TECHNOLOGICAL FEATURES OF MEAT GATHERED FROM *POLYODON SPATHULA* STURGEON BREED

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Abstract

Research were carried out on a number of 40 individuals of Polyodon spathula sturgeon (*paddlefish*) *of different ages (P.s.$_{0+}$, P.s.$_{1+}$, P.s.$_{2+}$, P.s.$_{3+}$), 10 individuals from each category of age; fishes were gathered from a fishery farm from the north of Botoşani County. The studied paddlefish were slaughtered and then were gathered samples (side muscles), which were evaluated for collagen content, establishment of the main tissue categories and rate of losses at different processing types (boiling, frying and frying preceded by flouring). For collagen content, the obtained values were between 3.99 and 4.21%. Regarding the rate of the main tissue categories in composition of side muscles from Polyodon spathula sturgeon breed (4th summer), was observed that the mean rate of muscular tissues was 70.47%, while mean rate of conjunctive tissues was of only 29.52%. From all the applied processing types to Polyodon spathula sturgeon breed meat (paddlefish), the highest losses were recorded at frying – in average 37.7% and the lowest ones were observed at boiling – in average 30.86%. At processing of paddlefish meat by flouring and frying were recorded mean losses of 33.11%.*

Key words: technological features, *Polyodon spathula,* collagen, tissues, losses by processing

INTRODUCTION

Polyodon spathula (paddlefish) is a member of *Polyodontidae* family from North America, natural area of the breed being represented by the basin of Mississippi River. It is a large waist fish, reaching around 1.5-2 m length and 50-70 kg weight, in its natural habitat [6]. Due to its trophic regime, mainly zoo-plankton based, and its high growing rhythm, *Polyodon spathula* breed (paddlefish) present a special interest for Romanian pisciculture capitalizing in an efficient way the autochthonous aquatic ecosystems [9].

Technological features of meat are determinate both by morph-structural features (rate between muscular tissue, conjunctive and fatty; meat structure determined by thermal state, maturation degree and utilisation of proteolytic enzymes) and also by physical-chemical features (meat pH value, content in miofibrilla proteins, conjunctive proteins and fat). Technological features represent those properties which must have the meat, to be able for processing [2], [3].

Meat technological features refers at: water retaining capacity, meat hydration capacity, retaining or releasing capacity of juice, losses rate by maturation and storage, losses rate by boiling or frying, meat resistance, those ones being influenced by physical-chemical and morph-structural proprieties [2], [3].

In connection with meat technological features, in our research were determined: collagen content, rate of different tissue categories and losses by boiling and frying (side muscles) of the meat gathered from *Polyodon spathula* breed of different ages.

MATERIAL AND METHOD

The current study was carried out on a number of 40 sturgeons from *Polyodon spathula* breed (paddlefish) of different ages (P.s.$_{0+}$, P.s.$_{1+}$, P.s.$_{2+}$ and P.s.$_{3+}$). The selected individuals were from fishery farm Hudeşti, Botoşani County.

For a fast determination of collagen content in meat was utilised a Food-Check

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infrared spectrophotometer. Food-Check meat automatic analyser is composed by a compact unit with keyboard, display and a drawer for samples' placing. Display is placed at the upper part being the interface for integrated software, displayed menu and obtained results. Meat samples (side muscles), fine chopped, placed on a glass tray were putted into the apparatus for analysing. The obtained results were posted on the display.

The samples for histometric studies were prepared through the section method in paraffin. For study of histometric samples and data interpretation was utilised a Motic DMWB1-223 digital photonic microscope, calibrated at 3 associations ocular-objective lens. For calibration was utilised the objective lens micrometer included into microscope kit (calibration blade) and packet Motic Images Plus ML. Calibration was realised for associations OB 4 X OC 10; OB 10 X OC 10; OB 40 X OC 10 and OB 90 X OC 10. After this calibration we studied the histological lamellas, for enlighten the best sections, then microphotography and the measurements were realised by computer using functions *line measurement* and *area computation* from the above mentioned software.

In this way, were made measurements regarding great and small diameter of **myocytes and muscular fascicles of I and II order**, and also the area of their transversal section. The obtained data served at calculation of **mean thick**, using the formula:

$$D\bar{x} = \frac{DM + Dm}{2} \ (\mu),$$

in which:

$D\bar{X}$ = mean diameter (μ);

DM = great diameter (μ);

Dm = small diameter (μ).

This information served for obtaining a general image on muscular ultra-structure elements, being also calculated **the existent ratio between the two diameters** (great and small), data which was used to enlightened the predominant shape of profile on transversal sections of the analysed samples.

For concretion of **muscular fibres density** (nr. fibre/mm^2 muscles) these ones were precisely counted, at the level of each FM I (Nr. f.m.); for concretion of transversal square area of FM I (S. FM I) and after that placing it into formula:

$$Dens = \frac{Nr.f.m.\ x\ 1.000.000}{S.FM\ I}$$

For calculus of **rate between muscular tissue and conjunctive tissue**, at the level of I order muscular fascicles the procedure was as follows: was determined the number of muscular fibres from each F.M. I are their square area per transversal section; was calculated the transversal square area of muscular fascicles (F.M. I) and then using the below formula were obtained the final values.

$$P_{TM(\%)} = \frac{(Nr.f.m.\ x\ S.f.m.)}{S.FM\ I} \cdot 100 \ ,$$

in which:

P_{TM} = rate of muscular tissue (%);

Nr. f.m. = number of muscular fibres;

S.f.m. = square area per transversal section of muscular fibres (μ^2);

S. FM I = square area of I order muscular fascicles (μ^2).

To calculate the rate of conjunctive tissue was applied the formula:

$$P_{TC} = 100 - P_{TM}\ (\%),$$

in which:

P_{TM} = rate of muscular tissue (%);

P_{TC} = rate of conjunctive tissue (%).

The main experimental data were statistically processed calculating: arithmetic mean, variance, standard deviation of mean, variability coefficient [10].

For testing statistical significance of differences between mean of the studied characters, was utilised ANOVA Single Factor algorithm, which is included in Microsoft Excel software kit.

RESULTS AND DISCUSSIONS

Collagen is the most resistant and abundant protein in conjunctive tissue with influence on meat technological features, which confers resistance for organism and contributes at maintaining the structural integrity of tissues. From chemical angle collagen is an incomplete protein, with a low biological value [2], [3], [5], [11].

Fraction of collagen proteins, unbalanced as content in essential amino acids, is situated for the majority of fish breeds between 3-10%, in comparison with the warm blod animals' meat, when could reach the level of 17% from total protein content [8], [7].

For *Polyodon spathula* breed, analysed by us, the collagen rate in studied muscles (dorsal epaxial muscles, coastal epaxial muscles, coastal hipaxial muscles, abdominals hipaxial muscles) had the following values (*table 1*):

- at *Polyodon spathula* – P.s.$_{0+}$, 3.74 – 4.22%;
- at *Polyodon spathula* – P.s.$_{1+}$, 3.78 – 4.27%;
- at *Polyodon spathula* – P.s.$_{2+}$, 3.95 – 4.31%;
- at *Polyodon spathula* – P.s.$_{3+}$, 4.06 – 4.43%.

It was observed that the highest collagen rate is in abdominals hipaxial muscles with values between 4.22% for P.s.$_{0+}$ and 4.43% for P.s.$_{3+}$.

Mean values of collagen rate of 3.93% for paddlefish of 1st summer; 4.00% for paddlefish of 2nd summer; 4.11% for paddlefish of 3rd summer and 4.21% for paddlefish of 4th summer, confirm the data from literature regarding the low rate in collagen of fish meat, fact which make that this one to be easier to be cooked [8], [7].

Variation coefficients had values which show a good homogeneity for the studied batches (V%<10).

Table 1 Collagen content of studied muscles gathered from *Polyodon spathula* of different ages

Age	Analysed muscles	Collagen %	
		$\overline{X} \pm s_{\overline{x}}$	V%
Polyodon spathula of 1st summer - P.s.$_{0+}$	ED	3.86±0.35	2.18
	EC	3.74±0.33	1.97
	HC	3.91±0.23	2.95
	HA	4.22±0.40	3.87
Polyodon spathula of 2nd summer - P.s.$_{1+}$	ED	3.91±0.41	2.80
	EC	3.78±0.45	2.04
	HC	4.07±0.55	2.98
	HA	4.27±0.32	3.98
Polyodon spathula of 3rd summer - P.s.$_{2+}$	ED	4.04±0.34	2.87
	EC	3.95±0.29	2.01
	HC	4.16±0.41	2.21
	HA	4.31±0.26	3.98
Polyodon spathula of 4th summer - P.s.$_{3+}$	ED	4.17±0.37	3.31
	EC	4.06±0.30	2.16
	HC	4.21±0.47	2.42
	HA	4.43±0.51	3.92

Note: ED – dorsal epaxial muscles; EC – coastal epaxial muscles; HC – coastal hipaxial muscles; HA – abdominals hipaxial muscles

To establish the rate of muscular and conjunctive tissues from *Polyodon spathula* sturgeon meat were previously realised histological studies (figure 1).

Many physical and chemical properties of fish meat are influenced by histological structure, which is influenced at her turn by breed, age and even by individual. Histological structure of meat is illustrated by a series of specific indicators such as: small diameter (DM), small diameter (Dm), mean diameter, rate between diameters (DM/Dm), format index of muscular fibres, and also square area per transversal section. The obtained values are presented table 2.

So, in the case of side muscles gathered from paddlefish of 4th summer, mean diameter had values between 38.78 μ and 47.07 μ, being calculated an intermediary value of 43.42 μ. These data leads to obtain a mean square area per transversal section of 1485.74 μ^2.

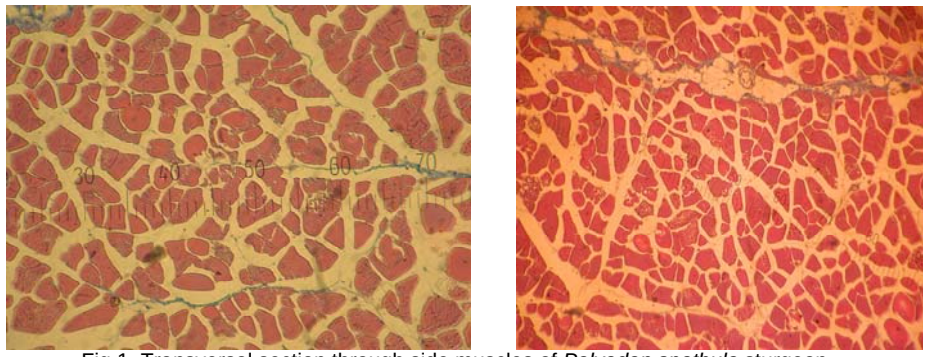

Fig.1. Transversal section through side muscles of *Polyodon spathula* sturgeon
100 x (OC 10 x OB 10)

Table 2 Muscular fibre thickness and rate of main tissue categories in side muscles of *Polyodon spathula* sturgeon

Muscular fascicles	n	Great diameter (μ)	Small diameter (μ)	Mean diameter (μ)	DM/Dm ratio (x/1)	Format index (%)	Square area per transversal section of muscular fibre (μ^2)	Density of muscular fibres (f.m./mm^2)	Rate of muscular tissue (%)	Rate of conjunctive tissue (%)
1	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
2	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
3	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

Note: ANOVA test – [ad] very significant differences ($\hat{F}$>F tab. α 0.001 at 1;21 GL)

Mean diameter of muscular fibre at paddlefish of 4th summer (43.42 μ) characterized a meat with a soft texture face to the one of rainbow trout (*Oncorhynchus mykiss*) of 12 months where was founded a mean thickness of muscular fibre of de 12 47.67 μ, and with the one of brook trout (*Salvelinus fontinalis*) of 12 months where was recorded a mean value of 67.67 μ [4].

Profile on transversal section of muscular fibres had an ellipsoidal shape; this fact was enlightened by the rate between great diameter and small diameter (DM/Dm) which varied between 1.35/1–1.61/1.

Regarding the proportion of main tissue categories in the structure of side muscles from *Polyodon spathula* sturgeon breed (4th summer), was noticed that the mean rate of muscular tissue was 70.47%, with variation limits of 49–97.10%, while the mean rate of conjunctive tissues was of only 29.52%, with variations between 2.90–50.10%.

The high rate of muscular tissue made that ANOVA test to show very significant statistical differences between the two types of analysed tissues.

Variation coefficients calculated for rate of both tissues (muscular and conjunctive) show great variances (V%=22.55–53.83) for the analysed characters.

Rate between muscular and conjunctive tissue was 2.38, value which show an important percentage of muscular tissue.

Meat losses by processing

Rate of losses resulted by boiling or frying is a feature of meat for loosing a certain amount of its own weight, representing a criteria for water retain capacity of processed or prepared meat.

Losses resulted by boiling or frying are recorded on the basis of water, fat and juice content. Those losses are provoked also by the structural of muscular tissue particularities (thick muscular fibres record a higher losses rate than the thin ones and also the fibres with large width of striation stripes in muscles, generate a lower losses rate by boiling or frying) [2], [3]. Losses rate by boiling or frying, influence directly meat capitalization mode in gastronomy.

Losses resulted by boiling

Losses recorded by boiling of the meat gathered from analysed sturgeons are presented in table 3.

Table 3 Losses recorded by boiling of *Polyodon spathula* meat of different ages

Specification		*Polyodon spathula* ***1st summer*** ***P.s.0+***	*Polyodon spathula* ***2nd summer*** ***P.s.1+***	*Polyodon spathula* ***3rd summer*** ***P.s.2+***	*Polyodon spathula* ***4th summer*** ***P.s.3+***
Initial weight of samples (g)	$\bar{x} \pm s_{\bar{x}}$	202.10±2.32	210.09±2.28	242.16±2.39	233.21±2.33
	V%	4.12	4.37	4.53	4.48
Final weight of samples (g)	$\bar{x} \pm s_{\bar{x}}$	137.06±1.54	144.13±1.75	169.01±1.88	164.00±1.84
	V%	3.34	3.45	3.56	3.62
Losses (g)	$\bar{x} \pm s_{\bar{x}}$	65.04±1.25	65.96±1.21	73.15±1.39	69.21±1.37
	V%	2.23	2.28	2.34	2.31
Losses (%)	$\bar{x} \pm s_{\bar{x}}$	32.18±0.59	31.39±0.77	30.20±0.57	29.67±0.62
	V%	4.10	5.53	4.26	4.74
Fisher test	3.0757 (F) < F 0.05 (3;36) *Insignificant differences.*				

Note: n=10 individuals for each age

From the obtained results could be observed that weren't significant differences between all four ages, calculated values being in the limits 29.67%, for $P.s._{3+}$ and 32.18% for $P.s._{0+}$.

Variability of samples was very good, for all situations were noticed very low values for V% (below 5%).

Losses resulted by frying

Regarding losses resulted by frying, could be remarked that at meat gathered from *Polyodon spathula* sturgeons of 1st summer was a losses percentage rate of 36.09%, with 2.12–6.77% higher face to values determined for other ages (table 4).

Variance testing for recorded losses by frying enlightened significant statistical differences between the losses percentage recorded for paddlefish meat of 1st summer and the one of 4th summer.

Homogeneity of the analysed batches was very good because were calculated values for variability coefficient (V%) between 1.20 and 1.83.

In the current paper were also calculated the losses from paddlefish meat recorded after its processing by frying preceded by flouring.

Flouring is a previous operation to fish frying which assure realisation of the followings targets [1]:

- protection of muscular tissue against darkness and apparition of bitter taste;
- protection of muscular tissue against high dehydration at frying;
- forming taste and flavour.

Meat samples gathered from studied paddlefish, after flouring were left at rest for 3-5 minutes for flour soaking with the water on the meat surface. Through this processing procedure of fish meat aimed:

- obtaining of products with specific aspect, taste and smell;
- inactivation of muscular tissue own enzymes;
- destroying of micro-organisms on the skin surface;
- increasing fish meat consistency through elimination of water in excess.

Table 4 Losses recorded by frying of *Polyodon spathula* meat of different ages

Specification		*Polyodon spathula* ***1st summer P.s.0+***	*Polyodon spathula* ***2nd summer P.s.1+***	*Polyodon spathula* ***3rd summer P.s.2+***	*Polyodon spathula* ***4th summer P.s.3+***
Initial weight of samples (g)	$\bar{x} \pm s_{\bar{x}}$	304.24±3.69	325.11±3.81	330.42±3.54	327.19±3.38
	V%	5.42	5.56	5.61	5.58
Final weight of samples (g)	$\bar{x} \pm s_{\bar{x}}$	185.29±1.79	200.72±2.11	208.03±2.23	207.93±2.08
	V%	3.72	4.02	4.28	4.21
Losses (g)	$\bar{x} \pm s_{\bar{x}}$	118.95±1.47	124.39±1.51	122.39±1.49	119.26±1.50
	V%	3.21	3.35	3.47	3.63
Losses (%)	$\bar{x} \pm s_{\bar{x}}$	39.09±0.54	38.26±0.53	37.04±0.82	36.44±0.57
	V%	1.22	1.20	1.83	1.28
Fisher test	3.5763 (F) > F 0.05 (3;36) 3.24* *Significant differences.*				

Tukey test W1 = 2.55 W2 = 3.27	Indicators		Differences between averages	Signification	Level
	P.s.0+	*P.s.3+*	2.65	significant	0.5
	P.s.0+	*P.s.2+*	2.05	insignificant	-
	P.s.0+	*P.s.1+*	0.83	insignificant	-
	P.s.1+	*P.s.3+*	1.82	insignificant	-
	P.s.1+	*P.s.2+*	1.22	insignificant	-
	P.s.2+	*P.s.3+*	0.6	insignificant	-

Note: n=10 individuals for each age

Through flouring and frying of paddlefish meat were recorded mean losses of 33.11%. Also this time the highest losses were observed at small ages (1st summer and 2nd summer) (table 5), those ones being with 0.33–6.07% higher that the average calculated for all four studied ages.

Table 5 Losses recorded by frying of flouring *Polyodon spathula* meat of different ages

Specification		*Polyodon spathula* ***1st summer P.s.0+***	*Polyodon spathula* ***2nd summer P.s.1+***	*Polyodon spathula* ***3rd summer P.s.2+***	*Polyodon spathula* ***4th summer P.s.3+***
Initial weight of samples (g)	$\bar{x} \pm s_{\bar{x}}$	256.72±2.96	286.68±3.21	210.90±2.34	245.62±2.67
	V%	4.4	4.6	3.8	4.2
Flour quantity (g)	$\bar{x} \pm s_{\bar{x}}$	12.23±0.28	13.64±0.34	10.00±0.18	11.45±0.23
Final weight of samples (g)	$\bar{x} \pm s_{\bar{x}}$	185.25±1.95	200.58±2.21	149.15±1.62	175.73±1.86
	V%	3.47	3.97	3.15	3.24
Losses (g)	$\bar{x} \pm s_{\bar{x}}$	83.70±0.82	99.74±1.07	80.75±0.87	81.34±0.96
	V%	2.68	2.94	2.21	2.49
Losses (%)	$\bar{x} \pm s_{\bar{x}}$	35.12±0.77	33.21±0.84	32.48±0.68	31.64±0.90
	V%	1.72	1.89	1.52	2.01
Fisher test	3.4057 (F) > F 0.05 (3;36) 3.24* *Significant differences.*				

Tukey test W1 = 3.26 W2 = 4.17	Indicators		Differences between averages	Signification	Level
	P.s.0+	*P.s.3+*	3.48	significant	0.5
	P.s.0+	*P.s.2+*	2.64	insignificant	-
	P.s.0+	*P.s.1+*	1.91	insignificant	-
	P.s.1+	*P.s.3+*	1.57	insignificant	-
	P.s.1+	*P.s.2+*	0.73	insignificant	-
	P.s.2+	*P.s.3+*	0.84	insignificant	-

Note: n=10 individuals for each age

Flour consumption for this operation was between 4.6 and 4.8% from the total weight of processed meat.

Homogeneity of the analysed samples for this parameter was very good, calculated values for variability coefficient was below 3%.

Significant statistical differences were calculated only between recorded losses for frying preceded by flouring of paddlefish meat of 1st summer and 4th summer. Between

other ages weren't enlightened significant statistical differences.

From all the processing types applied to *Polyodon spathula* sturgeon meat, the highest losses were recorded at frying – in average 37.7% and the lowest ones were observed at boiling – in average 30.86%.

Processing of paddlefish meat by flouring and frying recorded average losses of 33.11%, with 12.17% less than in the case of frying (without flouring), and with 7.29% higher than at boiling.

Analysing the recorded losses for all three types of processing function of age we observed that younger fishes (1st summer and 2nd summer) had higher losses than the ones with greater ages (3rd summer and 4th summer).

Losses resulted by boiling or frying were realised on the base of water and fat content, so paddlefishes with small ages but with a higher content in water recorded greater losses in comparison with the paddlefishes with great age.

Also the different losses function of age could be a consequence that at greater ages was observed an increased lipids content. By applied thermal processing a great majority from those lipids melt and pass in the processing environment (water, oil).

CONCLUSIONS

Mean values of collagen rate of 3.93% for paddlefish of 1st summer; 4.00% for paddlefish of 2nd summer; 4.11% for paddlefish of 3rd summer and 4.21% for paddlefish of 4th summer confirm the existence of a low rate in collagen for studied fish meat, fact which make that this one to be easier to be cooked.

To establish the rate of muscular and conjunctive tissue, the histological studies for side muscles gathered from paddlefishes of 4th summer, revealed a mean diameter with value between 38.78 μ and 47.07 μ, calculating an intermediary value of 43.42 μ. Those data lead to obtain a mean square area per transversal section of 1485.74 μ^2.

Mean diameter of paddlefish muscular fibre of 4th summer (43.42 μ) characterized a meat with a soft texture.

Profile on transversal section of muscular fibres had an ellipsoidal shape; this fact was enlightened by the rate between great diameter and small diameter (DM/Dm) which varied between 1.35/1–1.61/1.

Regarding the proportion of main tissue categories in the structure of side muscles from *Polyodon spathula* sturgeon breed (4th summer), was noticed that the mean rate of muscular tissue was 70.47%, while the mean rate of conjunctive tissues was of only 29.52%.

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