Sensorial, Physico-chemical and Nutritive Characterization of Paddlefish (*Polyodon spathula*) Meat

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In the current paper were studied a number of 200 sturgeons from Polyodon spathula of 4th summer (P.s.$_{3+}$) breed, reared in a fishery farm from North-East of Romania. Studying of modification of sensorial characteristics of meat, analysed just after fishing and during preservation by refrigeration during 15 days (+2 ÷ +4°C), show an optimal keeping period by refrigeration of the studied fishes for 5-6 days. The pH level from the studied muscles oscillated between values 7.9 and 7.11, after slaughtering, and at 24 h after slaughtering between 6.88 and 6.89. The water content of fillet (lateral muscles) had values of 75.41%; protein content of fillet (lateral muscles) had values of 19.89%; lipid content of fillet (lateral muscles) was 3.45%; collagen content of fillet (lateral muscles) had values of 4.14%. The values of water-protein rate (w/p = 3.79) placed the analyzed paddlefishes in the second category; energetic value of fillet gathered from studied fishes was 114.31 kcal/100 g. The rate of amino-acids from the total sum was 26.23% for the essential amino acids, 4.61% for semi-essential amino acids and 69.16% for non-essential amino acids. As rate the quantity of saturated fatty acids recorded the value of 25.64% for epaxial muscles, respectively 25.83% for hypaxial muscles; rate of mono-unsaturated fatty acids was 54.77% for epaxial muscles and 54.50% for hypaxial muscles; poly-unsaturated fatty acids had a rate of 19.59% for epaxial muscles and 19.67% for hypaxial muscles. Through histological studies for establishing the rate of muscular and conjunctive tissues from meat of studied paddlefishes, was observed that in case of lateral muscles mean diameter had an intermediary value of 43.42 µ. Those data leaded to obtain a mean area for transversal section of 1485.74 µ^2. Mean diameter of muscular fibre (43.42 µ) characterize a meat with fine texture. Profile on transversal section of muscular fibres had an ellipsoidal shape; fact which was enlightened by the rate between great diameter and small diameter (GD/SD) which varied between 1.35/1 -1.61/1. The rate of the main tissue categories in composition of lateral muscles gathered from analysed paddlefishes revealed the fact that mean rate of muscular tissue was of 70.47%, while mean rate of conjunctive tissues was of only 29.52%.

Keywords: *chemical composition, nutritive value, sensorial characteristics, Polyodon spathula*

Polyodon spathula (*Walbaum)* with a North-American origin, is an ancient fish [1], migratory [2], feeding with zoo-plankton [3], belonging to order *Acipenseriformes*, alike with sturgeons [4], being native from Mississippi and Missouri Rivers, but also could be founded in some drainages of Gulf Coast [5, 6], having a large distribution in North America [7]. Reproductive populations could be founded in Missouri River, in the North of Great Plains from Montana, at South-East of Texas and in Mississippi River from Louisiana [2, 8]. Even if breed was studied under various aspects for more than a century [9], are still many important questions regarding breed life and history and ecology [7, 10-12]. Breed sustained for a long time commercial and recreational fishing from central part of USA [6, 13]. Also, it is a source for caviar with a high price [2, 14-16].

Fish body is without scales, skin is smooth, its colour varying from light grey to black on sides and dorsal; abdomen being white-grey. Eyes are small, disposed at the base of rostrum, visual acuity being reduced [2, 17]. Gill apparatus is very well developed at adults, presenting adaptations for fishes which eat plankton. Mouth is big and disposed in a ventral position. Digestive tube presents a spiral valve, specific for *Acipenseriformes* [18] and it is specialized for filtration and utilization of zoo-plankton from water [19-22].

Polyodon spathula reaches sexual maturity at age of 7-8 years males and 10-13 years females [6]. Roes' diameter is of 2.5-3.0 mm [23]. Reproduction took place in spring, when water temperature is 11-14°C, fishes migrating for long distances [24]. Growing is rapidly in the first year of life and took place even in winter [18, 25]. Till the age of 5 years, length growing rate is around 5 cm/year, after age of 5 years, frequently double or triple their weight [2, 26-28].

Biological and ecological particularities of breed allow its rearing in ponds, in different formulas of poly-culture, without a consumption of concentrated fodders. Total ban of sturgeons fishing creates very favourable conditions for development of *Polyodon spathula* breed aquaculture. Besides the evident economical advantages, extension in culture of *Polyodon spathula* breed will have a positive impact of protection and preservation of autochthonous sturgeons. Each kilo of meat or caviar from *Polyodon spathula,* produced in fishery farms, will have as an effect the decreasing of pressure of industrial fishing (and especially of poaching) on sturgeons from Danube [29-31].

Meat of *Polyodon spathula* breed is firm, with and without bones, having a similar taste and texture with the meat gathered from other sturgeons [32]. After meat processing result 57% from paddlefish body as carcass (beheaded, eviscerated and without fins) and 27% as fillet (red meat and skin removed) [33, 34]. Historically speaking, sturgeon meat was known and accepted by early emigrants with European origins from USA, in the last period of years 1800,

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but paddlefish meat was less agreed. So, paddlefish meat was unknown for the majority of consumers and market remained limited [35, 36]. Content in *lipids* of fillet (side muscles) gathered from *Polyodon spathula* breed have values between 2.45-3.96%, values which place those sturgeons in category of fishes with a low content in lipids. Content in *proteins* of fillet (side muscles) gathered from *Polyodon spathula* breed have values between 18.08-19.89%, values which place those fishes in group of protein fishes [37, 38]. Meat is quite stable and could be kept by refrigeration up to 7 days and up to 7 months by freezing [34, 39].

Having in view the above-mentioned aspects, by the current paper we want to complete the existent information from literature by establishing of sensorial and physical-chemical characteristics, study of biological value of proteins, muscles' content in fatty acids and cholesterol and rate of different tissues categories in meat of *Polyodon spathula* sturgeons reared in Romania.

Experimental part

Material and method

In the current paper were studied 200 sturgeons belonging to *Polyodon spathula* breed of 4th summer ($P.s._{3+}$), reared into a fishery farm from Botosani County. From those ones were weighted around 10%; for laboratory measurements and determinations were choose 10 fishes with close weights to batch mean.

Sensorial evaluation is defined as a scientific method utilised for measuring, analysing and interpretation of characteristics of a food product, perceived by smell, taste, touching and visual perceiving. Nowadays, in Europe, the most frequent utilised method for sensorial evaluation in fish processing industry is named Quality Index Method. Application of QIM was discussed at FAIR, UE PL 98–4174 [40-42].

Quality Index Method uses an evaluation system in which the observed fishes were scored with indicators for each feature. For each feature named quality index was given a score from 0÷3, in a descending system, the maximum score being 24 points, knowing that the given maximum for being considered optimal from sensorial point of view is 10 points, further modifications allowing estimation of modification index. In table 1 is presented the scoring mode for each feature.

For determination of meat *p*H value was utilised the electro-mechanical method which suppose the measuring of potential difference between a control electrode and a measuring electrode, which are introduced into the studied extract [44-46].

Determination of meat chemical composition

Water determination was realised through *oven drying method* which consist in drying of analysed sample at a temperature of +105ºC, in according with standard SR ISO 1442/1997 [47-49].

Protein determination was realised using *Kjeldhal method*, adapted to system Velp Scientifica, composed by a DK6 digestion unit and a UDK7 distillation unit (method specified by the manufacturer - 981:10, AOAC Official methods of analysis/1990 [50], compatible with SR ISO 937:2007).

Fat determination was realised through *Soxhlet method* which consist in extraction of fats with an organic solvent organic using Velp Scientifica - SER 148 device (method specified by the manufacturer, AOAC Officinal methods of

Quality parameters		Description	Score
Skin	Colour/ Aspect	natural colour, glossy, slightly matte	0
		became matte	1
		yellow colour, mainly around abdomen	2
	Mucus	clear, non-coagulated	0
		milky, coagulated	1
		yellow and coagulated	2
	Smell	fresh, algae, neutral	0
		cucumber, metallic, hay	1
		sour	2
		putrid	3
	Texture	firm (rigid)	0
		finger trace disappears rapidly	1
		finger trace disappears after 3 seconds	2
Eyes	Eyeballs	clear and black, glossy	0
		dark grey	1
		matte grey	2
	Shape	convex	0
		flat	1
		deepened	2
Gills	Colour/ Aspect	red–brown	0
		pale red, pink-slightly brown	1
		grey-brown, brown, grey, green	2
	Mucus	transparent	0
		milky, coagulated	1
		brown, coagulated	2
	Smell	fresh, algae	0
		metallic, cucumber	1
		sour, mouldy	2
		putrid	3
Abdomen	Blood in abdomen	red blood – isn't present	0
		much brown blood, yellowish	1
	Smell	neutral	0
		cucumber, cantaloupe	1
		sour, fermented	2
		putrid (marred cabbage)	3
Total			0-24

Source: [43]

Table 1
QUALITY INDEX METHOD (QIM)

analysis/1990 [50, 51] and compatible with SR ISO 1443:2008) [52, 53].

To determine the mineral substances were utilised the *calcinations method in electric stove* at a temperature of +550°C (in according with standard SR ISO 936:1998).

For determination of nutritive value of meat gathered from the studied paddlefishes was made the caloricity calculus for the studied muscles using the theoretical formula based on gross caloric energy released at burning of one gram of proteins, fats and carbohydrates in the calorimetric bomb, in according with the formula: CE (kcal/kg) = 5.70 kcal x g CP + 9.50 kcal x g CF +4.2 kcal x NES [54, 55].

To determine meat content in collagen was utilised Food-Check infrared spectrophotometer [37].

For analysis of amino-acids was utilised the liquid-chromatographic analyse method (High Precision Liquid Chromatography - Thermo Electron) in according with standard SR EN ISO 13903:2005 [56-58].

The obtained results were statistically processed by calculating the statistics (arithmetic mean, variance, mean standard deviation and variability coefficient) [59]. For testing the statistical significance of differences between means of studied characters was used ANOVA Single Factor algorithm included in Microsoft Excel software.

Meat content in fatty acids and cholesterol was determined through liquid-chromatographic analyse methods (High Precision Liquid Chromatography -Thermo Electron), in according with AOCS Ce 1f-96 [60-63].

Processing of histological samples was realised through cutting method in paraffin, fixation, dehydration, clarification and after that impregnation in melted paraffin. Those operations were followed by casting of impregnated parts in paraffin blocks, shaping of paraffin blocks and sectioning of the parts at microtome. In parallel was prepared glass lamellae which were dried and after that we done the chromic coloration of sections with hematoxylin and eosin. Coloration was preceded by some operations of clarification and hydration. Finally, was effectuated the mounting, drying and labelling of lamellae [64-67].

For study of histological samples was used a digital photonic microscope Motic DMWB1-223, calibration being realised using Motic Images Plus ML pack, and the most remarkable sections were highlighted by micro-photography followed by measurements made by computer using functions *line measurement* and *area computation* from the above-mentioned software pack.

Results and discussions

Sensorial properties of meat

Study of sensorial characteristics modifications for *Polyodon spathula* meat, were made just after fishing and during period of preserving by refrigeration for 15 days at temperatures of +2 ÷ +4°C, in refrigerator. The samples were periodically analysed for macroscopic exam aiming to evaluate the freshness state during refrigeration period (15 days).

Sensorial evaluation was realised till apparition of some indicators which show the degradation of paddlefish meat, knowing that the main cause for modification of fish meat properties is contamination activity with micro-organisms, followed by autolytic process, which could be avoided through application of an adequate preservation method.

To establish the maximum refrigeration period, fishes were putted in sterile bags kept at refrigeration temperature of +2÷+4°C. Microscopically examination was made to evaluate the freshness state during a refrigeration period of 15 days, at the above-mentioned temperature.

In table 2 are presented the obtained results after application of QIM method to studied paddlefishes.

So, the first sensorial indicators which suffered modifications during refrigeration period were: aspect of skin, meat, abdomen and smell. The first degradation indexes appeared after 3-4 days of keeping in cold air (refrigeration). The analysed sensorial indicators show an optimal period of preserving by refrigeration (+2÷+4°C) for 4th summer paddlefishes, of 5-6 days, those one being the period in which the score of the analysed parameters reached the value of 10 points, maximum score till fishes are considered optimum for consumption. The analysed samples during refrigeration period reached the maximum score of 24 after 15 days.

pH-value

The *p*H level from studied muscles (dorsal epaxial, costal epaxial, costal hypaxial and abdominal hypaxial), was determined on fresh meat and respectively after 24 h from slaughtering, noticing that the obtained values are in the normal limits cited in literature (7-7.3 just after fishing) [44, 68].

So, meat pH value oscillated between values of 7.9 and 7.11, after slaughtering, and at 24 h after slaughtering between 6.88 and 6.89 (table 3).

Table 2

EVOLUTION OF QUALITY INDICATORS FOR SENSORIAL CHARACTERISTICS DURING REFRIGERATION PERIOD OF *POLYODON SPATHULA* STURGEONS

Quality indexes	Days							
	Initially	2	4	6	8	10	12	15
Skin	0	0	1	1	2	3	3	3
Meat	0	0	1	1	2	3	3	3
Smell	0	0	1	2	2	3	3	3
Rigidity	0	0	0	1	1	2	2	3
Abdomen	0	0	1	2	2	3	3	3
Eyes	0	0	1	1	2	2	3	3
Gills	0	0	1	1	1	2	2	3
Organs	0	0	1	1	2	2	3	3
Total	**0**	**0**	**7**	**10**	**14**	**20**	**22**	**24**

Table 3

pH VALUE OF THE STUDIED MUSCLES GATHERED FROM *POLYODON SPATHULA*

Age	Analysed muscles	After slaughtering		at 24 hours	
		$\bar{x} \pm s_{\bar{x}}$	V%	$\bar{x} \pm s_{\bar{x}}$	V%
Polyodon spathula of 4th summer	*DE*	7.11±0.02	1.57	6.89±0.08	1.36
	CE	7.09±0.09	1.71	6.89±0.06	1.68
	CH	7.10±0.04	1.63	6.88±0.05	1.73
	AH	7.10±0.08	1.81	6.88±0.03	1.92

Note: DE – dorsal epaxial muscles; CE - costal epaxial muscles; CH - costal hypaxial muscles; HA - abdominal hypaxial muscles; n=10

The established values for variation coefficients shown a very good homogeneity of the studied batches (V% < 5).

Chemical composition

Chemical composition of *Polyodon spathula* fish meat was determined on fillet gathered from paddlefishes of 4th summer.

Muscular tissue is the most valuable part of fish meat, being 40-50% from the mass of live organism [69]. Side muscles are the main mass of somatic musculature being situated on side parts of the body, just underneath tegument. In the profound zone are in contact with axial skeleton, in anterior part are inserted in the occipital area of neuro-skull and on the superior edge of scapular belt, and on inferior part are inserted at the base of caudal fin.

Water from muscular tissue. Due to high rate in chemical composition and to multiple roles that plays, water is the main component of all living organisms, with a capital importance in their organization and function.

Water content of fillets (lateral muscles) gathered from *Polyodon spathula* sturgeons breed of 4th summer had values of 75.41%; those values being in the cited limits by literature [34, 70].

Quite high-water content of fishes, in generally, so also for *Polyodon spathula* breed, show the fact that those one could favour the development of majority of micro-organisms, which made that refrigeration period to be more diminished, recommending consumption of fish meat as fresh as possible.

Proteins content of fillet (lateral muscles) gathered from *Polyodon spathula* breed had values of 19.89% for Ps_{3+}, values similar with the ones from literature [34]. Proteins content of meat of analysed *Polyodon spathula* sturgeons placed this breed in protein fishes group (15-20% proteins) [37, 38].

Lipids from fish meat varies in very large limits (0.1-28%), fishes being classified in: fat fishes with more than 8% fat; fishes with an average fattening state, between 4-8%; weak (skinny) fishes with less 4% fat [67].

Lipid content of fillet (lateral muscles) at analysed *Polyodon spathula* sturgeons was of 3.45%, values which place those sturgeons in category of fishes with low lipids content. Also in this case the obtained data were between the limits cited in the literature [34, 71, 72] (table 4).

Collagen is the most resistant and abundant proteins of conjunctive tissues, which contribute to maintaining of tissue structural integrity. From chemical point of view, collagen is an incomplete protein, with a reduced biological value [73]. Rate of collagen proteins, unbalanced from the point of view of content in essential amino acids, is placed for the majority of fish breeds between limits 3-10%, while meat of animals with warm blood could reach at the level of 17% from total protein content [68, 74].

In case of analysed *Polyodon spathula* breed, rate in collagen of fillet (lateral muscles) had values of 4.14%, being in the cited values.

Rate water-proteins (w/p) is an appreciation criterion for alimentary value of fish meat, in according with fishes are divided in 5 categories: 1st category – fishes with high alimentary value (w/p -2.5- 3.5); 2nd category - fishes with good alimentary value (w/p -3.5 - 4.2); 3rd category – fishes with mediocre alimentary value (w/p -4.2 -4.7); 4th category - fishes with low alimentary value (w/p -4.7 - 5.2); 5th category – fishes with advanced inanition state (w/p greater than 5.2). Rate w/p is an insufficient criterion for establishing of fish alimentary value, reason for what must be taken in consideration also the fat content of fish meat. At fish, proteins represent 12.3 -28% from the total meat mass, with a direct correlation between water and protein content [70].

Rate water-proteins (w/p) of analysed 4th summer paddlefishes indicated that those ones were in the 2nd category- fishes with good alimentary value (rate w/p = 3.79).

Energetic values of fillets (lateral muscles) gathered from studied *Polyodon spathula* sturgeons are presented in table 4. In according with the recorded data, the energetic value of studied fillet was of 114.31 kcal/100 g, due especially to accumulation of adipose tissue.

Table 4

CHEMICAL COMPOSITION AND NUTRITIVE VALUE *(n = 10)*

Notice		*Polyodon spathula* 4th summer
Water (%)	$\bar{x} \pm s_{\bar{x}}$	75.41±5.04
	V%	2.72
Dry matter (%)	$\bar{x} \pm s_{\bar{x}}$	24.59±2.83
	V%	2.61
Proteins (%)	$\bar{x} \pm s_{\bar{x}}$	19.89±1.88
	V%	2.71
Lipids (%)	$\bar{x} \pm s_{\bar{x}}$	3.45±0.18
	V%	2.63
Minerals (%)	$\bar{x} \pm s_{\bar{x}}$	1.25±0.089
	V%	3.17
Collagen (%)	$\bar{x} \pm s_{\bar{x}}$	4.14±0.36
	V%	3.71
Water/protein ratio	$\bar{x} \pm s_{\bar{x}}$	3.79±0.21
	V%	3.51
Nutritive value	kcal/100 g	114.31
	Mj/100 g	477.81

Table 5

CONTENT IN AMINO ACIDS (g/100 g) OF OBTAINED FILLET

Amino acids	*Polyodon spathula* 4th summer
Tryptophan	0.223±0.04
Threonine	0.872±0.05
Isoleucine	0.917±0.06
Leucine	1.617±0.08
Lysine	1.828±0.09
Methionine	0.589±0.04
Cysteine	0.213±0.02
Phenylalanine	0.776±0.06
Tyrosine	0.672±0.04
Valine	1.025±0.06
Arginine	1.190±0.07
Histidine	0.585±0.03
Alanine	1.202±0.04
Aspartic acid	2.037±0.09
Glutamic acid	2.970±0.11
Glycine	0.955±0.07
Proline	0.704±0.04
Serine	0.812±0.07
∑ amino acids	19.187
∑ essential amino acids	5.033
∑ semi-essential amino acids	0.885
∑ non-essential amino acids	13.269

In comparison with nutritive value of meat from other sturgeons (105 kcal/100 g) [75], the calculated values were close, which demonstrate a strong genetic influence of the presented aspect.

Content in amino acids of meat gathered from 4th summer *Polyodon spathula* sturgeons is presented in table 5. From those 18 presented amino acids 9 are essential for children and adults [76] (histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine), two semi-essentials (cysteine and tyrosine) and 7 non-essentials (alanine, arginine, aspartic acid, glutamic acid, glycine, praline and serine) [37, 76-78].

In the case of analysed fishes was observed that the order of content in amino acids from high to low was as follows: glutamic acid, aspartic acid, lysine, leucine, alanine, arginine, valine, glycine, isoleucine, threonine; at the end of the list with those 18 studied amino acids being tryptophan. The first three amino acids (glutamic acid, aspartic acid and lysine) were presented in the same order also by other authors [79-81]. Glutamic acid is not only an amino acid which give a certain taste but have also a determinant role for brain metabolism participating at synthesis of many physiological substances [82-86].

Finally, were calculated the sum of amino acids (ΣA), essential amino acids (ΣEA), semi-essential amino acids (ΣSEA) and non-essential ones (ΣNEA). Rating ΣEA, ΣSEA and ΣNEA at total content in amino acids (ΣA) in case of studied fishes the rate of amino acids from total sum was 26.23% for essential amino acids, 4.61% for semi-essential amino acids and 69.16% for non-essential amino acids.

Muscles content in fatty acids and cholesterol

Quantity of saturated fatty acids was higher in hypaxial muscles in comparison with epaxial muscles, values being of 0.735 g/100g at hypaxial muscles and of 0.661 g/100g at epaxial muscles. As rate the quantity of saturated fatty acids recorded 25.64% for epaxial muscles, respectively 25.83% for hypaxial muscles, values which were lower with around 10% face to the data presented in literature - 28.5% [85] (table 6).

Regarding mono non-saturated fatty acids, the highest quantity was also founded in hypaxial muscles in comparison with the epaxial ones. The recorded values were 1.551 g/100g at hypaxial muscles and 1.412 g/100g at epaxial muscles. The rate of mono non-saturated fatty acids was 54.77% for epaxial muscles and 54.50% for hypaxial muscles, values which were lower with around 3% face to data presented in literature- 56.1% [87].

Quantity of poly non-saturated fatty acids was, also, higher in hypaxial muscles, values of 0.560 g/100g for hypaxial muscles and 0.505 g/100g for epaxial ones. Poly non-saturated fatty acids had a rate of 19.59% for epaxial muscles and 19.67% for hypaxial ones, values which were higher with around 28% face to data presented in literature - 15.3% [87].

The highest content of mono non-saturated and poly non-saturated fatty acids, knowing for their beneficial effect on role that they exercise on human health especially on protector role on risk of heart diseases; as well as content in cholesterol (in epaxial muscles of 43.96 mg/100g and in hypaxial muscles 48.77 mg/100g), made from paddlefish meat an important source of *good fats*. The assimilation degree of fish fats, face to other fats, is very high, fact explained, primary by character of fatty acids, predominant mono non-saturated and poly non-saturated from fats of this fish (linoleic, linolenic, arachidonic, eicosapentaenoic, docosapentaenoic, docosahexaenoic acid).

Share of different tissues categories

To establish the rate of muscular and conjunctive tissues from *Polyodon spathula* sturgeon meat we firstly made some histological studies (fig. 1).

Table 6

CONTENT OF THE STUDIED MUSCLES IN FATTY ACIDS AND CHOLESTEROL AT *POLYODON SPATHULA*

Determined component	M.U.	*Polyodon spathula* 4th summer	
		E	H
FA saturated from which:	**g/100g**	**0.661**	**0.735**
myristic 14:0	g/100g	0.111	0.121
palmitic 16:0	g/100g	0.498	0.551
stearic 18:0	g/100g	0.052	0.063
FA mono non-saturated from which:	**g/100g**	**1.412**	**1.551**
palmitoleic 16:1	g/100g	0.302	0.334
oleic 18:1	g/100g	1.053	1.161
gadoleic 20:1	g/100g	0.044	0.041
erucic 22:1	g/100g	0.013	0.015
FA poly non-saturated from which:	**g/100g**	**0.505**	**0.560**
linoleic 18:2	g/100g	0.052	0.052
linolenic 18:3	g/100g	0.083	0.091
stearidonic 18:4	g/100g	0.098	0.099
arachidonic 20:4	g/100g	0.042	0.046
eicosapentaenoic 20:5 ù-3	g/100g	0.138	0.160
clupanodonic 22:5 ù-3	g/100g	0.028	0.039
docosahexaenoic 22:6 ù-3	g/100g	0.064	0.073
Cholesterol	**mg/100g**	**43.96**	**48.77**

Note: E – group of epaxial muscles; H – group of hypaxial muscles

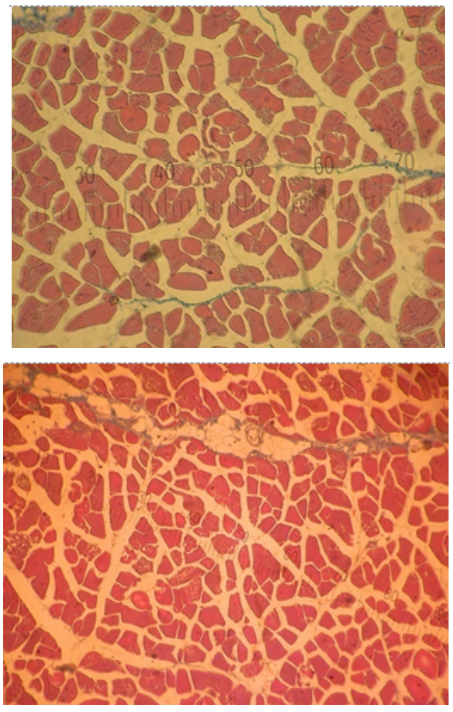

Fig. 1. Transversal sections through side muscles of *Polyodon spathula* sturgeons 100 x (OC 10 x OB 10)

Table 7

THICKNESS OF THE MUSCULAR FIBRE AND THE SHARE OF THE MAIN TISSUES IN SIDE MUSCLES FROM *POLYODON SPATHULA* STURGEONS

Muscular fascicule	n	Great diameter (μ)	Small diameter (μ)	Mean diameter (μ)	Rate GD/SD (x/1)	Format index (%)	Area on transversal section of muscular fibre (μ^2)	Density of muscular fibres (m.f./mm^2)	Rate of muscular tissue (%)	Rate of conjunctive tissue (%)
N1	40	48	38.8	40.83	1.53/1	68.66	1325.75	452.45	60	40
	29	45.95	31.62	38.78	1.48/1	69.87	1174.07	488.8	57.4	42.6
	51	51.79	33.52	42.65	1.57/1	67.88	1410.4	688.43	97.1	2.9
N2	28	54.51	39.63	47.07	1.44/1	74.88	1765.73	459.78	81.19	18.81
	22	53.34	34.72	44.03	1.61/1	67.75	1482.93	405.05	60.07	39.93
	30	50.49	35.01	42.75	1.49/1	70.74	1439.77	551.37	79.39	20.61
	24	52.98	37.46	45.22	1.45/1	71.79	1633.07	577.05	94.24	5.76
	20	52.83	29.73	46.28	1.35/1	76.32	1721.5	433.07	74.55	25.45
N3	40	56	35.82	45.91	1.59/1	65.2	1639.53	396.31	64.98	35.02
	35	49.37	34.09	41.73	1.49/1	69.45	1340.82	372.12	49.9	50.1
	41	49.5	35.29	42.39	1.44/1	72.64	1409.64	400.02	56.39	43.61
$\bar{x}$		51.34	35.06	43.42	1.49	70.47	1485.74	474.95	**70.47^a**	**29.52^d**
$\pm s_{\bar{x}}$		0.89	0.87	0.76	0.02	0.98	55.32	28.88	4.79	4.8
V%		5.81	8.31	5.84	5.13	4.63	12.34	20.17	22.55	53.83
Maxim		56	39.63	47.07	1.61	76.32	1765.73	688.43	97.1	50.1
Minim		45.95	29.73	38.78	1.35	65.2	1174.07	372.12	49.9	2.9

ANOVA test – ^{ad} very significant differences ($\hat{F}$ > F tab. α 0.001 at 1;21 LD).

Many of physical, chemical, sensorial and technological properties of fish meat are influenced by histological structure, which is also influenced by breed, age and even by individual. Histological structure of meat is illustrated by a series of specific indictors such as: great diameter (GD), small diameter (SD), mean diameter, rate between those diameters (GD/SD), index of muscular fibres format and area on transversal section. The obtained values are presented in table 7.

So, in case of lateral muscles gathered from 4th summer paddlefishes mean diameter had values between 38.78 μ and 47.07 μ, calculating an intermediary value of 43.42 μ. Those data lead to obtain a mean surface on transversal section of 1485.74 μ^2.

Mean diameter of muscular fibre at 4th summer paddlefishes (43.42 μ) characterize a meat with a smooth texture, in comparison with other breeds, such as rainbow trout (*Oncorhynchus mykiss*) with age of 12 months, where was founded a mean thickness for muscular fibre of 47.67 μ, and the one of brook trout (*Salvelinus fontinalis*) with age of 12 months, with a recorded mean value of 67.67 μ [88, 89].

Profile on transversal section of muscular fibres had an ellipsoidal shape; this fact being enlightened by rate between great diameter and small one (GD/SD) which varied between 1.35/1 - 1.61/1.

Regarding the rate of the main tissue categories in composition of lateral muscles at breed *Polyodon spathula* (4th summer), was noticed the fact that mean rate of muscular tissue was 70.47%, with variation limits between 49.9÷97.10%, while mean rate of conjunctive tissues was of only 29.52%, with variations between 2.90÷50.10%.

In comparison with the meat of other breeds respectively the one from broiler chickens, meat from sturgeons *Polyodon spathula* of 4th summer recorded a rate of conjunctive tissues lower with 6.07-66.66%, and a superior rate of muscular tissue with 2.77-26.47% [90]. The very high rate of muscular tissue made that ANOVA test to highlight very significant statistical differences between those two types of analysed tissues.

The calculated variation coefficients for rate of those two tissues (muscular and conjunctive) indicated very large variations (V% = 22.55-53.83) for analysed characters.

Rate between muscular and conjunctive tissues was 2.38, value which characterize a meat with an important percentage of muscular tissue.

Conclusions

From our research and from analyse of the obtained data which are presented in the current paper, which mainly aimed to establish the sensorial and physical-chemical characteristics, nutritive and biological value of proteins, muscles content in fatty acids and cholesterol and rate of different tissue categories from meat of *Polyodon spathula* sturgeon meat, we can formulate the conclusions which are mentioned bellow.

The first sensorial indicators which suffered modifications during 15 days of refrigeration period, at +2 ÷ +4°C, appeared after 3-4 days of keeping in cold air (refrigeration), and were aspect of skin, meat, abdomen and smell. The analysed sensorial indicators show an optimal period of preserving by refrigeration (+2÷+4°C) for 4th summer paddlefishes, of 5-6 days.

*p*H value from lateral muscles studied (dorsal epaxial, costal epaxial, costal hypaxial and abdominal hypaxial) which was determined on fresh meat and respectively after 24 hours from slaughtering oscillated between values of 7.9 and 7.11, after slaughtering, and at 24 h after slaughtering between 6.88 and 6.89.

Filets gathered from 4th summer *Polyodon spathula* sturgeons had the following chemical content: water 75.41%, proteins 19.89%, (value which place this fishes in group of protein fishes), lipids 3.45% (value which place those sturgeons in category of fishes with a low content in lipids), collagen 4.14% (which indicate low values for proteins with low quality in the meat of those sturgeons). The obtained data were in the limits cited in literature.

Sturgeons of 4th summer were placed in 2nd category – fishes with good alimentary value (rate w/p = 3.79). Energetic value of studied fillets was of 114.31 kcal/100g.

Proteins' quality is based on their content in amino acids, as well as on the rate of those 8 essential amino acids. So, in the case of meat from studied fishes was observed that rate of amino acids from total sum was 26.23% for essential

amino acids, 4.61% for semi-essential amino acids and 69.16% for non-essential amino acids.

Quantity of saturated fatty acids was higher for hypaxial muscles (0.735 g/100g) in comparison with epaxial muscles (0.661 g/100g). As rate the quantity of saturated fatty acids recorded 25.64% for epaxial muscles, respectively 25.83% for hypaxial muscles.

Regarding mono non-saturated fatty acids, the highest quantity was also founded in hypaxial muscles (1.551 g/100g) in comparison with the epaxial ones (1.412 g/100g). The rate of mono non-saturated fatty acids was 54.77% for epaxial muscles and 54.50% for hypaxial muscles.

Quantity of poly non-saturated fatty acids was, also, higher in hypaxial muscles, values of 0.560 g/100g for hypaxial muscles and 0.505 g/100g for epaxial ones. Poly non-saturated fatty acids had a rate of 19.59% for epaxial muscles and 19.67% for hypaxial ones.

By histological studies for establishing the rate of muscular and conjunctive tissues from meat of 4th summer *Polyodon spathula* sturgeons was noticed that in case of lateral muscles gathered from paddlefishes, mean diameter had values between 38.78 µ and 47.07 µ, calculating an intermediary value of 43.42 µ. Those data leaded to obtaining a mean surface on transversal section of 1485.74 µ^2.

Mean diameter of muscular fibre at 4th summer paddlefishes (43.42 µ) characterize a meat with a smooth texture. Profile on transversal section of muscular fibres had an ellipsoidal shape; this fact being enlightened by rate between great diameter and small one (GD/SD) which varied between 1.35/1 – 1.61/1.

Regarding the rate of the main tissue categories in composition of lateral muscles at breed *Polyodon spathula* (4th summer), was noticed the fact that mean rate of muscular tissue was 70.47%, while mean rate of conjunctive tissues was of only 29.52%.

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