TARBAGAN FAT, ITS COMPOSITION AND PROPERTIES

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The tarbagan is a terrestrial animal belonging to the family Sciuridae, which comprises about 30 genera, including the genus *Marmotta*. One of the varieties of this genus is *Marmotta sibirica* (Siberian marmot), which has almost the same name in English, French, and German. Only the inhabitants of the Mongolian People's Republic call this variety by the Turkic name "tarbagan," and this name has been adopted in the Soviet scientific literature [1, 2].

The tarbagan plays an important role in the life of the Mongolian people: tarbagan fur is exported in considerable amounts, and the meat is consumed by the local population for food. In spite of the fact that about a million or more tarbagans are caught and processed each year, their fat is collected in extremely small amounts.

Tarbagan fat is liquid with a high iodine number, which is a consequence of the living conditions of this animal at low temperatures — of the order of −40-52°C. For nine months of the year, the animal sleeps in its burrow. So that the normal vital activity of the organism can take place at such low temperatures, the animal's fat must remain liquid and must be able to circulate freely in the body.

We have studied the fatty-acid and glyceride compositions of tarbagan fat and its physical and chemical properties.

The fat was extracted from the fatty-acid tissues of the tarbagan by classical methods — by pressing after heating at 80-90°C for 1-1.5 h or by extraction with 1,2-dichloroethane followed by the elimination of the solvent by distillation. The first method extracted 71-83% of the total amount of fat, and the second method 90-93%.

In view of the peculiar living conditions of the animal, we repeated this experiment twice: in September, before the animal fell asleep we extracted the "autumn" fat, and on the second day after it left its burrow — the "spring" fat. In the determination of the physicochemical indices of these fats we used the standard methods of investigation and, in particular, for determining iodine numbers, Hübl's method. The indices obtained are given in Table 1. The dependence of the physicochemical properties of the fat on the sex and age of the animal and the position of deposition of the fat are given in Table 2.

On comparing the figures in the tables, attention is attracted by the following facts. The fats obtained by the melting-out method under similar conditions have different acid numbers: in the autumn fat the acid number is 10 times greater than in the spring fat. The iodine number of the autumn fat is 2% lower than that of the spring fat. This is apparently the result of a reduction of the thickness of the subcutaneous layer of fat during the period of hibernation. Fairly high values of the iodine numbers, which characterize the degree of unsaturation of the fat, were observed for the subcutaneous fat as compared with the internal fat.

For the spring fat, the value of the Reichert–Meissl number is much higher (3.96%) than for the autumn fat (1.52%). Since the Reichert–Meissl number is an index of the amount of low-molecular-weight water-soluble fatty acids, we must ascribe this rise at the moment when the animal issues from hibernation to the fact that in the hibernation period the animal feeds on its "reserves," i.e., it digests the stores of fat accumulated by the autumn, which contain high-molecular-weight fatty acids. The same situation can explain the even-greater increase in the Polenske number on passing from autumn fat to spring fat (0.38-1.76%).

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TABLE 1. Physicochemical Properties of Tarbagan Fat According to the Seasons of the Year*

Index	Autumn fat	Spring fat
Consistency	Liquid	Liquid
Color	Yellowish white	Yellowish white
Odor	Peculiar	Peculiar
Refractive index at 20°C, n_D^{20}	1,4712	1,4710
Density index at 20°C, g/cm³	0,9060	0,9069
Melting point, °C	−2° to −4°	−2° to −4°
Viscosity, °E	7,12	7,18
Acid No., mg KOH/g	0,13	1,36
Saponification No., mg KOH/g	193,28	191,50
Ester No., mg KOH/g	193,15	190,14
Iodine No., mg KOH/g	92,89	90,50
Peroxide No., mg KOH/g	0,09	0,83
Reichert–Meissl No., ml of 0.1 N KOH per 5 g of fat	1,52	3,96
Polenske No., ml of 0.1 N KOH per 5 g of fat	0,38	1,76
Unsaponifiables, %	0,49	0,38

*Samples of the mixed fat of animals of both sexes and different ages were analyzed.

TABLE 2. Physicochemical Properties of Tarbagan Autumn Fat in Dependence on the Sex and Age of the Animal and the Site of Deposition of the Fat

Index	Young animal		Male	
	subcutan.	internal	subcutan.	internal
Density at 20°C, g/cm³	0,9240	0,9232	0,9240	0,9310
Refractive index at 20°C, n_D^{20}	1,4746	1,4721	1,4715	1,4714
Melting point, °C	−4,1	−5,3	−4,3	−6,4
Viscosity, °E	7,4	7,3	7,4	7,8
Acid No., mg KOH/g	1,07	1,10	2,46	2,77
Saponification No., mg KOH/g	190,09	190,14	185,07	187,83
Iodine No., % I_2	109,70	99,66	95,50	92,59
Peroxide No., % I_2	0,59	0,62	1,94	1,33
Reichert–Meissl number, ml 0.1 N KOH per 5 g of fat	1,63	1,87	1,64	1,39
Polenske number, ml 0.1 N KOH per 5 g of fat	0,74	0,76	1,01	1,01
Unsaponifiables, %	0,48	0,44	0,49	0,53

Index	Female		Two-year animal	
	subcutan.	internal	subcutan.	internal
Density at 20°C, g/cm³	0,9213	0,9214	0,9256	0,9236
Refractive index at 20°C, n_D^{20}	1,4718	1,4714	1,4720	1,4715
Melting point, °C	−5,0	−5,3	−3,0	−6,0
Viscosity, °E	7,4	7,6	7,6	7,5
Acid No., mg KOH/g	1,94	1,80	1,10	1,90
Saponification No., mg KOH/g	189,04	178,76	194,26	187,83
Iodine No., % I_2	96,39	94,90	99,50	95,63
Peroxide No., % I_2	1,59	1,17	1,03	0,83
Reichert–Meissl number, ml 0.1 N KOH per 5 g of fat	1,62	1,34	1,73	1,70
Polenske number, ml 0.1 N KOH per 5 g of fat	0,54	0,39	0,56	0,58
Unsaponifiables, %	0,47	0,47	0,49	0,34

TABLE 3. Fatty-Acid Compositions of the Triglycerides

Group of acids	Acid	Content of acids, %	
		in triglycerides	in monoglycerides
Saturated	C_{10}—C_{14}	1,02	5,01
	C_{15}	0,15	0,66
	C_{16}	18,35	8,02
	C_{17}	0,98	0,87
	C_{18}	2,62	1,34
Total saturated		23,12	15,90
Monoenoic	$C_{16:1}$	2,51	3,57
	$C_{17:1}$	0,82	0,81
	$C_{18:1}$	57,02	58,98
Total monoenoic		60,35	63,36
Dienoic	$C_{18:2}$	6,46	10,40
Trienoic	$C_{18:3}$	10,07	10,34
Grand total		100,0	100,0

Table 2 shows the absence of an appreciable difference between the fats of the males and females and of young and adult animals and between the subcutaneous and internal fat.

The most important characteristics of any fat are its fatty-acid and glyceride compositions. To determine the fatty-acid composition of the fat we freed it from accompanying unsaponifiable matter [3] and then, making use of the method of cold saponification, we subjected the acids liberated in this way to methylation [4] and analyzed the resulting mixture of fatty-acid methyl esters by gas–liquid chromatography.

Since the indices of the fatty-acid composition of an oil are insufficient to establish its glyceride composition, we used for this purpose the β-monoglyceride fraction obtained by the selective enzymatic hydrolysis of the fat with the aid of cattle pancreatic lipase. The combination of the indices of the fatty-acid composition of the triglyceride and the monoglyceride fractions (Table 3) permitted the compositions and structures of all the glycerides of this fat to be calculated, for which purpose we used Coleman's method [5-7] in Markman's variant [8].

Calculation by this method gave the results shown below [the following abbreviations are used: St — sum of the saturated acids (stearic); Ol — monoenoic (oleic) acids; L — linoleic acid; and Le — linolenic acid]:

Glyceride	Amount, %	Glyceride	Amount, %
StStSt	1.14	StLL	9.25
OlStSt	5,00	OlLL	0,55
LStSt	0,38	LLL	0,02
LeStSt	0,84	LeLL	0,10
OlStOl	5,51	StLLe	0,56
LStOl	0,84	OlLLe	1,22
LeStOl	1,86	LeLLe	0,10
LStL	0,03	OlLOl	3,30
LeStL	0,14	StLSt	0,74
LeStLe	0,16	LLOl	3,28
StOlOl	19,92	StLeLe	0,55
OlOlOl	21,93	OlLeLe	1,21
LOlOl	3,34	LLeLe	0,10
LeOlOl	7,42	LeLeLe	0,10
StOlSt	2,53	StLeL	0,24
LOlSt	1,52	OlLeL	0,54
LeOlSt	3,36	LLeL	0,02
LOlL	0,13	StLeOl	3,26
LeOlL	0,56	OlLeOl	3,58
LeOlLe	0,63	StLeSt	0,74

On summing the figures given with respect to the characteristic of saturation (S) and unsaturation (U) of the fatty-acid radicals, without taking position isomerism into account, we obtain four types of glycerides:

Glycerides	Amount, %
GlS_3	1.14
GlS_2U	12.23

$GlSU_2$	41.48
GlU_3	41.15

and taking isomerism into account, six types of glycerides:

Glycerides	Amount, %
GlSSS	1.14
GlSSU	6.23
GlSUS	6.01
GlSUU	32.95
GlUSU	8.54
GlUUU	45.15

It is not surprising that with such a high amount of highly unsaturated glycerides ($SU_2 + U_3 \approx 87\%$) the fat remains liquid even under the winter conditions of the Arctic regions.

SUMMARY

The fatty-acid composition of tarbagan fat has been determined. An amount of unsaturated acids has been found in it which is unusually high for terrestrial animals. This fact is one more argument in confirmation of the validity of the climatic theory of the structure of fats due to Ivanov [9-12].

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