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by I.V. Kizevetter

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Chemical and Technological Characteristics of Fish from the Pacific Basin

UDC: 664.95

by I.V.Kizevetter
(Doctor of Technical Sciences, Professor)

Preface

The Soviet fishing industry of the Pacific basin has and is encountering a variety of marine life ranging from numerous species of fish, crustaceans, molluscs and mammals, to sea weeds. Fish constitute the basis (78--82%) for the Soviet fishing industry in this area.

The large variety of commercial fish constitute a raw material that essentially differs in chemical composition and technological properties. Hence in order to process these catches efficiently and economically it is important to understand something about their mechanical, physical, and chemical properties.

The appearance of the 21st volume of TINRO NEWS (1942), which contained the first summary of a study of the chemical and technological properties of fish from the Far East, has been followed by other wide-ranging, systematic investigations. The data resulting from these studies have enabled us to establish more precisely the chemical composition and technological assets of traditional fish catches in the Far East as well as of numerous species from different areas of the Pacific frequented by the Soviet fishing fleet.

We studied numerous species from the western and eastern zone of the North Pacific, from the eastern areas down to the tropic latitudes, including species from the Korea Strait, the East China Sea, and from the Gulf of Tonkin. We also investigated fish species caught in the eastern part of the Indian Ocean, off the coast of western Australia in the Great Australian Bight and off the coastof New Zealand.

In recent years research conducted at the laboratories of our Far East fishing industry has resulted in important data on the technological characteristics of fish from that area.

Finally, new research on the chemical composition of commercial species from the Pacific area has also been published in foreign countries.

Our goal is to summarize the fragmented data and to identify /4 the aims of technological research. The combined data will be a useful reference for the technologists and merchandizers of our Far East fishing industry.

In compiling this summary we consulted the data already published by members of TINRO, technological reports of the scientific archives of TINRO, and numerous sources (see bibliography) dealing with the chemical composition and technological assets of commercial fish encountered in the fishing areas of the Pacific basin.

In order to arrange the extensive factual material, we adopted the system presently used in the zoological classification of fish. The content and structure of individual divisions and chapters were predetermined by the volume of pertinent data.

Fish bodies, as is known, consist of tissues made up of biophilous and biogenic substances which make up the structural material and foodstuffs of the hydrobiont. The bulk of organic substances that participate in the biochemical processes of synthesis and decomposition appear to be very unstable. As a result there is an ongoing change in the chemical composition of the tissues of the fish body; this change is regulated mainly by biological causes. No less significant are the chemical changes occurring in fish tissue posthumously,when tissue enzymes and microorganisms and various external factors (temperature, the oxygen of the air, sun light and so on) begin to affect the body. Posthumous changes in chemical composition and in the property of unprocessed fish enormously affect the latter's technological characteristics, and research in this area is significant enough to deserve a separate chapter.

An investigation into tissue composition of various commercial fish may be desireable for the purpose of establishing qualitative characteristics, or for determining the quantity either of individual elements (establishment of basic chemical comp.), or of individual substances, or groups of substances, that form part of the material under study (establishment of combined chemical composition).

Both these approaches, besides being of important biochemical and biological significance, also have considerable practical value. They make it possible to determine the rate at which the nutritive and technological qualities of the fish are changing, measued by time and location of a given catch, and thus determine its most efficient use.

In our research the second approach predominated; the chemical analyses were conducted according to well-known methods.

Along with preparing the materials for chemical analysis, the parts of the fish were also correlated by weight. In this area numerous tasks were carried out especially by V. Bogachev, M. Borisova, I. Varpakhovskii, V. Gotovets, P. Kantemirov, B. Kalinin, E. Kleie, E. Koshubo, A. Lisachenko, O. Omel'yanenko and I. Frolov.

The chemical analyses were conducted by the following members of the technological and chemical laboratories of TINRO:

V. Adistanova	G. Gudaeva	I. Varpakhovskii
M. Borisova	L. Bukhryakova	R. Velichanskaya
V. Bochkareva	L. Vakulyuk	V. Vinogradova
L. Vysotskaya	A. Krivets	A. Podoba
V. Gaivoronskaya	E. Lagovskaya	Z. Repina
A. Glinkova	O. Legen'ko	M. Reshetnyak
V. Gordievskaya	A. Lisachenko	N. Rublevskaya
A. Dvinina	V. Mas'ko	V. Rudakova
G. Dolbish	O. Mel'nikova	A. Semenova
T. Dyupina	A. Men'shutina	N. Skorobogatova
G. Ermakova	K. Mershina	N. Strashuk
A. Zyulina	Ya. Mikulich	M. Syromyatnikova

/5

T. Ivanyushina
(Soboleva)
P. Kozakova
S. Kanevskaya
E. Kaletina
A. Kirillova
E. Kleie
L. Konysheva
T. Korenchuk
A. Koroleva
E. Koshubo
A. Krasnitskaya

L. Milanina
V. Mikhaleva
A. Myaksha
V. Myasoedova
E. Nagibko
E. Nasedkina
I. Nikitina
N. Nikonova
O. Omel'yanenko
E. Ochkurova
E. Pavlyuchenko
V. Petrochenko

M. Sycheva
(Vakhrusheva)
A. Teplitskaya
T. Udelova
G. Fil'e
N. Firsov
N. Khalina
O. Kholosha
L. Khorynskaya
R. Shikhanova
T. Shul'ga
L. Ertel'

In compiling the tables, we saw no need to calculate arithmetical mean values, since we assumed that the indicated ranges within which the various changes in size, weight, chemical composition, and so on, occurred would be sufficient for an objective evaluation of the technological properties of the fish.

Readers who may wish to comment on the content of this article should address their correspondence to: The TINRO Editorial Staff, 20 Lenin Street, Vladivostok, USSR.

I. Cyclostomata

Lampreys (Petromyzontidae). The lamprey family includes 8 genera of protozoans, having an elongated, almost cylindrical, body which lacks scales but which is copiously covered with mucus. In Far East waters there are two species of lampreys: the first belongs to the Pacific genus Lampetra (Lampetra japonica Martens) and the second is a Far East river lamprey (Lampetra reissneri). The first is found in the rivers of the coastal area and of Kamchatka, including large numbers in the Amur river. The second species is found in the rivers of the Khabarovsk region, Sakhalin and Kamchatka, and in the Anadyr river. /6

Lampreys are migratory fish which cover long distances in preparation for spawning. Every year at the beginning of winter a large number of lampreys enter the mouth of the Amur river and, searching for spawning grounds, migrate upstream beyond the city of Khabarovsk. In the Nikolaevsk area the lamprey run climaxes from the end of September to the beginning of November; at Khabarovsk it peaks at the beginning of December. Once the spawning grounds are reached, the lampreys winter there and spawn only at the beginning of summer. The developmental changes of the lamprey are as follows: the young lamprey (sand eels), after spending 3--4 years in the river, gradually find their way to the sea. This sequence in their life cycle causes a change in the chemical composition of their body tissue, which is especially apparent during feeding and spawning periods.

The adult Pacific lamprey is 31.5--50 cm in length and weighs 60--186 g; the females are somewhat larger than the males (90--110 and 60--80 grams, respectively). In the Pacific lamprey there is a direct relationship between the length of its body and its weight (Table 1). The river lamprey usually is 12--18 cm in length.

Table 1

Таблица 1

a - Длина тела миноги, мм	380—390	410—430	450—470
b - Вес рыбы, г	85—87	105—125	110—135

a - length of lamprey (mm)
b - weight (g)

The Amur lampreys which were caught in the Oct--Dec period had a head which constituted 5--7% of the weight of the body, the gills 4.1--8.1%, the dressed carcass 74.2--85.6%, viscera 6.8--11.8, including the liver 1.2--1.5, gonads 4.6--5.5%; the weight of the ovaries with membranes varies from 6 to 15.1% (average 9.1) relative to that of the female body, while the weight of the milt varies from 2.9 to 4.8% (average 4.5) relative to the weight of the male body.

According to V. Zyryanova and N. Rublevskaya, the meat of the Pacific lamprey has a fat content of up to 30--35% (Table 2), but it diminishes noticeably as the spawning season approaches. The lampreys caught in winter have the greatest technological assets.

Таблица 2*)

Химический состав мяса миног

	Место лова place of capture	d Пределы содержания, % влага moisture	жир fat	белок protein	зола ash
a	р. Амур, в 945 км от устья, декабрь	54,6 / 59,7	23,7 / 32,7	12,4 / 15,6	0,7 / 0,8
b	р. Сучан, южное Приморье, ноябрь	52,0 / 53,5	32,6 / 33,1	12,6 / 13,7	1,0 / 1,2
c	То же, после нереста (май—июнь)	68,6	13,3	16,1	1,9

*) Всюду в таблицах числитель — наименьшее значение, знаменатель — наибольшее значение данного показателя. In all Tables and for any given index the numerator has the least, and the denominator the greatest, value.

Table 2. Chemical composition of lamprey meat

a-river Amur, 945 km from its mouth (December)
b-river Suchan, southern coastal area (November)
c-same, after spawning (May-June)
d-percentage composition

The fat content increases proportionately to the size of the lamprey. Thus at a body weight of 65--85 g (length: 37--42 cm) the meat contains 23--24% fat, and at a weight of 120--170 g (45--50 cm) the fat content rises to 30--33%.

According to M. Osipova (1931), the meat of the Volga lamprey contains from 21.3--33.7% fat, and that of the Neva lamprey from 14.6 to 21.2% (Zakharov and Dal'berg). /7

(Continued on next page)

Table 3 Таблица 3

Химический состав частей тела тихоокеанской миноги (р. Амур, декабрь)

	Части тела body parts	content Содержание, % влага moisture	жир fat	белок protein	зола ash
head	Голова	65,2	19,8	14,2	0,7
gonads with roe	Ястыки с икрой	51,7	20,0	22,8	1,6
milt	Молоки	75,3	11,2	12,3	1,2
liver	Печень	62,1	19,0	17,5	1,4
intestine	Кишечник	70,3	12,0	16,6	1,1

Table 3. Chemical composition of body parts of Pacific lamprey (Amur river, December).

In contrast to bony fish, in lampreys each myotome is surrounded by fat, and the myosepta consist almost entirely of fatty tissue. There is an absence of brown muscle tissue [sic]. The fatty tissue is thickest near the head and decreases toward the tail end. N. Rublevskaya's analyses (Table 3) indicate a high fat content in different body parts of the Pacific lamprey.

The investigations of Kh. Khigashi and co-workers (1958, 1959) showed that the meat and tissue from different body parts of the Pacific lamprey contains significant amounts of vitamin A (Table 4).

Table 4 Таблица 4

Содержание витамина А в тканях тела тихоокеанской миноги

	Части тела parts of body	e Пределы содержания жира, %	f Пределы содержания витамина А в и. е. на 1 г f1 вещества	f2 тканевого жира
a	Мясо	5,5—21,8	150—1690	700—9950
b	Печень	2,2—49,0	1010—17300	7600—200000
c	Кишечник и желудок	4,2—15,7	1820—113600	292000—725000
d	Икра	1,8—22,9	60—5220	640—173000

Table 4. Vitamin A content in tissues of the Pacific lamprey.

a-meat; b-liver; c-intestine and stomach; d-roe; e-percentage of fat content; f-content of vitamin A (in international units per gram); f1-in tissue; f2-in fatty tissue.

Of the overall quantity of vitamin A in the lamprey body, 25-53% is concentrated in the meat, 47--75% in visceral parts of which 29--48% is found in stomach and intestinal tissue.

According to the above investigators, the content of water-soluble vitamins varies within the ranges indicated in Table 5. /8

Judging by the group of important vitamins found in the lamprey, the latter is a valuable source of food.

Table 5 Таблица 5

Содержание водорастворимых витаминов в тканях тела миног

	Витамин vitamin	content of in raw tissue Пределы содержания (γ%) в сыром веществе			
		мясо flesh	шкурка skin	печень liver	гонады gonads
a	Тиамин (B_1)	46—150	175—1080	70—420	70—250
b	Рибофлавин (B_2)	160—690	220—2660	600—900	200—630
c	Адермин (B_6)	160—220	60—260	110—270	50—360
d	Цианкобаламин (B_{12})	3,3—5,4	0,8—3,8	1,2—23,0	4,6—11,5
e	Фолиевая кислота (BC)	20—30	30	190—570	60—100
f	Пантотеновая кислота	280—570	следы traces	1200—1400	870—1560

Table 5. Content of water-soluble vitamins in the lamprey

a-thiamine (B_1); b-riboflavin (B_2); c-adermin (B_6); d-cyanocobalamin (B_{12}); e-folic acid (BC); f-pantothenic acid.

The fat extracted from the lamprey by melting has a pale-brown color and pleasant taste; at 20°C the fat is liquid. Its physical and chemical properties, according to M. Borisova and I. Varpakhovskii (1938) and Kh. Khigashi (1959), are characterized by the following constants: specific weight (d_4^{15}) 0.9235--0.9441, index of refraction (n_D^{20}) 1.4650--1.4875, iodine number 121.1--194.3, saponification value 167.8--198.6, content of non-saponifying substances 0.7--15.1%.

According to A. Matveeva (1934), the fat of the Volga lamprey has a lower iodine number (101.3--133.7), this also applies to the fluid fatty acids extracted from the fat (65.6%) whose iodine number is 155.7. This suggests that the glycerides of the Volga lampreys contain fewer unsaturated fatty acids. A higher content of unsaturated fatty acids in its fat may be the distinguishing biochemical feature of the Pacific lamprey.

Lamprey fat easily oxidizes and hydrolizes, and, after 30 to 45 days of storage, frozen lampreys rapidly loose their organoleptic qualities due to oxidation of the tissue fat. Hence glazed and frozen lamprey should be stored at low (minus 20 to 25°C) temperatures.

Baked lampreys constitute a first-rate product; they are used for preparing smoked, marinated, and canned lamprey products, whose chemical composition, as determined by V. Podsevalov (1935), M.Il'in (1911) and other investigators, is shown in Table 6.

Таблица 6
Table 6

Химический состав пищевых продуктов из миноги

Тип продукции / type of product	d Пределы содержания, % — влага / water	жир / fat	белок / protein	зола / ash
a Консервы*) «Минога в собственном соку»	48,4 / 55,5	26,6 / 30,2	14,1 / 21,1	2,3 / 3,3
b Минога пропеченная	37,7 / 55,5	19,0 / 31,7	20,3 / 30,1	4,5 / 6,3
c Минога горячего копчения	50,9 / 51,2	20,2 / 21,3	24,8 / 25,6	1,4 / 2,2

*) Применение разных способов тепловой обработки: подсушка, пропекание, копчение, бланшировка. Prepared by various methods of heat treatment: predrying, baking, smoking, blanching

Table 6. Chemical composition of lamprey products

a-canned lamprey ("Lamprey in lamprey sauce"); b-baked lamprey; c-hot-smoked lamprey; d-percentage content.

II. Lamellibranchia (Elasmobranchii)

/9

This subclass includes the order Selachii, which comprises several suborders of sharks and suborders of skates (Batoidei).

Sharks. The sharks whose habitat is the Pacific Ocean comprise 14 Families and constitute 3 suborders. These Families are characterized by numerous genera and species. For example, in the Sea of Japan, the Sea of Okhotsk, and in the Bering Sea the porbeagle (Lamna cornubica), and the spiny dogfish (Squalus acanthias) can have commercial significance. Many species of sharks are caught during tuna-fishing operations in the open waters of the Pacific, including representatives of the grey or blue family of sharks (Carcharhinidae), dogfish (Scyliorhinidae), porbeagle sharks (Lamnidae), and spiny dogfishes (Squaliformes).

The sharks that get hooked usually weigh 20--30 kg but individual animals can weigh as much as 200--250 kg; the largest of these sharks can be 4 and even up to 7 meters in length.

Weight correlations of the different parts of the body depend on the anatomical structure of the body and can change considerably.

In systematizing the research results of E. Koshubo, E. Kleie, L. Konysheva, Z. Repina, V. Gordievskaya, and others, who established weight correlations for 36 species of edible Pacific sharks, one can prove that the meat yield from sharks depends not only on the relative size of the heads and viscera but also on the changing dimensions of fins, cartilage and skin (Table 7).

Table 7 Таблица 7

	Вид акулы shark species	a Пределы веса 1 экз., кг	b Пределы изменения относительного веса частей тела, %						
			b1 голова	b2 внутренности	b3 тушка	b4 в числе тушки			
						b5 хрящи	b6 плавники	b7 кожа	b8 мясо
c	Малоголовая, мягкогубая, кривозубая	0,5—11,9	17,2—22,4	8,3—11,9	58,8—67,2	2,4—6,3	4,2—6,0	4,0—7,4	50,1—60,8
d	Серая, косячная, кунья, палазоррах, протозигаена усатая, молот	1,1—16,2	19,6—31,5	8,1—23,0	50,0—62,7	3,1—10,6	3,0—12,9	4,7—10,6	37,0—49,6
e	Ковровая, кошачья, синяя, белоперая, серая, короткохвостая, плавниковая, морской ангел, семижаберная	0,4—250,0	18,9—32,4	9,0—26,6	41,8—68,1	2,2—16,8	4,4—14,7	5,0—15,1	32,4—40,0
f	Рогатая, гребенчатая, черная	2,4 25,5	17,1 38,6	7,9 46,9	33,3 39,6	3,0 6,4	2,5 22,0	7,3 12,1	20,8 23,0

a-weight range of a single specimen, in kg; b-changes in relative weight of body parts, in percent; b1-head; b2-viscera; b3-carcass; b4-including: b5-cartilage; b6-fins; b7-skin; b8-meat.

c-soft-headed sharks, soft-mouthed sharks, krivozubaya*;

d-gray, Galeus australia, smooth hound, palasorrah, protozigaena,* nurse shark, hammerhead shark;

e-carpet shark, lesser spotted dogfish, blue shark, whitefin shark, gray, short-tailed shark, fin sharks, angel sharks, seven-gilled sharks;

f-horn shark, cowshark, black shark;

It may be noted that the shark species of the suborder Lamniformes have a higher meat yield than those of the Heterodontidae and Hexanchidae.

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*Translator's Note: Species for which no reliable translation could be established are transliterated and followed by an asterisk.

The relative weight of shark meat, coming from animals of the same species, depends on their physiological condition. For example, female sharks always yield less meat than males of the same size. And the meat yield of pregnant females is considerably reduced; the embryos may constitute 15--19% of the overall weight of the animal. /10

Table 8 Таблица 8

Химический состав мяса акул

Семейство, вид shark family	a Пределы содержания, %			
	a1 влага	a2 жир	a3 азот (по Кьельдалю)	a4 зола
Рогатые акулы (Heterodontidae)	79,6	0,3	3,84	1,8
Гребнезубые акулы (Hexanchidae)	67,9	13,1	3,3	1,2
Ковровые акулы (Orectolobidae)	76,9	0,5	4,22	1,3
Песчаные акулы (Odontaspidae)	76,4	0,4	3,51	1,5
Сельдевые акулы (Lamnidae)	70,3—76,8	0,2—8,6	3,8—4,3	1,6—1,7
Кошачьи акулы (Scyliorhinidae)	70,8—76,5	0,1—0,6	4,0—4,5	0,9—1,6
Серые и голубые акулы (Carcharhinidae)	68,5—80,6	0,1—6,7	3,5—4,6	0,8—1,6
Акулы-молот (Sphyrnidae)	74,6—75,6	0,2—4,2	3,3—3,6	0,9—1,7
Катранообразные акулы (Squaliformes)	69,5—80,3	0,3—4,4	3,8—4,4	1,0—1,3
Морские ангелы (Squatinidae)	75,2—77,2	0,2—1,4	4,0—4,4	1,0—1,4

a-contents, in percent; a1-moisture; a2-fat; a3-nitrogen, determined according to Kjeldahl's method; a4-ash.

Thus the relative weight of shark meat varies within 20.8 to 60.8%, depending on a multitude of biological factors.

The shark meat most suitable for human consumption is the back fillet and the part near the tail, which together constitute 50--60%, the rest may be utilized for animal feed. But regardless whether it is used for human or animal consumption, shark meat must be frozen.

The research of I. Navor (1921), E. Bauman (1952) and others, as well as that of TINRO investigators (V. Adistanova, N. Nikonova, V. Novozhilova, V. Rudakova, E. Kleie, T. Soboleva, T. Udelova, and others), warrants the conclusion that the meat of most of the sharks investigated is lean. Still, the meat of the Hexanchidae, Squaliformes, Carcharhinidae, and Lamnidae may contain 7--12% fat (Table 8).

Shark meat perceptibly differs from that of other bony fish by its darker color, its coarse-fibered structure, its resilient consistency and peculiar taste. The meat of young sharks has the better organoleptic qualities.

The boiled meat (after defrosting) of the various shark species has specific properties (Table 9). The boiled meat of black sharks had the best organoleptic qualities. The meat of the Pacific hammerhead shark (Sphyrna zygaena) received a favorable evaluation, while that of the hammerhead shark (Sphyrna blochii) found in the Indian Ocean, according to V. Tishina (1967), was tough, dark-colored, and had a sourish-bitter taste.

The flavor of shark meat is due to its nitrogenous substances. We know that shark meat contains from 3.3 to 4.6% nitrogen
and that on conversion this gives a very high protein content 11
(20.6--28.7%). However, according to S. Bitti (1937), G. Rei, K. Kutting (1943), E. Naguchi (1932), and many other investigators, the biochemical

Таблица 9

Вид акулы species	Свойства вареного мяса (boiled) meat properties — окраска color (a)	консистенция consistency (b)	вкус taste (c)
1 Колючая (Squalidae)	От почти белой до сероватой	Сочная, нежная	Приятный
2 СЕРАЯ СЕЛЬДЕВАЯ (Lamna ditropus)	Светлая	Плотная	Удовлетворительный
3 Серо-голубая (Isurus glauca)	Почти белая	Нежная	Специфический кисловатый
4 Кунья акула (Mustelus manago)	Серая	Упругая	Кисло-горький
5 Акула-молот (Sphyrna zygaena)	Белая	Нежная, сочная	Вкус и запах приятные
6 Ковровая (Orectolobus ornatus)	Светлая	Водянистая, крошливая	В дефростированном резкий запах мочевины, после отмочки — легкий запах мочевины
7 Черная акула (Dalatias phillipsi)	Белая	Водянистая, крошливая	Хороший
8 Косячная (Galeus australia)	Сероватая, быстро темнеет на воздухе	Водянистая, крошливая	Приятный
9 Короткохвостая (Carcharinus)	Светлая, на воздухе быстро темнеет	Плотная	Удовлетворительный
10. Гребенчатая (Brachaelurus)	Серая	Плотная	Неприятные вкус и запах, не исчезающие после отмочки

	a	b	c
1	from almost white to greyish	juicy, tender	pleasant
2	light	compact	satisfactory
3	almost white	tender	distinctly acidic
4	gray	elastic	bitter/sour
5	white	tender, juicy	pleasant taste and smell
6	light	watery, friable	defrosted meat has strong urea odor which diminishes after soaking
7	white	watery, friable	excellent
8	greyish but darkens quickly in open air	watery, friable	pleasant
9	light-colored but darkens quickly in open air	compact	satisfactory
10	gray	compact	unpleasant smell and taste which persist even after soaking

feature of shark meat is its high content of nonprotein nitrogen: that of volatile matter (up to 80--120 mg percent), urea (1.5--2.8%), and trimethylamine oxide (up to 150 mg percent).

The analyses of N. Rublevskaya, who investigated the meat of 32 species of Pacific sharks, showed as well that the urea content of this meat varied from 1.56 to 2.33%, trimethylamine from 1 to 34 mg percent, trimethylamine oxide from 220 to 950 mg percent and nitrogen of volatile matter from 16 to 55 mg percent.

A consistently high urea content (above 2%) was found in the meat of horn-, _Galeus australia_, white-eye- and hammerhead sharks. In the meat of spiny dogfish, gray-, cow- and seven-gilled sharks the urea content does not exceed 1.5--1.75%.

In the meat of soft-headed and white-finned sharks and angel sharks the content of trimethylamine oxide does not exceed 220--330 mg percent, but in that of smooth hound-, lesser spotted-, gray-, fin- and horn sharks it exceeds 700 mg percent.

Evidently the level of urea and trimethylamine oxide accumulation depends on the biochemical features of the nitrogen metabolism in individual shark species.

Based on the data of E. Nasedkina, it can be stated that the overall nitrogen content of the meat of the Pacific sharks investigated falls within the ranges given in Table 10.

Table 10 Таблица 10

Показатели indices	Пределы limits
Содержание в мясе, % percentage content (in the meat) of:	
Азот общий overall nitrogen	3,5—4,5
Азот небелковый nonprotein nitrogen	1,35—1,65
в т. ч.: including:	
a) азот триметиламиноксида	0,05—0,18
b) азот мочевины	0,74—1,06
$\frac{\text{\% N небелковый} \cdot 100}{\text{\% N общий}}$ $\frac{\text{nonprotein N}}{\text{overall N}}$	24,4—42,0
$\frac{\text{\% N TMAO} \cdot 100}{\text{\% N небелковый}}$ $\frac{\text{TMAO}}{\text{nonprotein N}}$	3,0—11,4
$\frac{\text{\% N мочевины} \cdot 100}{\text{\% N небелковый}}$ $\frac{\text{urea N}}{\text{nonprotein N}}$	54,4—724

a-nitrogen trimethylamine oxide; b-urea nitrogen.

According to S. Komarov (1933), Zh. Kambel (1935), M. Sakaguchi /12 and M. Khuzhita (1964) and others, shark meat contains somewhat less creatine than that of bony fish (326—600 and 580—740 mg percent, respectively).

The high content of nonprotein nitrogen determines the given organoleptic qualities so apparent in the culinary products of shark meat on the one hand, and, on the other, it is responsible for the fact that the nitrogen of simple proteins constitutes from 58 to not more than 74% of the overall nitrogen content. Hence the content of simple proteins in the meat of the Pacific sharks studied has a low average, ranging within 12.7—18.9%.

According to E. Nasedkina, the meat of various shark species contains from 50 to 290 mg percent of free amino acids, which is .5 to 2/3 that contained in the meat of most bony fish species. Again, judging by the work of M. Sakaguchi, M. Khuzhita (1964) and others, and by the conclusions E. Nasedkina draws, the composition of free amino acids of shark meat differs from that of other deep-sea fish by a lower content of essential amino acids and, particularly, of valine, lysine and histidine, and by a higher content of methionine. But with regards to non-essential free amino acids, shark meat is richer than other deep-sea fish in the monoamino acids glycine, alanine, and serine, in aspartic acid, and in the sulfoamino acids cystine and taurine. This suggests that the free amino acids in shark meat are of lesser biological importance.

The overall amino acid composition of the protein of shark meat has a distinct biochemical character. A comparison of the known data regarding the composition of amino acids of the protein of bony deep-sea fish with the results of T. Paskhina's and N. Tyuleneva's analyses of the amino acids of the protein of 8 species of Pacific sharks makes it clear that the protein of shark meat contains noticeably fewer essential amino acids (41.8--56.3 and 21.6 and 45.9, respectively). Especially poor in essential amino acids is the protein of the Nebrins concolor, seven-gilled (Notorhynchus), Carcharinus dorsalis and of the Scoliodon palasorrah (Table 11).

Of the non-essential amino acids shark protein, compared to that /13
of other deep-sea fish, contains somewhat more arginine and cystine but

perceptibly less aspartic and glutamic acid.

According to data provided by A. Teplitskaya and I. Nikitina, the content of water-soluble vitamins of the B group varies little in 32 shark species, changing within (γ%): vitamin B_2 from 100--500, B_c 30--300, PP 3000--19500, B_{12} 0,5--8.5.

According to K. Takeda, Zh. Nishimoto (1958), Kh. Khigashi (1959) and others, shark meat contains 25--250 intern. units of vitamin A per gram of light meat, and 21--114 intern. units per gram of dark meat; pantothenic acid (800--860%); folic acid (2.5--3.5 γ%) and a high content of choline (35--80mg%).

(continued on next page)

Table 11 Таблица 11

Аминокислоты amino acids	1 Пределы содержания в сухом белке мяса, %			
	морских пелагических костистых рыб 2	белоперой (Carcharhinus albimarginatus) и косячной (Galeorhinus australis) 3	голубой (Prionace glauca), акула-молот (Sphyrna blochi) 4	семижаберной, малоголовой, высокоперой, мягкогубой 5
I. Незаменимые аминокислоты essential amino acids				
a Валин и метионин	8,7—13,0	5,1—5,8	4,5—5,6	3,7—8,6
b Фенилаланин, лейцин, изолейцин	13,8—21,5	9,1—10,4	11,4—14,6	7,3—13,4
c Лизин, гистидин	12,1—20,2	14,9—19,3	16,8—17,5	6,1—9,0
Всего Total	36,6—54,7	31,1—33,5	44,8—45,9	21,6—23,5
II. Заменимые аминокислоты nonessential amino acids				
d Глицин	3,8—5,5	4,7	—	2,5—5,3
e Аланин	5,1—7,3	5,4	5,3—6,0	4,1—6,0
f Серин	4,6—5,5	—	3,9	2,6—6,1
g Аргинин	5,9—6,9	6,8	6,5—7,0	4,2—8,1
h Аспарагиновая кислота	6,2—11,5	3,8	—	2,0—3,0
i Глютаминовая кислота	13,4—16,9	12,8—14,2	13,0—14,0	7,8—10,9
j Цистин	0,9—2,0	1,2—2,4	1,8—3,4	0,8—3,4

1-percentage content of amino acids in dry protein;
2-bony deep-sea fish;
5-in seven-gilled, in Nebrins concolor, in Carcharinus dorsalis, and in Scoliodon palasorrah.

a-valine and methionine; b-phenylalanine, leucine, isoleucine; c-lysine, histidine;

d-glycine; e-alanine; f-serine; g-arginine; h-aspartic acid; i-glutamic acid; j-cystine.

(continued on next page)

Table 12 shows the results of an analysis of products prepared from spiny dogfish.

Table 12 Таблица 12

Наименование name of product	a Пределы содержания, %			
	a1 влага	a2 жир	a3 азот (по Кьельдалю)	a4 зола
1 Копченые балыки	36,4—41,6	19,8—27,4	2,7—3,1	11,3—12,1
2 Вяленые балыки	34,6—39,9	20,4—31,6	3,2—3,5	12,1—13,6
3 Кормовая мука из тушек (без печени)	8,9—12,6	10,6—16,7	10,4—11,5	4,6—6,2

1-smoked balyk*; 2-sun-dried fish; 3-fish meal made from carcasses (excluding liver);
a-ranges of percentage content; a1-moisture; a2-fat; a3-nitrogen, determined according to Kjeldahl's method; a4-ash.

Apart from the liver, all inedible parts of the various species of sharks have some fat on them. The chemical composition of these parts (analyses by E. Kleie, T. Soboleva, T. Udelova) is shown in Table 13.

Table 13 Таблица 13

Части тела body parts	1 Пределы содержания, %			
	1a влага	1b жир	1c азот (по Кьельдалю)	1d зола
head Голова	70,2—77,8	0,9—4,5	3,98—9,5	3,4—7,3
fins Плавники	55,5—73,0	0,1—0,6	3,3—6,7	6,2—11,9
viscera Внутренности	73,3—81,0	0,6—1,1	1,2—1,6	3,1—3,96
skin Кожа	61,5—72,8	0,4—5,5	4,4—8,2	3,6—7,8
spine Хребет	62,5—71,3	0,4—0,9	3,9—1,7	8,3—14,4
liver Печень	17,6—52,0	22,5—80,4	0,28—1,5	0,6—1,5

1-ranges of percentage content; 1a-moisture; 1b-fat; 1c-nitrogen (determined according to Kjeldahl's method); 1d-ash.

The shark skins are used in the manufacture of haberdashery items. /14

The dimensions of the skin, of course, are determined by the size of the animal; thus in the Squalidae the skin is no more than

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*Specially prepared longitudinal cuts (Tr.).

0.4--0.5 m^2, while in large gray and blue sharks it is up to 1.5--2 m^2. Skins may be preserved by freezing to prevent swelling and the hydrolysis of collagen in shark skins when they are cured with brine, they should be stored at a temperature of minus 5--10°C.

In eastern countries the tails and fins of sharks are used in the preparation of food products. They are marketed in dried and frozen varieties; pickled shark fins are not in great demand.

The skin, the gristly parts of the head, tail and fins can be used in preparing gelatin and glue. The percentage weight of collagenic material obtained from the head, fins and tail of a shark of the family Squalidae, relative to the undressed weight of the animal, was 10.6--12.4 and 8.1--10.4%, respectively. The amount of gristly material obtained from the head, relative to its weight, was 76.4--80.1%. The yield of dry glue was 3--8%, relative to the raw cartilage.

The liver of sharks is valued for its fat content and for its vitamin A. Its percentage weight, relative to that of the body, and depending on the species, varies from 1.6--31.1%. However, in almost 50% of the shark species investigated the percentage weight of the liver did not exceed 5% (Table 14). In 25--28% of the species the liver was considered as large in size, with a percentage weight of 5--10% of that of the body; and up to 20% of the sharks had a very large liver whose weight amounted to 10--21% of that of the body.

Таблица 14

Вид акулы . species	Относительный вес печени, % (пределы) a
b Высокоперая, кунья, кошачья, кривозубая, малоголовая, мягкогубая, молот, морской ангел, негогалеус, семижаберная, серая, суповая, синяя, усатая, рогатая	1,6—5,0
c Ковровая, гребенчатая, мягкоголовая, белогрудая, косячная, тигровая, белоперая, плавниковая	5,1—10,0
d Сельдевая, колючая, лиса, короткохвостая, черная	10,1—21,1

a-ranges of percentage weight of liver relative to body weight; b-Carcharinus dorsalis, Smooth hound, Lesser spotted dogfish, krivozubaya*, Scoliodon palasorrah, smooth hammerhead shark, angel sharks, negogaleus*, seven-gilled sharks, gray, Soupfin sharks, blue, nurse, and horn sharks;

c-carpet sharks, Brachaelurus, soft-headed, white-breasted, Galeus australia, tiger shark, whitefin shark, fin shark;

d-porbeagle, spiny dogfish, thresher shark, short-tailed shark, black shark.

Changes in the relative weight of the liver did not seem to be linked either to the size, sex or stage of embryo development, or to the area or season when a given animal was caught.

The work of E. Lagovskaya and G. Dolbish indicates that the relative weight of the liver differs even among animals of the same species; in the Squalidae, for example, it varies from 5--21.1% of the weight of the body.

Different species of sharks accumulate from 8--80% of fat in their liver. The fat content depends on a series of biological factors. In one species, for example, the fat content in the liver increases with age, and sharks caught in the spring have less fat in their liver than those caught in the fall, and so on. /15

The content of vitamin A also depends on the species of sharks, their age, condition, area and season of capture.

Based on the published data of Broklesbi (1932), Schmidt-Nil'sen

*See footnote, p. 13. (Tr.).

(1932), Lovern (1934), Pugslei (1940), Toioki (1930) and others, and on the analyses conducted by E. Lagovskaya, G. Dolbish, and I. Denisov, one can generalize to the effect that, subject to the above

Таблица 15

Характеристика печени акул

Вид акулы species	a Пределы содержания жира, %	b Пределы содержания витамина А в *и. е.* на 1 г	
		b1 печени	b2 печеночного жира
Колючая акула (сем. Squalidae)	22,5—77,3	60—19480	110—40440
Сельдевая (сем. Isuridae)	16,1—70,3	120—1260	190—23100
Акула-лиса (сем. Alopiidae)	13,4—55,9	170—4100	300—32900
Серые и голубые акулы (сем. Carcharinidae)	12,0—68,3	180—9800	270—81600
Акула-молот (сем. Sphyrnidae)	8,4—54,9	1270—20800	3100—247900
Ковровая акула (сем. Orectolobidae)	34,3	690	2040

Table 15. Characteristics of shark liver.

a-fat content, in percent; b-vitamin A content in international units per gram, in: b1-liver; b2-liver-oil

factors, the oil and vitamin A content in the liver of various species of sharks varies considerably (Table 15).

The smooth hammerhead shark is of particular interest, for its liver is unusually rich in vitamin A.

According to Kh. Khigashi, S. Muroyama (1959) and the analyses conducted by A. Teplitskaya and I. Nikitina, the liver tissue in sharks is very rich in vitamin B_{12} (Table 16).

Table 16 Таблица 16

Витамины vitamins	Пределы содержания (γ%) в сыром веществе печени content in raw liver tissue
B_1	11—970
B_2	370—1500
Bc	40—530
B_{12}	8—310
PP	3500—22000
Пантотеновая кислота pantothenic acid	640—1700
Фолиевая кислота folic acid	75—155

Intestinal and gastric tissue in sharks contains 0.6--3.5% fat and up to 250 international units of vitamin A. Of the overall amount of vitamin A contained in the shark organism, 85--90% is concentrated in the liver.

The available material on liver-oil in the various species of sharks (Ttsuzhimoto (1919, 1928, 1929), Toioki (1934), Schmidt-Nil'sen (1933), Flud (1934), and others) suggests that its physical and chemical composition varies greatly (Table 17).

Таблица 17

Характеристика жира печени акул

a Пределы содержания неомыляемых веществ, %	b Пределы значения: удельный вес (d^{15}_{4}) b1	коэффициент рефракции (n^{20}_{D}) b2	коэффициент омыления b3	йодное число b4
0,7—4,3	0,9116—0,9351	1,4720—1,4854	175,3—194,4	103,0—200,8
4,8—8,4	0,9078—0,9270	1,4717—1,4841	158,6—185,7	120,5—160,0
9,8—14,6	0,9048—0,9254	1,4715—1,4842	149,7—174,9	75,2—183,9
16,2—28,8	0,9009—0,9176	1,4702—1,4836	131,7—149,2	91,3—174,4
35,8—58,3	0,8749—[illegible]	1,4716—1,4845	76,2—130,1	122,2—236,6
60,5—96,2	0,8658—0,8866	1,4817—1,4930	23,0—75,0	230,0—344,6

Table 17. Characteristics of liver-oil in sharks.
a-content range of nonsaponifying substances; b-range of values; b1-specific weight; b2-coefficient of refraction; b3-saponification number; b4-iodine number.

The figures in Table 17 show that a rising content of nonsaponifying substances in the fat is accompanied by a lower specific weight and saponification number and by a rising coefficient of refraction. The iodine number decreases in a more complex pattern. At first, the increase in nonsaponifying substances, consisting mostly of saturated compounds, causes a relative decrease in unsaturated glycerides, which in turn lowers the iodine number. But the latter rises as highly unsaturated alcohols and hydrocarbons begin to predominate in the nonsaponifying fraction. /16

High iodine numbers make shark-liver oil susceptible to oxidation.

The biochemical feature of shark-liver oil is the high fraction of nonsaponifying substances. The latter do not exceed 2% in only 20% of the investigated species of sharks, in 40% of these species the nonsaponifying substances exceed 15% (Table 18).

(continued on next page)

Table 18 Таблица 18

species Вид акулы (латинское название вида)	a Пределы содержания неомыляемых веществ в жире, %	b Количество видов.
Alopias pelagicus, A. vulpes, Apisturus macrorhynchus, Catulus torazame, Cephalloscyllium umbratile, Cynias manazo, C griseus, Isuropsis sp., I. glauca, Heterodontus zebra, Pristiurus eastamanii, Sphyrna zygaena, Orectolobus japonica	до 2	13 (20%)
Carcharias faurus, C. isobeli, Lamna cornubica, Eugaleus japonica, Mustelus aniarcticus, Orectolobus ornatus Pristiophorus japonica, Pristiurus cattulus, Scoliodon Laticoudus, Squalus mitsukuri, Squatina nebuloska, S. japonica, Scyllium variolitum	2,1—5,0	13 (20%)
Charharinus sp., Carcharinidae albimarginatus, Nebrius concoler Prionace glaucus, Triakis scyllium, Squalus acanthias.	5,1—10,0	6 (10%)
Galeocordo tigrinus, Squalus sp., S. Wakiyae, Heptranchis deani, Uitsukurina owstoni, Xexanchus corinus.	10,1—15,0	6 (10%)
Brachaclurus sp., Cirrhigaleus barbifer, Etmopterus lucifer, E. frontimaculatus, Cetorhinus maxinus, Somniosus brevipinus, Notorhynchus sp., Carcharhinus sp.	15,0—30,0	8 (12%)
Carcharias ferox, Centrohcymnus owstoni, Centrophorus atromarginatus, Centroshyllium ritteri, Lacmargus borealis, Scymnorhinus licho, Zameus squamulosus, Lipidorhinus kinbei Scymnorhinus iicha.	30,1—60	10 (16%)
Dalatius phillipsi, Centrophorus sp., Pristiurus pilosus, Acanthidium aglantinna, Charcharias owstoni, Etmopterus spinax, Echinorhinus brucus, Lepidorhinus foliaceus	60,1—90,?	8 (12%)

a-percentage content of non-saponifying substances in the fat; b-number of species.

The nonsaponifying substances in shark-liver oil consist, apart from cholesterol, of hydrocarbons (squalene, pristane, and substitutes) and to a lesser degree of glycerol ethers (chymiferous, batyl, selachyl) and higher alcohols such as oleic acid and cetyl alcohol. In sharks the bulk of the nonsaponifying substances consist of squalene, which is an unsaturated (iodine number 388.1) terpene hydrocarbon with an empirical formula of $C_{30}H_{50}$. /17

According to M. Ttsuzhimoto (1919), O. Toioki (1935), and others, squalene is present only in liver oil with a high content of nonsaponifying substances. Thus squalene is absent when the nonsaponifying substances amount to only 15%. In oil containing from 16.2--28.8% of nonsaponifying substances the squalene content increases to 13.8%, when the former rises to 30.3--58.3% the squalene rises to 13.5--53.3, and when the nonsaponifying substances increase to 60.5--90.2%, the squalene reaches 58.3--84.8%.

According to Ttsuzhimoto (1928), shark-liver oil contains, in addition to squalene, pristane ($C_{18}H_{38}$) whose content usually does not exceed 1.5%, but in the basking shark it reaches up to 10%.

According to published data, processed shark-liver oil contains from 5.3 to 21.5% (average 10--12%) of nonsaponifying substances. Characteristic of shark livers is a high content of non-saponifying substances, which are biochemical in nature. This is important to remember when shark liver oil is to be used for food or medicinal purposes.

A high content of vitamin A in the liver oil of several species of sharks (for example, the hammerhead species) makes their liver an important source of an oil from which subsequently a vitamin A concentrate is obtained by way of molecular distillation.

The fluctuations of the physical and chemical properties of shark-liver oil are illustrated in Table 19, where the data

(continued on next page)

Таблица 19

Химические и физические константы печеночных жиров тихоокеанских видов акул

Наименование семейства family	d_4^{15}	$n_Д^{20}$	Число омыления a	Йодное число b	Неомыляемых веществ, % c
		Подотряд рогатых акул (Heterodontiformes)			
Рогатые акулы (Heterodontidae)	0,9291 / 0.9305	1,4745 / 1,4781	178,5 / 186,3	119,6 / 138.5	2,2 / 3,9
		Подотряд гребнезубых акул (Hexanchiformes)			
Гребнезубые акулы (Hexanchidae)	0,9146 / 0,9246	1.4734 / 1,4800	165,8 / 183,0	103,1 / 171,3	3,5 / 15,2
Плащеносные акулы (Chlamydoselachidae)	0,8749 / 0,8885	1,4716 / 1,4725	93,4 / 115,8	130,3 / 134,4	37,1 / 51,7
		Подотряд сельдеобразных (Lamniformes)			
Сельдевые акулы (Isuridae)	0,9178 / 0,9393	1,4741 / 1,4815	175,2 / 188,1	109,3 / 181,2	0,8 / 3,6
Лисьи акулы (Alopiidae)	0,9197 / 0,9293	1,4750 / 1,4829	183,9 / 188,1	123,2 / 181,2	0,7 / 3,6
Кошачьи акулы (Scyliorhinidae)	0,9161 / 0,9308	1,4725 / 1,4815	178,8 / 184,5	103,1 / 197,9	0,9 / 1,5
Молот-акулы (Sphyrnidae)	0,9312 / 0,9334	1,4853 / 1,4854	174,0 / 184,2	155,6 / 205,6	1.0 / 8,3
Серые и голубые акулы (Carcharhinidae)	0,9094 / 0,9334	1.4729 / 1,4853	147,0 / 187,2	100,5 / 205,6	2,9 / 21,6
Ковровые акулы (Orectolobidae)	0,9277	1,4798	194,4	169,5	1,3
		Катранообразные акулы (Squaliniformes)			
Колючие акулы (Squalidae)	0.8633 / 0,9254	1,4707 / 1,4930	29,0 / 178,3	102,2 / 281,4	6,3 / 90,2
Echinorhinidae	0,8806 / 0,8990	1,4790 / 1,4872	62,9 / 130,1	122,2 / 269,2	35,8 / 68,6

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Table 19. Chemical and physical constants of liver oils of Pacific sharks.
a-saponification number; b-iodine number; c-percentage of non-saponification number.

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of the above-mentioned researchers (M. Ttsuzhimoto, O. Toioka, A. Flud, and others) and of the TINRO researchers (L. Vakulyuk, E. Lagovskaya, V. Adistanova, L. Khorynskaya, L. Kaletina, V. Bochkareva and others) are systematized according to individual shark families which inhabit the Pacific Ocean and adjacent seas.

The triglyceride content in shark-liver oil is inversely proportional to the nonsaponifying fraction. The following fatty acids were discovered in the triglycerides (Ttsuzhimoto (1928), Toioki (1935), Lovern (1936) and others): saturated: C_{14} from 1 to 6; C_{16} from 10.5 to 14.5; C_{18} from 0.5 to 3.0; C_{20} not more than 1.0; unsaturated: C_{14} from single traces to 1.5; C_{16} (--2.0) from 4.0 to 12.0; C_{18} (--2.2) from 19.0 to 35.5; C_{20} (--2.6) from 10.5 to 32.5; C_{22} (--6.1) from 12.0 to 26.0; C_{24} (--6.0) from 6.0 to 12.0. (The figures in parenthesis indicate the number of double bonds).

Thus the bulk of the fatty acids consists mainly of palmitic acid, while myristic and stearic acid is present in considerably lower quantities.

Predominant among the unsaturated fatty acids are C_{18}, C_{20} and C_{22}; and the highly unsaturated acids included linolenic acid ($C_{18}H_{30}O_2$), moroctitic* ($C_{10}H_{28}O_2$), clupanodonic acid ($C_{22}H_{34}O_2$) and $C_{20}H_{30}O_2$, $C_{20}H_{32}O_2$, $C_{22}H_{36}O_2$ acids.

The presence of highly unsaturated fatty acids makes shark-liver oil extremely unstable with respect to the oxygen of the air. At the same time, the presence in the liver of active hydrolytic enzymes rapidly hydrolyzes the oil. Hence when shark livers are processed the tissue enzymes should be inactivated as quickly as possible to prevent the oil from oxidizing. As soon as the sharks are hoisted aboard, the liver is removed, washed with sea water and

*Transliterated from Russian (Tr.).

packed and sealed into airtight metal containers (14--16 kg). Shark liver is preserved variously--by freezing, and by dry-salting (10--15%) and subsequent cold storage. The enzymes can be deactivated quickly by heating the packed open containers to 90--100°C, followed by sealing, cooling, and cold storage. Recently the liver has been frozen and stored in thermostable sacks made of synthetic material.

Skates. Of the skates (suborder Batoidea), common skates of the family Rajidae (9 species) and stingrays of the family Dasyatidae (3 species) are harvested in considerable quantities in all Far Eastern seas. In the southern Pacific representatives of the Rhinobatidae are encountered also.

Skates caught on the bottom of the sea usually weigh 2.5--5.5 kg; however, their weight can vary from 0.5 to 250 kg. There are no notable distinctions in the weight ratios between parts of the body /19
in skates and stingrays, but characteristic of all the species investigated was a relatively high weight ratio between the viscera and the heads (Table 20).

(continued on next page)

Таблица 20

Весовые соотношения частей тела скатов

	Части тела body parts	Пределы, % percentages: обыкновенные скаты (Rajidae)	скаты-хвостоколы (род Dasyatidae)	скаты рохлевые или морские гитары (Rdinobatidae)
a	Голова	16,8—21,7	24,6—28,6	26,0
b	Хвост	8,6—12,5		
c	Внутренности,	17,0—26,7	20,1—25,0	5,3
	в т. ч. печень	3,6—9,2	6,6—9,4	1,8
d	Тушка	—	—	61,0
e	Плавники	1,5—3,0	2,5—3,5	6,5
f	Хрящи	4,0—6,0	4,0—6,0	9,0
g	Мясо с кожей	42,9—48,6	41,2—45,4	51,2
h	Кожа	—	—	8,8
i	Мясо без кожи	—	—	41,5

Table 20. Weight correlations of body parts in skates

a-head; b-tail; c-viscera including liver; d-carcass; e-fins; f-cartilage; g-meat with skin; h-skin; i-meat without skin;

The analyses of I. Varpakhovskii, Z. Podoba, and V. Adistanova indicate that skate meat has a low fat content but that it is well hydrated (Table 21).

Таблица 21

Химический состав частей тела скатов

Вид species	Что исследовалось body part studied	a Пределы содержания, %: влага a1	жир a2	азот (по Кьельдалю) a3	зола a4
Скат южный (Raja clavata)	Мясо flesh	73,6/80,1	0,4/0,8	2,9/3,9	1,3/3,0
	Внутренности (без печени) viscera without liver	70,1/72,7	1,9/2,0	1,9/2,3	1,0/1,9
	Печень liver	—	13,5/37,4	—	—
Скат Смирнова (Raja smirnovi)	Мясо flesh	74,2	0,7	3,7	2,0
Рохля пятнистая (Rhinobatus djidensis)	Мясо flesh	74,6	0,2	4,2	1,7
Скат хвостокол (Dasyatis acajei)	Мясо flesh	76,5/82,5	0,9/1,2	2,5/3,2	1,9/2,6
	Печень liver	38,6/39,7	49,8/51,6	1,3/1,6	0,3/0,5
Скат хвостокол (Dasyatis sephen)	Мясо flesh	75,6/79,4	0,8/1,1	3,1/3,5	1,3/2,6

Table 21. Chemical composition of body parts in skates

a-percentage content; a1-moisture; a2-fat; a3-nitrogen (determined according to Kjeldahl's method); a4-ash.

N. Rublevskaya's analyses showed that skate meat (Rhinobatus djidensiss and Rhyna ancylostoma) contains 2.1--2.15% of urea, 0.48% of trimethyl amine oxide and 2.4--2.9 mg% of trimethyl amine.

Of the overall N-content in skate meat 25--30% (30--38% according to Sh'yuen) is nonprotein N which consists mainly of urea nitrate. Thus skate meat contains relatively little simple protein--it varies from 10.8--18.4% and on the average doesn't exceed 15%, that is to say, noticeably less than in shark meat.

The fragmentary data that have appeared in the literature, along with E. Nasedkina's analyses, indicate that, compared to the proteins of shark meat, those of skate meat contain somewhat fewer essential amino acids and that the nonessential amino acids in the vitamins of skate meat contain much more arginine. /20

Skate meat, according to A. Teplitskaya, contains ($\gamma\%$) vitamin B_{12} (0.5--2.5), B_2 (100--300), Bc (100) and PP (3000--10500).

Moreover, compared to shark meat, skate meat has the less attractive organoleptic qualities. Skates, after their liver has been removed, should be processed for feed products. Of the visceral parts in skates the liver is of considerable interest; it contains significant amounts of oil and vitamin A.

The investigations of E. Lagovskaya, G. Dolbish and others have shown that in stingrays (Dasvatis acajei), caught in the period from July to October in various areas of the Far East (the maritime coast, Sakhalin, Kuril Islands, and Kamchatka), the weight of the liver varies within 3.6 to 9% (usually 5--7%) of the weight of the body, and the oil content of the liver also varies greatly (from 4.8 to 52.3%, usually 26--30%).

The vitamin A content in 1 g of liver tissue varies from 5 to 7190 international units, while that of 1 g of liver oil varies from 110 to 60940 intern. units (usually 1200-1500).

E. Lagovskaya established in stingrays a direct relationship between the vitamin A content in liver oil and body weight. Skates weighing up to 5 kg had a vitamin A content of 500--600 intern. units per g of liver oil. In animals weighing over 12 kg the vitamin A content rose to 1100--3200 i. u. per g of liver oil. In summer liver oil contains more vitamin A than in other seasons.

According to G. Dolbish, in the species Raja parmifera the weight of the liver, relative to that of the body, varies from 5.1 to 6.3% and its oil content varies from 13.5 to 37.4% with 480 to 2120 i. u. of vitamin A per gram.

The common European skates (Rajidae) (Schmidt-Nil'sen, 1933) have a larger liver (from 4 to 12% and usually from 8--10% relative to the weight of the animal's body). The oil content of the liver also varies significantly (from 7.0 to 61.5%), depending on the species (for example, Raja tullonica 7.0--14.0%, Raja nidrosiensis 44.0--61.5%) and on other causes of a biological character. A. Teplitskaya also discovered vitamin B_{12} in skate livers (from 6.5 to 20.5 γ%), B_1 (127), B_2 (500--1000), Bc (100--500) and PP (2500--15500).

Fresh skate-liver oil has a pale yellow color and satisfactory organoleptic qualities. At 18--22°C the oil is transparent, but at 10--12°C hard glycerides begin to precipitate. Skate-liver oil is distinct in that its physical and chemical properties make it fairly unstable, especially with regards to the iodine number and content of nonsaponifying substances. The data of E. Lagovskaya, E. Kaletina, M. Ttsuzhimoto (1916), Schmidt-Nil'sen and A. Flud (1933) on the chemical composition of skate-liver oil are summarized in Table 22.

K. Gukh, T. Khildich, and Zh. Lovern (1930, 1934, 1936) have noted that the saturated fatty acids in the liver oil of common skates (Rajidae) consist of mainly palmitic (14%) and myristic (4%)-- and in angel sharks of palmitic (17%) acid. Their unsaturated fatty acids consist of the acids C_{18}--C_{22}, but the ratio of the individual /21
acids shows sharp distinctions (Table 23).

Table 22 Таблица 22

Наименование Family	d_4^{15}	$\eta_Д^{20}$	Число омыления a	Йодное число b	Неомыляемые вещества, % c
Скаты хвостоколы (Dasyatidae)	0,9106 0,9316	1,4728 1,4843	140,2 194,2	105,7 200,0	1,0 12,6
Обыкновенные скаты (Rajidae)	0,9099 0,9345	1,4678 1,4860	149,0 186,1	105,8 186,6	1,1 23,7
Морские ангелы (Squatinidae)	0,8866 0,9393	1,4720 1,4843	120,9 189,0	106,0 225,0	1,7 57,1
Длинные скаты рохлевые (Rhinobatidae)	0,9267	1,4825	182,8	183,7	3,2
Скаты рогачи-манта (Mobulidae)	0,9328	1,4855	182,3	202,2	3,2

a-saponification number; b-iodine number; c-percentage of nonsaponifying substances.

Thus, in comparison with shark-liver oils, skate-liver oils contain a little more polyene acids of high molecular weight and hence oxidize more quickly. The high iodine numbers indicate that skate-liver oils are unstable, while the high upper limits of the nonsaponifying fraction precludes the use of skate-liver oil for medicinal purposes.

Table 23 Таблица 23

Семейство family	acid content Содержание кислот, % in percent				
	C_{14}	C_{16}	C_{18}	C_{20}	C_{22}
Rajidae	traces of следы	10,5 (—2,0)	20,5 (—3,3)	32,5 (—7,5)	18,5 (—9,5)
Squatinidae		6,5 (—2,0)	20,7 (—3,0)	21,9 (—6,0)	30,5 (—10,2)

HOLOCEPHALI

(Chimaeridae)

Of the numerous species of the family Chimaeridae caught in Far Eastern waters, the Hydrologus barbouri is encountered most frequently. Dressed, its carcass constitutes up to 50.8% of the weight of the body, the head has a percentage weight of 25.3--30.7%, the viscera 18.9--23.9%, the liver 14.1% and the fins 6.2--7.9% (analysis by M. Borisova).

The meat and tissues of all the other parts of its body, excluding the liver, contain very little fat (Table 24). Due to the high content of proteins in the meat, their degree of hydration does not exceed 340--350%. The meat has an unpleasant smell and taste. A. Teplitskaya found that the meat of the speckled chimaeras contained

Таблица 24

Химический состав частей тела химеры

Части тела body parts	Пределы содержания contents			
	влага water	жир fat	белок protein	зола ash
Мясо flesh	78,3 79,3	0,06 0,10	20,2 22,2	1,2 1,4
Печень liver	14,3	66,4	—	—
vertebrae, fins, head Позвонки, плавники, голова	78,8 82,4	0,5 0,9	14,1 19,6	2,3 3,0

Table 24. Chemical composition of body parts of the chimaeras.

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the vitamins B_2(300), B_{12}(2), and PP(4000 γ %). Kh. Khigashi's data (1959) indicate that the flesh of this fish is low on pantothenic (110 γ %) and folic (2.7 γ %) acid.

Khigashi also found (1959) that these acids are in low supply /22 in the chimaera-liver (pantothenic up to 70 γ % and folic up to 32 γ %).

Chimaera-liver oil has a low iodine number (93--94), a saponification value of 138.0--140.6 and a high percentage (19.9--22.2%) of non-saponifying substances (Kleie, 1959). Its vitamin A content does not exceed 210--220 i.u. per gram (Ttsuzhimoto, 1919, 1926; Nil'sen, Flud, 1933, 1936; Toioki, 1935, and others). Chimaera-liver oil has a $d^{15}4$ - 0.8980--0.9184, a refractive index of 1.4682--1.4755, a saponification value of 131.3--172.8, a low iodine number of 82.6--128.7, a high percentage (18.5--37.5%) of non-saponifying substances and low (82.6--128.7) iodine numbers [sic]. Zh. Lovern established that the fatty acids C_{18} and C_{20}

(70.2%) predominate in chimaera-liver oil and that the saturated fatty acids consist of palmitic (8.4%) and stearic (7.2%) acid.

Acids predominate among the unsaturated fatty acids (50.6%), and the acids C_{20} and C_{22}, which constitute 27.5%, are dominated by acids with triple and double bonds. The composition of chimaera-liver oil makes it useful only for industrial purposes.

IV. The Higher Fishes (Teleostomi)

I. Cartilaginous Ganoids (Chondrostei)

The family of sturgeon fish (Acipenseridae) belongs to the suborder of cartilaginous ganoids (Chondrostei).

In the Far Eastern waters there are three representatives of this family: the Amur sturgeon (Huso dauricus)*, the Amur sturgeon (Acipenser schrencki) and the Sakhalin sturgeon (Acipenser medirostris). In the Far East these species are sought after in the lower Amur river basin (from Khabarovsk to the estuary), with the largest fish being caught in the estuary. Here the Huso dauricus and other sturgeons reached a weight of 100--150 and 20--30 kg, respectively, and midway upstream 20--50 and 2--5 kg, respectively. The largest species of Huso dauricus encountered in the estuary weighed 950--1200 kg.

The weight ratios of body parts of Amur sturgeon, as researched by E. Koshubo and I. Varpakhovskii, are given in Table 25.

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*"Huso dauricus": also known as "kaluga" (Tr.).

Table 25 Таблица 25

Части тела body parts	a Пределы содержания в % к весу рыбы	
	осетр Amur sturgeon	калуга Huso dauricus
head Голова	11,6—20,6	10,9—14,2
tail and fins Хвост и плавники	2,4—6,9	3,0—7,6
cartilage Хрящи	10,8—13,6	9,4—12,6
dried spinal cord Вязига	0,7—1,2	0,3—0,7
bony plates Жучки	1,0—1,7	1,6—2,3
fillet with skin Филе с кожей	52,6—59,0	50,6—54,9
skin Кожа	7,5	6,5—8,3
viscera Внутренности,		
milt в т. ч. молоки	1,5—4,5	0,1—5,6
roe икра	11,4	8,3—12,6
liver печень	2,4	1,8—2,6
swim bladder плавательный пузырь	0,6	0,4—0,6
other visceral parts прочие внутренности	5,1	4,3—6,8

a-percentage weight of parts relative to body

On the production line the percentage weight (relative to that of the body) of the Amur sturgeon and Huso dauricus is as follows: gutted: 82.5--87%; gutted, decapitated and without fins: 75--78%; fillets with skin; 56--57%.

Sturgeon meat has excellent organoleptic qualities. Data on the chemical composition of the meat of Amur sturgeon and the

Таблица 26

Химический состав мяса осетровых рыб

	Вид species	Пределы содержания, % content			
		влага water	жир oil	белок protein	зола ash
a	Осетр амурский	71,5—74,9	6,2—9,4	17,7—18,1	0,9—1,2
b	Осетр волго-каспийский и сибирский	61,9—74.7	8,9—17,7	14,7—16,7	0,9—1,7
c	Калуга амурская	75,4—76,9	3,9—5,8	16,8—17,2	1,1—1,4
d	Белуга волго-каспийская	71,0—79,9	3,4—8,2	15,2—19,4	0,9—1,2

Table 26. Chemical composition of sturgeon meat.

a-Amur sturgeon: b-Volga-Caspian and Siberian sturgeon;
c-Huso dauricus; d-Volga-Caspian beluga.

Huso dauricus, compiled by L. Vakulyuk and I. Varpakhovskii, are presented /23 in Table 26. Also included in this Table are comparative data, compiled by A. Popov, V. Osipov, V. Podsevalov, and O. Yudanov, on the meat composition of the Caspian beluga and on the Volga-Caspian and Siberian sturgeon.

The chemical composition of the meat of the Huso dauricus is similar to that of the Caspian beluga. But the meat of the Amur sturgeon, compared to that of the Siberean and Volga-Caspian sturgeon, is less fatty.

The color of sturgeon oil varies from intense yellow to reddish-orange, with a pleasant taste and smell. At room temperature this oil is liquid and transparent. The values of the physical and chemical constants of sturgeon oil, based on analyses of E. Kaletina, V. Adistanova and Z. Podoba and on the work of T. Kir'yanova (1934), A. Matveeva (1934), A. Matveeeva (1934) and others, are presented in Table 27.

Table 27 Таблица 27

Вид species	Откуда получен жир part from where fat was taken	d_4^{15}	n_D^{20}	a Кислотность	b Число омыления	c Йодное число	d Неомыляемых веществ, %
Amur sturgeon Осетр амурский	Мясо flesh	0,9190	1,4680	0,4	187,6	127,8	0,7
		0,9220	1,4720	0,6	192,3	130,7	2,3
	Внутренности viscera	0,9180	1,4680	1,3	195,9	138,2	1,8
		0,9230	1,4770	2,6	198,7	140,1	2,8
Volga-Caspian and Persian sturgeons Осетр волго-каспийский и куринский	Мясо flesh	0,9224	—	0,2	186,3	122,4	1,0
		0,9236	1,4747	0,3	189,1	125,3	3,0
	Икра roe	0,9242	1,4776	1,1	190,7	140,1	1,0

a-acidity; b-saponification number; c-iodine number; d-percentage of non-saponifying substances.

The body fat of the Amur sturgeon differs from that of the Volga-Caspian and Persian sturgeons by its higher iodine numbers. Oil from visceral parts and from roe have the highest iodine numbers. The

Table 28 Таблица 28

Наименование продукта product	Пределы содержания, % content: влага water	жир fat	белок protein	зола ash	в числе золы соль salt in ash
a Балык копченый из амурского осетра	47,4 53,4	18,3 29,5	18,6 23,8	6,7 10,5	5,7 9,7
b Теша копченая из амурского осетра	45,3	30,4	15,3	8,7	7,8
c Балык копченый из амурской калуги	49,8 51,2	15,3 17,0	26,7 26,8	6,6 8,8	5,8 7,8

a-smoked balyk (Amur sturgeon); b-smoked belly (Amur sturgeon); c-smoked balyk (Huso dauricus).

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amount of low-molecular fatty acids contained in sturgeon oil is insignificant (Reichert-Meissl number 0.5--0.8 and Polenske number 0.8--1.8). The content of saturated fatty acids varies within 17.3--19.5% and that of the unsaturated fatty acids within 75--78%.

Sturgeons are an excellent source from which to prepare smoked and dried balyk, belly and flank fillets. The chemical composition of these products, made from Amur sturgeon and Huso dauricus, is given in Table 28.