A STUDY INTO THE FATTY ACID COMPOSITION AND THE PHYSICO-CHEMICAL INDICES OF BONE FAT AND METHODS FOR IMPROVING ITS QUALITY

A high fat content in bones allows to utilize them as a raw material for the production of fats having different physico-chemical characteristics.

There is scanty information characterizing differential fatty acid composition and physico-chemical indices of bone fat as related to the nomenclature of bone from which fat is produced.

Bone fat, produced according to hygienic rules, is a standard-quality product having milder consistency as compared to beef and mutton tallow. It contains essential fatty acids, has a pleasant specific odour and taste and a yellow colour determined by the availability of vitamin and provitamin A (carotene), is easily digested (97%) /1, 2/.

An extensive study was carried out, aimed at determining the fatty acid composition of the fat produced from various skeletal bones of cattle and pigs, viz. of vertebrae, epiphyses, pelvic bones and ribs of cattle and of long bones of pigs.

Bones were ground into pieces no more than 40 mm, defatted at 90°C, re-ground down to 25 mm and centrifuged.

The fat after primary and secondary defatting was purified and bleached in a separator and sampled for chemical analyses.

Fatty acid composition was determined by gas-liquid chromatography with preliminary methylation of the samples by A.G.Vereshtchagin's method /3/. Fatty acid methyl esters were separated with a "Pye" chromatograph (England): carrier gas - argon; detector - argon, ionization; hard carrier - Celit-545 (100-120 mesh); liquid phase - polyethylene glycol-adipate (15% of carrier weight). They were identified by the values of relative retention volumes.

Results are given in Table 1.

In all the samples of bone fat, produced from different bones, octadecaenoic acid prevailed (from 38.1% in the fat from beef ribs to 52.6% in the fat from pig long bones). Essential fatty acids content is comparatively low, in fat from pig bones it was

2.3-5.8%.

We established that the level of octadecanoic acid was within 11.7-19.4%, it being least in the fat from pig long bones (9.7%); this is determined with a lower melting temperature and a higher iodine number.

Of saturated acids, hexadecanoic acid content is highest (22.3-31.2%), in pig bone fat it is 22.3-23.5%.

In all the cases the fat after secondary defatting of bones has a higher iodine number.

The comparison of the fatty acid compositions of various bone fats allows to determine from what kind of bones, mixed bones or fats mixture a given fat was manufactured.

The following correlations are suggested and calculated (Table 2):

$$R_1 = \frac{\text{unsaturated acids } C_{14}}{C_{14}\text{(tetradecanoic)}} \times 100$$

$$R_2 = \frac{\text{total acids } C_{14} + \text{total acids } C_{15}}{C_{16}\text{(hexanoic)}} \times 100$$

$$R_3 = \frac{C_{18}\ 11}{C_{16}} \times 100$$

Simultaneously, the basic physico-chemical characteristics of fat differentiated by bone anatomical features (Table 3).

Total unsaponifiables in bone fats are significantly higher than in other animal fats produced from soft fatty materials. Lecithine content in bone fat is 4-6 times as high as in fat produced from soft raw materials. Bone fat has good emulsifying capacity.

Dilatometric studies (Fig. 1) showed that fat from epiphyses, mixed beef bones and pig long bones is of the best plasticity as it contains 15-30% hard triglycerides at 20°C.

Bone fat quality is greatly determined with processing conditions and the equipment used for extraction. The analysis of the available methods for bone defatting indicates that they are time-consuming, accompanied with a considerable loss of proteinaceous substances, the finished product gives low yields and is of low quality, this being conditioned by the use, in most cases,

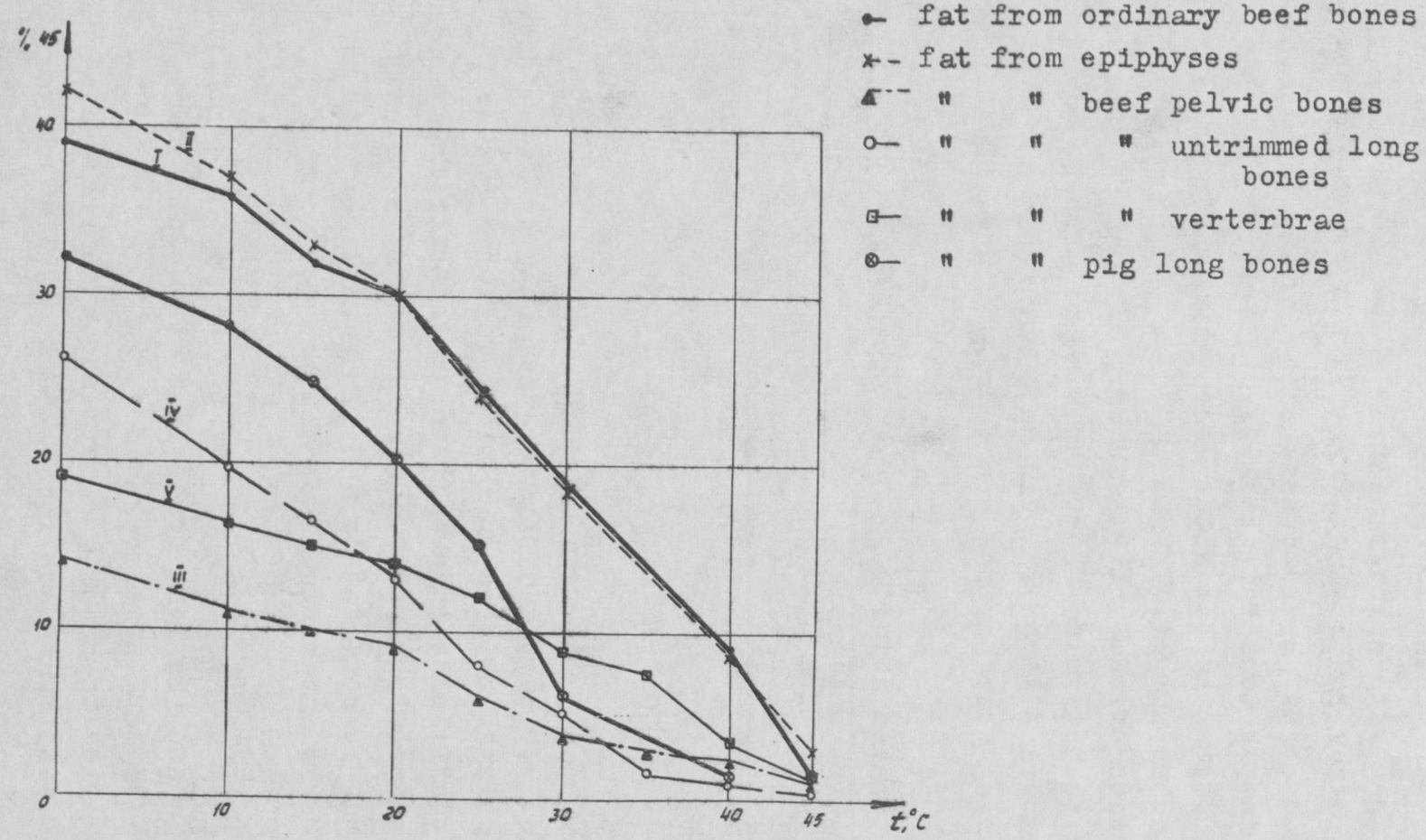

Fig. 1. Hard triglycerides content in various bone fats as influenced with temperature

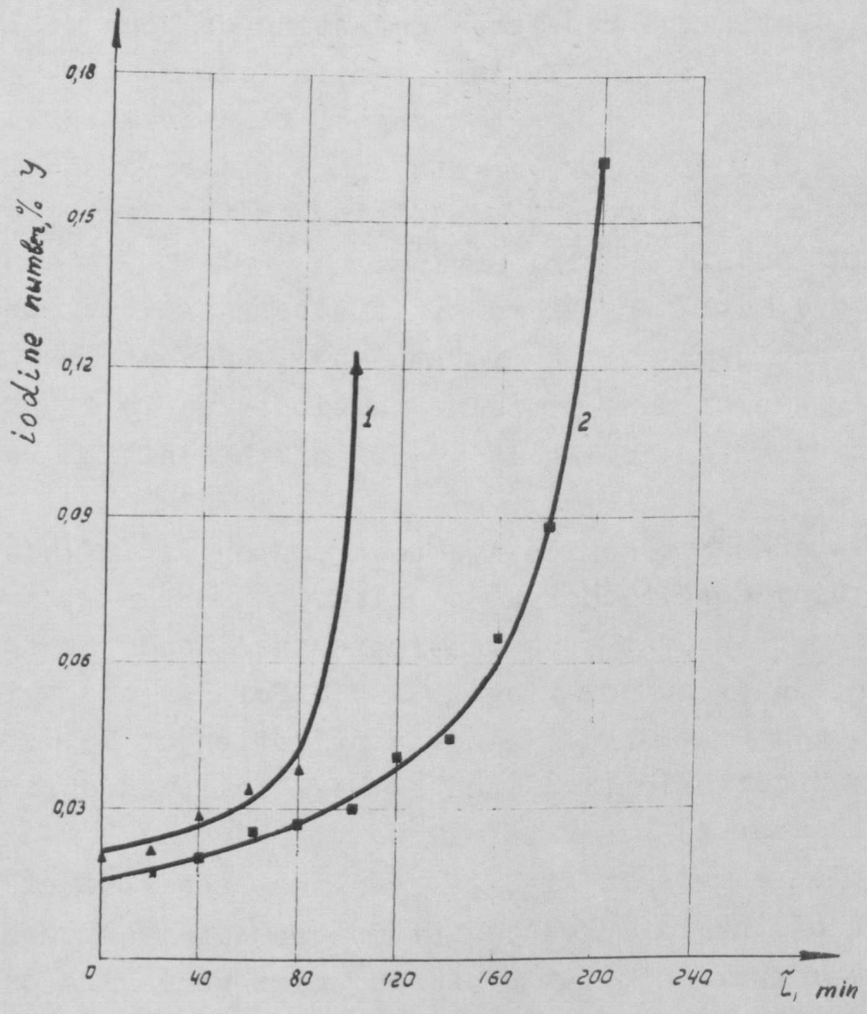

Fig. 2. Kinetic curves of bone fat oxidation: 1 – fat produced by means of autoclaving; 2 – fat produced by the developed technology

of batch-type apparatuses. Procedures of continuous bone defatting by means of impulse methods require great consumption of water, are connected with protein losses and with complicated separation of fat from water due to fat emulsification.

In the All-Union Meat Research Institute (VNIIMP) a rational complex technological process has been developed, which provides fast continuous two-stage defatting of bone with simultaneous dehydration of the latter at mild temperatures /5/. The process consists in the dry heating of thin-layer ground bones at 80-85°C for 10-12 min., in the immediate removal of fat from the heating zone, in bone re-defatting in the centrifugal field for 3-4 min. and in 30 min. drying.

The above method provides satisfactory sanitary production conditions and high yields of fat (85%), prevents the decomposition and losses of bone protein fraction; due to it, the yield of the latter after drying is 49-50% of the initial raw material weight.

Fat resistance to oxidative destruction as influenced with bone defatting conditions was studied.

Samples of the fat produced from mixed bones by the developed method and by autoclaving at 130°C for 3.5 hrs were comparatively studied by means of kinetic oxidation at 98°C; at the same time, their oxidative changes were followed during extended storage (13 months) at -8 to -10°C.

Oxidation curves in Fig. 2 shows that the rate of iodine number growth of the fat produced at moderate temperatures is twice as less as compared to fat produced under very high temperature conditions. Storage for 6 months did not affect the characteristics of fat samples, manufactured by the method developed, whereas it did deteriorate the sensoty qualities of fat, produced in autoclaves.

High temperatures cause the destruction of natural antioxidants, this being accompanied with a reduced stability of bone fat to oxidation, thus, carotene content in autoclaved bone fat was 0.21 mg%, while in fat produced by the new method it was 0.33mg% /6/.

Moderate temperatures and a short processing time prevent lipids and lipoids decomposition, this providing high qualities of

bone fat and permitting its utilization in various branches of industry.

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Table 1

Fatty acid composition of bone fats

Characteristics	Kind of bone										
	pig long bone		beef ribs		beef pelvic bone		beef epiphysis		mixed epiphyses and vertebrae (50%/50%)		beef vertebrae
	Defatting										
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st
1	2	3	4	5	6	7	8	9	10	11	12
Content of acids, %:											
tridecenoic C_{13}/I/	Traces								022	Traces	
tetradecanoic C_{14}/0/	115	155	184	280	21	18	20	163	191	140	22
tetradecenoic C_{14}/I/	112	013	075	103	09	08	06	092	129	072	09
pentadecanoic C_{15}/0/	015	010	062	097	08	07	06	049	089	053	07
pentadecadienoic C_{15}/II/	003	Traces	025	038	02	01	01	020	069	021	02
hexanoic C_{16}/0/	2231	2351	3120	3947	244	244	237	2522	2275	2586	267
hexadecaenoic C_{16}/I/	445	532	397	361	37	44	28	361	557	368	43
heptadecanoic C_{17}/0/	069	046	133	167	12	13	10	086	137	137	08
heptadecenoic C_{17}/I/	079	049	072	084	10	08	07	061	128	095	06
octadecanoic C_{18}/0/	970	975	1700	1828	152	165	140	1429	1170	1378	194
octadecaenoic C_{18}/I/	5030	5264	3952	3813	482	464	517	4978	4591	4816	412
octadecadienoic C_{18}/II/	1014	605	369	282	23	28	27	238	478	308	30
octadecatrienoic C_{18}/III/	018		Traces						106	026	Traces
eucosenoic C_{20}/I/	011		Traces						0,65[x]	Traces	
Total	10000	10000	9999	10000	10000	10000	999	9990	10000	10000	10000

1	2	3	4	5	6	7	8	9	10	11	12
Iodine number, g J	6240	6240	4410	4460	488	496	521	5230	4920	5060	436
Melting point, °C	3950	4070	-	-	410	435	410	410	425	415	460

x not identified

Table 2

Bone fat samples	Correlations, %				
	R_1	R_2	R_3	$S=R_1+R_2$	R_1/R_2
Beef fat from bones:					
pelvic	42.8	16.4	9.4	59.2	2.6
epiphysis	30	13.5	11.4	43.5	2.2
vertebrae	40.9	14.9	11.2	55.8	2.8
r i b s	40.7	11.1	11.8	51.8	3.6
mixed (50% vertebrae and 50% epiphyses)	67.5	21.0	21.0	88.5	3.2
Fat from pig long bones	97.4	10.9	45.4	108.3	8.9

Table 3

Characteristics	Unit	Bones		
		mixed	epiphyses	pig long
Hardness	g/cm	300	226	71
Hardening temperature	°C	31.2	28.1	23.3
Melting point	°C	41.8	41.0	39.5
Lecithine content	%	0.147	0.131	0.176
Iodine number	% J	50.3	52.2	62.4
Unsaponifiable substances	%	0.73	0.70	0.86