14,4	—	—	—
3,6	—	—	18,1	—
4,6	17,1—18,1	—	—	15,8—18,3
5,7	—	9,8	—	—
6,2	15,1	—	—	—
7,4	5,4	1,4—3,9	—	—
9,4	—	8,5	—	—
10,3	—	6,0	—	—
19,8	—	4,5	—	—

<u>Table 398.</u>
1 - Average weight of the fish, kg
2 - Range of the fat content in the meat, %
3 - <u>Greenland halibut</u>
4 - <u>(True) halibut</u>
5 - <u>Arrow-toothed halibut</u>
6 - American
7 - Asiatic

One of the contributing factors causing a drastic decrease of the fat content in the meat of large fish is the exhaustion of the fish due to spawning and also due to parasite infestation.

By classifying the results of the analyses of halibut meat, one may conclude that the highest fat content in the meat is found in the months of June and July in the case of the <u>Greenland halibut</u> and of the <u>(true) halibut</u>

and in the months of August and September in the case of the arrow-toothed halibut (table 399).

Таблица 399

Период лова рыбы (1)	Пределы содержания жира в мясе, % (2)			
	(3) черного палтуса	(4) белокорого палтуса	(5) стрелозубых палтусов	
			(6) азиатского	(7) американского
(8) Февраль — март	11,1	0,8—3,6	8,2—11,0	9,3—11,1
(9) Апрель	14,3	1,2—2,2	—	11,7—13,5
(10) Июнь — июль	11,1—18,6	1,4—6,0	11,0—14,6	10,2—15,6
(11) Август — сентябрь	5,4—18,1	0,2—9,8	10,2—21,4	9,3—21,2
(12) Октябрь	—	—	14,8—19,7	9,8—12,0

Table 399.
1 - Period of fishing
2 - Range of the fat content in the meat, %
3 - Greenland halibut
4 - (True) halibut
5 - Arrow-toothed halibut
6 - Asiatic
7 - American
8 - February-March
9 - April
10 - June-July
11 - August-September
12 - October

The data of N. Zvyagina, V. Bochkareva, N. Khalina and others show that the iodine number values of the fat obtained from halibut meat by melting out in water varied in the range of 90 to 145. The lowest iodine number was found for the fat of the Greenland halibut and of the Asiatic arrow-toothed halibut (from 90.6 to 115.2) and the highest iodine number was found in the fat of the (true) halibut (from 128 to 145).

The inedible parts of the body of various species of halibut were analysed (Velichanskaya, Konysheva, Rublevskaya and others). These analyses showed that there is a rather high fat accumulation in the bony parts of the body of all the halibut species. A high fat content was also found in the skin because, when the latter is removed, the subcutaneous fat layer is also partially removed. The liver contains fat accumulations up to 38% (table 400).

Таблица 400 /283

Химический состав несъедобных частей тела палтусов

Вид палтуса	Период лова	Пределы содержания, % влага	жир	белок	зола
Голова					
Черный	Апрель—июль, август	63,9—68,6	18,0—22,9	8,4—11,8	2,7—4,0
Белокорый	Февраль—август	61,9—68,0	11,5—19,9	14,9—17,1	3,2—4,5
Стрелозубый азиатский	Июль	62,1—62,4	17,8—21,5	12,5—15,6	3,8—8,6
Стрелозубый американский	Март, апрель, июль	66,0—72,0	7,9—16,0	12,5—13,5	4,3—6,6
Плавники и позвоночник					
Черный	Апрель, июль, август	56,8—64,4	22,0—30,1	9,5—18,9	3,9—5,2
Белокорый	Август	52,3—66,0	13,4—28,7	12,9—15,8	4,8—6,1
Стрелозубый азиатский	Июль	49,4—55,0	28,0—31,8	11,5—13,4	5,5—7,2
Стрелозубый американский	Июнь	72,0	8,9	12,4	6,7
Кожа					
Черный	Июль	62,5	21,3	13,9	2,3
Белокорый	Август	61,3	10,2	25,4	2,6
Стрелозубый азиатский	Июль	49,9	29,5	18,1	2,2
Кишечник и желудок					
Черный	Апрель	87,5	1,1	10,1	1,3
Белокорый	Август	77,0	10,2	11,6	1,0
Стрелозубый азиатский	Июль	79,3	6,1	13,4	1,1
Гонады (яичники)					
Стрелозубый азиатский	Июль	78,5—85,7	0,5—2,4	12,5—17,8	1,3—2,0
Печень					
Черный	Апрель	67,0	19,8	11,6	1,6
	Август	49,5	37,7	11,9	0,9
Стрелозубый азиатский	Июль	55,6	30,2	13,0	1,2

Table 400.
1 - The chemical composition of the inedible parts of the body of the halibut.
2 - Halibut species
3 - Fishing period
4 - Range of contents, %
5 - Moisture
6 - Fat
7 - Protein
8 - Ash
9 - Head
10 - Greenland halibut
11 - (True) halibut
12 - Asiatic arrow-toothed halibut
13 - American arrow-toothed halibut
14 - April-July, August
15 - February-August
16 - July
17 - March, April, July
18 - Fins and spine
19 - August
20 - June
21 - Skin
22 - Intestines and stomach
23 - April
24 - Gonads (Ovaries)
25 - Liver

The yield of liver, its fat content, and also the Vitamin A content in the liver fat (Dolbish, Petrochenko, Kleie) vary for each halibut species in the following range (table 401).

No evidence was found of any regularities in the changes in the yield of liver relative to the fishing period of the halibut nor of any substantial differences in relation to the type of species. Large halibut gives after cutting a slightly higher yield of liver.

The fat content in the liver of the various species of halibut varies practically in the same range. It was found that there is noticeably more fat in the liver of the large halibut than in the liver of the small halibut.

No evidence was found of any regularities in the changes of the fat in the liver or of the Vitamin A content in the liver fat relative to the time of fishing of the halibut. However, the maximum Vitamin A content in the liver fat can be found in September in the case of the arrow-toothed halibut and in August in the case of the true halibut and the Greeland halibut (table 402). /284

Таблица 401

(1) Характеристика печени палтусов

(2) Показатели	(3) Вид палтусов			
	(4) черный	(5) белокорый	(6) стрелозубые	
			(7) азиатский	(8) американский
(9) Вес рыбы, кг	0,9—6,5	1,1—25,6	0,49—3,92	0,72—2,35
(10) Вес печени в % к весу рыбы	0,8—5,1	0,7—3,3	1,1—4,0	1,1—3,0
(11) Содержание жира в печени, %	14,7—35 1	7,4—61,1	12,4—36,6	13,0—39,5
(12) Содержание витамина А, в и. е. в 1 г:				
(13) печени	850—33280	310—33910	640—26850	1190—3700
(14) печеночного жира	3060—131100	1510—127500	2570—125690	3300—15460

Table 401.

1 - The characteristics of halibut liver
2 - Properties
3 - Halibut species
4 - Greenland halibut
5 - (True) halibut
6 - Arrow-toothed halibut
7 - Asiatic
8 - American
9 - Weight of fish, kg
10 - Weight of liver in % to the weight of fish
11 - Fat content in the liver, %
12 - Vitamin A content in IU in 1 gm of:
13 - Liver
14 - Liver fat

Таблица 402

(1) Содержание жира и витамина А в печени палтусов

(2) Печень	(3) Период	(4) Пределы содержания жира, %	(5) Пределы содержания витамина А в и. е. в 1 г печёночного жира
(6) Белокорого палтуса	(10) Январь, март	7,4—34,6	5330—17840
	(11) Июль-август	8,4—15,4	12830—22670
		17,8—36,1	2820—127500
	(12) Сентябрь-октябрь	8,7—35,9	1510—20000
(7) Черного палтуса	(13) Январь	19,6	21430
	(14) Август	14,7—28,4	3060—131100
	(15) Сентябрь-октябрь	23,9—33,3	12590—118860
(8) Стрелозубого азиатского палтуса	(16) Январь	28,9—32,6	10620—16660
	(17) Март	12,7—19,2	9940—31810
	(18) Август	20,3—30,1	15400—17830
	(19) Сентябрь	16,6—30,2	89030—125670
	(20) Октябрь	23,2—31,9	2570—40790
(9) Стрелозубого американского палтуса	(21) Январь-март	26,5—36,2	3300—13980
	(22) Апрель	13,0—29,9	9350—11470
	(23) Август-сентябрь	21,6—27,7	5510—15460

Table 402.

1 - Content of fat and Vitamin A in the liver of the halibut.
2 - Liver
3 - Period
4 - Range of fat content, %
5 - Range of Vitamin A content in IU in I gm of liver fat
6 - (True) halibut
7 - Greenland halibut
8 - Arrow-toothed halibut, Asiatic
9 - Arrow-toothed halibut, American
10 - January-March
11 - July-August
12 - September-October
13 - January
14 - August
15 - September-October
16 - January
17 - March
18 - August
19 - September
20 - October
21 - January-March
22 - April
23 - August-September

The liver fat of the (true) halibut obtained in the same months of the year in the central and eastern zones of the Bering Sea contains noticeably more Vitamin A than the fat of the halibut from the regions of the La Perouse Strait and the southern Kuril islands (16400-127500 and 1510-8440 IU in 1 gm respectively).

A rather high content of fat and Vitamin A in the liver of the halibut makes it a valuable raw material for the hydrolytic method of Vitamin A extraction.

The fat obtained from the liver of the Greenland halibut contains 6.4% non-saponifiable substances and it has the following values of constants: d_4^{15} - 0.9213, n_D^{20} - 1.4712, saponification number - 266.6, iodine number - 198.0.

The data in the literature (Lovern, 1934, Pugsley, 1940 and others) show that the liver fat of the halibut has a higher percentage of non-saponifiable substances (5.1-15.8%).

In the composition of the fatty acids of the liver/285 fat of the halibut one finds: 81% unsaturated (including 27.9% highly unsaturated) and 19% saturated fatty acids.

According to the data of G. Dolbish, the fat content in the tissues of the intestines and of the stomach is not more than 6-6.5% in the various species of halibut, while the amount of Vitamin A varies in a very wide range (table 403).

Таблица 403

(1) Показатель	(2) Белокорый палтус	(3) Черный палтус	(4) Стрелозубые палтусы
(5) Содержание жира в тканях, %	1,7—4,8	4,0—4,8	2,4—6,2
(6) Содержание витамина A в и. е. на 1 г			
(7) тканей	170—2910	90—3090	1550—12180
(8) тканевого жира	7810—145300	2500—166430	25520—297070

Table 403.
1 - Properties
2 - (True) halibut
3 - Greenland halibut
4 - Arrow-toothed halibut
5 - Fat content in the tissues, %
6 - Vitamin A content in IU in 1 gm:
7 - Tissues
8 - Tissue fat

A. Teplitskaya and M. Syromyatnikova have established that there are no substantial differences in the content of water-soluble vitamins in the tissues of the species of halibut investigated by them. However, the highest content of vitamins was found in the tissues of the intestines and of the liver (table 404).

Таблица 404

(1) Части тела	(2) Пределы содержания (γ%) в сыром веществе			
	B_{12}	B_2	Bc	PP
(3) Голова, плавники, кости	0,4—5,2	10—80	—	—
(4) Внутренности (без печени)	4,8—6,5	30—140	—	—
(5) Печень	10—195	150—600	600	3000

Table 404.
1 - Part of the body
2 - Range of contents (γ%) in the raw material

3 - Head, fins, bones
4 - Viscera (without liver)
5 - Liver

Fishes of the Order Tetradontiformes.

To this Order belong several families with peculiar body forms: the gray triggerfish, the trunkfish, the puffer, the ocean sunfish, etc. The data of N. Nikonova and V. Adistanova show that the meat of the Tetradontiformes fishes has an average fat content (table 405).

Таблица 405

(1) Химический состав мяса сростночелюстных

(2) Название	(3) Пределы содержания, %			
	(4) влага	(5) жир	(6) белок	(7) зола
(8) Мясо единорогов	74,9 / 78,0	0,6 / 1,6	19,8 / 22,3	1,4 / 1,6
(9) Мясо луны-рыбы	76,4 / 79,0	2,6 / 4,7	16,8 / 18,2	1,3 / 1,9
(10) Мясо собаки-рыбы (фугу)	79,3 / 80,1	4,2 / 6,0	16,4 / 17,7	1,2 / 1,5

Table 405.
1 - The chemical composition of the meat of Tetradontiformes
2 - Name
3 - Range of contents, %
4 - Moisture
5 - Fat
6 - Protein
7 - Ash
8 - Meat of the gray triggerfish
9 - Meat of the ocean sunfish
10 - Meat of the puffer (fugu)(transliterated)

It is known that these species of fish can cause food poisoning with fatal results. The investigations of B. Shura-Bura (1943) have shown that the poisonous matter of puffer is concentrated in the milt. The poison is thermo stable and it attacks the central nervous system. The meat of this fish is not poisonous when the viscera are completely removed and after careful cooking. However, these /286 species of fish should not be considered edible.

Among the internal organs of Tetradontiformes, the liver is of some interest: the relative weight of the liver of puffer ranges from 1.5-3.2% and in gray triggerfish up to 4.5% based on the weight of the body.

The amount of fat in the liver of gray triggerfish reaches 33.9%, in the liver of ocean sunfish 36.2%, and in the liver of puffer 21.6%.

The liver fat of puffer and ocean sunfish has the following values of physico-chemical constants: d_4^{15} - 0.9259-0.9269, n_D^{20} - 1.4785, saponification number 169.7-182.2, iodine number 142.7-159.9, unsaponifiable matter 1.5-8.4%. The fat does not have any toxic properties and it can be used as a common liver fat.

In the liver of the gray triggerfish, caught in the gulf of Tonkin, G. Dolbish found 33.9% fat and 170 IU Vitamin A in 1 gm of liver. This corresponds with a content of 800 IU Vitamin A in 1 gm of liver fat.

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