AGRICULTURAL UNIVERSITY PLOVDIV
FACULTY OF AGRONOMY
DEPARTMENT OF ANIMAL SCIENCE

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MORPHO-PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERISTICS OF FISH FROM ACIPENSERIDAE FAMILY

AUTHOR'S SUMMARY

OF THE DISSERTATION
FOR AWARDING EDUCATIONAL AND SCIENTIFIC DEGREE 'DOCTOR' IN A SCIENTIFIC SPECIALTY 'BREEDING OF AGRICULTURAL ANIMALS, BIOLOGY AND BIOTECHNICS OF REPRODUCTION"

Scientific supervisors:

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The dissertation comprises 191 pages and includes 38 tables and 43 figure. The cited literature list indicates 277 sources, of which 77 in Cyrilic and 200 in Latin script.

The dissertation was discussed and allowed to be defended in front of the board of professors at the Department of Animal Science, Faculty of Agronomy, Agricultural University Plovdiv.

The defence of the dissertation will be performed on…..at….in…..at the Faculty of Agronomy at AU- Plovdiv at a meeting of the Specialised scientific jury designated by the Rector of the Agricultural University following order № РД 16-613 / 14.05.2025

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INTRODUCTION

The aquaculture is becoming increasingly important worldwide. This is connected to the growing need to supply the growing global population with quality products. The human population has already reached 8 billion people by 2022. The demand for fishery products has been rising, and fish consumption worldwide has increased by 122% in the last three decades. The natural hydrobiont populations are depleted and cannot meet the ever-growing needs. The situation of the sturgeon population is especially grim. This is due to a combination of factors: deterioration in the natural habitat conditions, hydraulic work, which is not in compliance with the requirements of the anadromous fish; unsustainable fishery practices, poaching, etc. To save the natural sturgeon populations, Bulgaria and other countries from the European Union have imposed a total ban on sturgeon fishing. Sturgeon species are a source of delicacy products with a high market value. Therefore, sturgeon farming has been widely developed in the last decades. The sturgeon farming in Bulgaria is particularly noted for its very good development. At the same time, the scientific studies in our country are largely insufficient. This is especially true for fish which are cultivated in industrial super-intensive farming. To develop and implement technologies meeting the contemporary requirements for sustainable aquaculture, it is necessary to gain knowledge with reference to the specifics of the development of particular sturgeon species and the quality of their production. The Acipenseridae family is rich in species. It includes freshwater and anadromous species, which widely differ in terms of their biological characteristics. Previously, the sturgeon farming in Bulgaria was mostly based on the cultivation of the Russian sturgeon. Gradually, new species were introduced, and in recent years it is the Siberian sturgeon that has sparked marked interest. Different hybrids are also cultivated in Bulgarian fish farms, with those of the Russian and Siberian sturgeon being the most widespread. The present dissertation elaborates on issues related to the industrial cultivation of species and hybrids of importance for sturgeon farming both locally and globally: Siberian sturgeon, Russian sturgeon, and a hybrid of the Siberian and the Russian sturgeon. Subject to analysis were the characteristics of the development, slaughter parameters, and quality of the meat of fish with different live weights cultivated in a super-intensive cage farm.

AIMS AND TASKS

Purpose of the Dissertation:

Study on the morpho-physiological and biochemical characteristics of fish of the Acipenseridae family- Siberian sturgeon (*Acipenser baerii*), Russian sturgeon (*Acipenser gueldenstaedtii*), hybrid of Siberian sturgeon x Russian sturgeon (F_1 *A. baerii* x *A. gueldenstaedtii*), with different live weight, cultivated in a cage industrial farm.

To achieve the aim, the following tasks were set:

1. Morpho-physiological analysis of Siberian sturgeon with different live weight:
    a. Plastic Features
    b. Morphometric and morpho-physiological indices.
    c. Slaughter parameters.

2. Analysis of the meat of Siberian sturgeon with different live weights:
    a. Chemical composition and energy content of the meat.
    b. Amino Acid profile.
    c. Protein profile.
3. Morpho-physiological analysis of Russian sturgeon with different live weights:
    a. Plastic Features
    b. Morphometric and morpho-physiological indices.
    c. Slaughter parameters.
4. Analysis of the meat of Russian sturgeon with different live weights:
    a. Chemical composition and energy content of the meat.
    b. Amino Acid profile.
    c. Protein profile.
5. Morpho-physiological analysis of the Siberian and Russian sturgeon hybrid with different live weights:
    a. Plastic Features
    b. Morphometric and morpho-physiological indices.
    c. Slaughter parameters.
6. Analysis of the meat of the Siberian and Russian sturgeon hybrid with different live weights:
    a. Chemical composition and energy content of the meat.
    b. Amino Acid profile.
    c. Protein profile.
7. Comparative analysis of the morpho-physiological parameters of Siberian sturgeon, Russian sturgeon, and their hybrid with different live weights.
8. Comparative analysis of the protein profile of the meat of Siberian sturgeon, Russian sturgeon, and their hybrid with different live weights.

MATERIALS AND METHODS.

Characteristics of the farm.

The studies were performed in an industrial cage farm in Kardzhali Reservoir. The species from different breeds and categories were reared in different cages. Sentinal catch and regular sorting of the fish by live weight were carried out during the vegetation period. The fish were reared in the same conditions throughout the entire period of the study. The hydrochemical and hydrophysical parameters in the farm were suitable for the cultivation of sturgeon species (Nukolova & Bonev, 2020b). Tables 1 and 2 display the main parameters related to the quality of the water in different periods.

Feeding was performed with specialized granular feed (Table 3). All fish were divided by origin and category and were reared separately in different cages. During the vegetation period, the fish were periodically sorted to have fish with equal live weight at the end of the vegetation period.

Table 1. Quality of the water in the farm during the spring-summer period (Nikolova & Bonev, 2020b).

Parameters	Months				
	IV	V	VI	VII	VIII
Temperature, ^{0}C	12.47	17.10	22.04	25.17	26.06
Conductivity, µS.cm^{-1}	300	300	450	180	160
Total hardness, mg eqv.dm^{-3}	3.95	3.96	3.82	1.32	1.60
pH	7.35	6.79	7.31	8.80	7.42
O_2, mg.dm^{-3}	9.86	8.99	7.04	5.25	4.75
O_2, %	128.9	129.5	112.1	88.5	81.2
N-NH_4^+, mg. dm^{-3}	0.22	0.17	0.15	0.27	0.14
N-NO_3^-, mg. dm^{-3}	1.50	1.40	1.30	1.1	1.00
P-PO_4^{3-}, mg. dm^{-3}	0.04	0.17	0.08	0.05	0.06
Permanganate oxidation, mgO_2.dm^3	4.16	4.00	2.93	3.44	4.90
BOD_5 mg. dm^{-3}	4.22	1.29	3.82	3.03	9.10

Table 2. Quality of the water in the farm during the Autumn- Winter period (Nikolova & Bonev, 2020b).

Parameters	Months			
	IX	X	XI	XII
Temperature, ^{0}C	24.49	20.44	16.08	10.60
Conductivity, µS.cm^{-1}	320	320	175.5	159.5
Total hardness, mg eqv.dm^{-3}	1.50	1.46	1.50	1.50
pH	8.15	6.88	6.81	7.50
O_2, mg.dm^{-3}	4.67	5.30	5.72	7.05
O_2, %	77.7	81.8	80.8	88.3
N-NH_4^+, mg. dm^{-3}	0.96	0.22	0.21	0.17
N-NO_3^-, mg. dm^{-3}	1.00	1.50	1.30	1.60
P-PO_4^{3-}, mg. dm^{-3}	0.18	0.11	0.08	0.08
Permanganate oxidation, mgO_2.dm^3	3.40	3.63	3.22	4.66
BOD_5 mg. dm^{-3}	1.36	1.00	0.95	2.03

Table 3. Feed content.

Parameters, %	Values	Parameters	Values
Crude protein, %	46	**Na, %**	0.3%
Crude fat, %	15	**Vitamin A, IU.kg^{-1}**	10 000
Crude fibre, %	1.4	**Vitamin C, mg.kg^{-1}**	520
Minerals, %	6.5	**Vitamin E, mg.kg^{-1}**	200
Phosphorus, %	1.03	**Vitamin D3, IU.kg^{-1}**	2 303
Calcium, %	1.4	**Digestible energy, MJ.kg^{-1}**	19.2

Fish- subject to the study.

The fish subject to the study were from the the commercial flocks:

- Siberian sturgeon (*Acipenser baerii* Brandt, 1869);
- Russian sturgeon (*Acipenser gueldenstaedtii* Brandt et Ratzeburg, 1833);
- A hybrid of Siberian and Russian sturgeon (F_1 *A. baerii* x *A. gueldenstaedtii*).

Morpho-physiological analysis

At the end of the vegetation period, a set of five individuals were randomly taken from different groups of male fish. Two weight groups were formed within each species and hybrid from cages with lower (1-first weight group- Ab-1; Ag-1; Hy-1) and higher (2- second weight group- Ab-2; Ag-2; Hy-2) live weight (Table 4). During the morpho-physiological analysis, the morpho-physiological parameters and indices as well as the slaughter parameters of each individual were examined. Table. 5 displays the parameters and indices examined as well as the codes used to indicate them.

Table 4. Characteristics of the groups studied.

Species/ hybrid	**Weight group**	**code**	**Age, years**	**n**	**Live weight, g** X ± SE
Siberian sturgeon	1	Ab-1	3+	5	2823.0±126.04[a]
	2	Ab-2	3+	5	4273.2±110.29[a]
Russian sturgeon	1	Ag-1	5+	5	3010.8±72.95[b]
	2	Ag-2	5+	5	4910.0±100.30[b]
Hybrid	1	Hy-1	5+	5	2796.6±129.84[c]
	2	Hy-2	5+	5	4934.8±192.54[c]

[a, b, c] *The differences between the values, indicated with identical letters, within each genotype are statistically different; (p<0.001).*

Table 5. Parameters and indices studied.

Parameter	**Code**
1	***2***
Body Weight	**BW**
Eviscerated weight, kg	**EW**
Exterior measurements	
Total length	**TL**
Fork length /from the tip of the rostrum to the end of the caudal fin medium rays/	**FL**
Standard length /from the tip of the rostrum to the tip of the caudal fin medium rays/	**SL**
Maximum body width	**SC**
Maximum body height	**H**
Maximum body girth	**CC**
Slaughter analysis	
Carcass weight, g	**CW**
Fillet with skin, g	**FS**
Fillet with skin without the belly flap, g	**FSwB**
Scutes, g	**Sc**
Total viscera, g	**TV**
Gonads, g	**GO**
Liver, g	**LW**
Spleen, g	**SW**
Hearth, g	**Ht**
Swim bladder, g	**Sb**
Pyloric appendage, g	**Pa**
Chord, g	**CH**
Fins and tail, g	**FT**

1	2
Head without gills, g	**Hw**
Gills, g	**G**
Yield	
Slaughter yield (gutted fish weight), %	**1- Sv**
Consumable yield (weight without the viscera and the gills), %	**2- Sv**
Carcass yield (headed and gutted fish weight), %	**3- Sv**
Morphometric indices	
Fulton's coefficient (BW/SL^3)*100)), %	**CFF**
Clarc's coefficient (EW/ SL^3)*100)), %	**CFC**
Condition index ((BW/(SL*H*CC)) *100), %	**IC**
Condition index (modified Fulton's coefficient by Jones et al., 1999 (following Richter et al., 2000) ((BW/(SL^{2}H))*100)	**ICR**
High-backed index (SL/H))	**IHB**
Broad-backed index ((SC/SL)*100), %	**IBB**
Hardness index ((CC/SL)*100)), %	**IH**
Morpho-physiological indices	
Viscerosomatic index (TV/BW)*100), %	**VSI**
Hepatosomatic index (LW/BW)*100), %	**HSI**
Gonadosomatic index (GO/BW)*100), %	**GSI**
Spleenomatic index (SW/BW)*100), %	**SSI**
Cardiosomatic index (Ht/BW)*100), %	**HtSI**

Morphometric and morpho-physiological parameters and indices

The methods applied are the classical ones used in the studies on living hydrobionts (Pravdin 1966; Morev, 1999; Svirski and Skirin, 2007). The morphological analysis scheme used was developed by Krylova and Sokolov (1981) for sturgeon species and sturgeon hybrids (Fig. 1; Table 6)

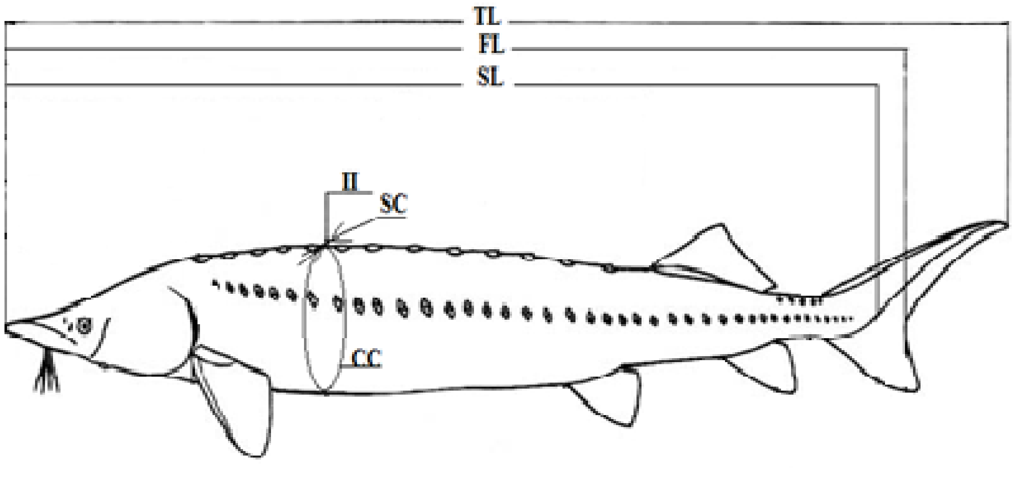


Figure 1. Fish measurements scheme.

The morphometric measurements were performed with the use of a fish measuring board with an accuracy of up to 1 mm and a graduated tape with an accuracy of up to 1mm. The morphometric indices were calculated based on the morphometric measurements (Table 5).

Slaughter parameters

The fish slaughter analysis was performed following the classical methods (Todorov and Ivancheva, 1992; Pokorni, 1988; Prikryl and Janecek, 1991). The pre-slaughter live weight, carcass weight, fins, head without gills, total viscera weight, separate organ weight, and fillet with the skin of each fish were measured. The percentage proportion of the separate organs in the body (morpho-physiological indices), slaughter yield (1) (eviscerated weight), consumable yield (2) (weight without viscera and gills), carcass yield (3) (headed and gutted fish weight), and the meat quantity in the carcass (fillet and fillet without the belly flap) were calculated.

Meat analysis

During the slaughter analysis of the musculature of the fillet without skin, homogenized samples were prepared for the analysis of the chemical composition and the energy content of the meat, and its amino acid and protein profile. The analyses were conducted in the laboratories of UFT-Plovdiv and AU- Plovdiv.

Chemical composition and energy content of the meat

- Crude protein- following Kjeldhal (AOAC, 1990).
- Total lipids- under the Bligh and Dyer method (1959).
- Dry matter and ash content- via weighing method (ICC Standard № 104/1, 1990). The samples were dried in a thermostat at a temperature of 105°C until reaching constant weight.
- Energy content of the meat- based on the chemical composition of the meat and coefficients 23.90 $kJ.g^{-1}$ per the proteins and 39.75 $kJ.g^{-1}$ regarding the fats (Hadjinikolova et al., 2008).
- Total carbohydrates- following the Dubois method (Dubois et al., 1956).

Amino Acid Profile

Amino Acids- employing high-performance liquid chromatography (ELITE LaChrome, Hitachi High Technologies America, Inc., San Jose, CA, USA).

Protein profile

Total protein- by the Lowry method in compliance with Deepachandi et al. (2020). Protein profile- it is defined through a polyacrylamide gel electrophoresis under denaturing conditions (SDS- PAGE) following a method described by Laemmli (1970). The determination of the molecular weight (Mm) of the fractions obtained under SDS-PAGE was made with the use of protein markers- „SigmaMarker™ Wide range, molecular weight 250 кDa". The information gained from the gels was processed and displayed with the 'Totallab' specialized software.

Statistical processing of data

The morpho-physiological and slaughter parameters data were statistically processed via IBM SPSS Statistics 21. One-way analysis of variance (ANOVA) was made for the comparative analysis of all genotypes examined. The biochemical composition and the protein profiles of the meat data were processed via one-way analysis of variance (ANOVA) with the statistical program Statgraphics Centurion (version XVI, 2009) (

Stat Point Technologies, Ins., Warrenton, VA, USA). The differences between the groups were ascertained following the Fisher's LSD method with a reliability level of p≤ 0.05; 0.01; 0.001. where X is the arithmetic mean per each sample, Sx is the arithmetic mean error, and SD is a standard deviation.

RESULTS AND DISCUSSION

Morpho-physiological characteristics, slaughter parameters, and quality of the meat of the Siberian sturgeon (*Acipenser baerii*).

Morpho-physiological and slaughter parameters

Tables 6 and 7 display the exterior and weight parameters of the fish from the separate groups studied.

Table 6. Exterior parameters of the Siberian sturgeon from different weight groups, cm

Group / Parameters	Ab - 1 (n=5)			Ab - 2 (n=5)		
	X	±Sx	SD	X	±Sx	SD
Total length	88.14	2.178	4.870	99.82	0.723	1.617
Fork length	76.12	1.947	4.353	85.98	0.881	1.969
Standard length	71.98	1.761	3.939	80.46	0.331	0.740
Maximum body height	9.90	0.100	0.224	10.68	0.208	0.466
Maximum body width	10.78	0.196	0.438	12.08	0.213	0.476
Maximum body girth	31.40	0.579	1.294	35.00	0.389	0.869

Under the conditions of the technology studied by us, the Siberian sturgeon gained weight adequately. At the age of four years, the group of smaller fish had an average live weight of 2823.0 g, and that of the larger ones- 4273.2g, with the difference between the groups being 1.5 times (*p<0.001*). The heavier fish displayed a larger difference in all length parameters; it had a total length which was 11.7% more, fork length, and standard length of 11.5 and 10.5% more, respectively. The fish from the second group(with bigger live weight) also displayed higher maximum body height, width, and girth- 7.3, 10.8, and 10.3%, respectively. Regardless of the higher values for all exterior indices in fish from the second group, the differences between the groups were insignificant. Significantly lower values were reported for the smaller fish regarding the weight of their carcass (37.5%, *p<0.001*), fillet (40.5%, *p<0.001*), fillet without the belly flap (57.5%, *p<0.001*), viscera (42.4%, *p<0.05*), gonads (65.6%, *p<0.05*), liver (39.7%, *p<0.05*), tail and fins (28.6%, *p<0.001*), head without the gills (25.1%, *p<0.01*), gills (28.8%, *p<0.01*), swim bladder (38.8%, *p<0.001*) and the chord (21.7%, *p<0.05*) (Table 7).

The fish from both weight groups did not differ significantly in their heart, spleen, pyloric appendage, and scutes weight. As a whole, it can be claimed that the relative shares of the head, gills, fins, chord, and scutes in the fish with larger live weight were lower - 13.5, 8.2, 8.2, 19, and 36.9%, respectively. It was only the swim bladder that displayed higher values (6.9%) in the fish from groups Ab- 2 (Table 8). The differences ascertained, however, were not significant regarding any of the parameters indicated.

Table 7. Weight parameters of Siberian sturgeon from different weight groups, g

Parameters	Ab - 1 (n=5)			Ab - 2 (n=5)		
	X	±Sx	SD	X	±Sx	SD
Live weight	2823.0a	126.0	281.8	4273.2a	110.3	246.6
Carcass weight	1646.1a	126.1	282.0	2633.8a	127.3	284.7
Fillet with skin	1293.2a	11.47	247.0	2173.6a	110.6	247.4
Fillet with skin without belly flap	1084.4a	121.2	270.9	1884.0a	74.58	166.8
Total viscera	381.4c	21.823	48.80	560.8c	58.16	130.0
Gonads	65.12c	26.97	60.30	189.3c	33.98	75.98
Liver	58.84c	11.81	26.41	97.55c	10.04	22.45
Spleen	4.11	0.695	1.554	6.53	1.288	2.881
Hearth	3.26	0.485	1.085	3.67	0.115	0.258
Fins and tail	163.1a	7.885	17.63	228.4a	5.681	12.70
Head without gills	551.9b	30.66	68.55	736.9b	20.29	45.37
Gills	80.54b	6.224	13.92	113.2b	20.29	45.37
Scutes	79.80	23.89	53.42	87.48	11.61	25.95
Swim bladder	24.00a	2.025	4.528	39.20a	1.158	2.588
Pyloric appendage	6.034	12.24	2.162	22.18	12.24	38.64
Chord	56.10c	4.197	9.385	71.65c	2.371	5.303

The differences between the values, indicated with identical letters on the rows are significant: a-p<0.001; b- p<0.01; c- p<0.05

Table 8. Relative share of separate body parts in Siberian sturgeon from different groups live weight, %

Parameters	Ab - 1 (n=5)			Ab - 2 (n=5)		
	X	±Sx	SD	X	±Sx	SD
Head without gills	19.64	1.156	2.584	17.30	0.717	1.603
Gills	2.89	0.283	0.632	2.67	0.213	0.475
Fins and tail	5.81	0.312	0.698	5.37	0.225	0.502
Swim bladder	0.86	0.075	1.666	0.92	0.029	0.064
Chord	2.00	0.170	0.379	1.68	0.064	0.142
Scutes	2.82	0.853	1.907	2.06	0.285	0.637

The slaughter parameters of the Siberian sturgeon with different live weights are displayed in Table 9. All parameters examined were higher in the fish with larger live weight, however, the differences were significant only with reference to the relative share of the fillet in the carcass. The data obtained from us indicate that the Siberian sturgeon is characterised by good slaughter parameters. The slaughter yield was 86.4-86.8 6%; the consumable- 83.51- 84.19%, and the carcass- 58.07- 61.52%. The calculated indices for Siberian sturgeon of different weight groups are displayed in

Table 10. The fish with larger live weight had a higher condition index IC and ICR, with the difference being 1.61 (*p< 0.01*) and 0.67 % (*p<0.05*) respectively. No significant difference was reported with reference to the other condition indices- CFF and CFC, however, the values of the fish from the group with greater weight (Ab- 2) were again higher.

Table 9 General slaughter parameters of Siberian sturgeon from different groups, %

Parameters	Ab - 1 (n=5)			Ab - 2 (n=5)		
	X	±Sx	SD	X	±Sx	SD
Slaughter yield	86.40	0.904	2.021	86.86	1.384	3.095
Consumable yield	83.51	1.117	2.498	84.19	1.417	3.168
Carcass yield	58.07	2.463	5.507	61.52	1.836	4.105
Relative share in the whole fish						
Fillet	45.61	2.541	5.682	50.75	1.466	3.278
Fillet without the body flap	38.06	3.161	7.068	44.04	0.897	2.007
Relative share in the carcass						
Fillet	78.38a	1.640	3.667	82.54a	1.164	2.603
Fillet without the body flap	65.19	3.391	7.583	71.73	1.595	3.567

The differences between the values, indicated with identical letters on the lines are significant: a- p<0.001

Table 10. Morphometric and morpho-physiological indices of Siberian sturgeon from different weight groups

Indices	Ab - 1 (n=5)			Ab - 2 (n=5)		
	X	±Sx	SD	X	±Sx	SD
IHB	7.28	0.225	0.502	7.55	0.170	0.380
IBB	15.02	0.540	1.208	15.01	0.261	0.584
IH	43.71	1.172	2.620	43.50	0.451	1.008
CFF	0.76	0.042	0.094	0.82	0.024	0.054
CFC	0.66	0.036	0.081	0.71	0.026	0.057
IC	12.60b	0.275	0.615	14.21b	0.121	0.271
ICR	5.51a	0.197	0.440	6.18a	0.109	0.243
VSI	13.60	0.904	2.021	13.14	1.384	3.095
HSI	2.06	0.351	0.784	2.27	0.185	0.415
GSI	2.18a	0.827	1.849	4.37a	0.697	1.557
SSI	0.14	0.019	0.043	0.15	0.031	0.069
HtSI	0.12	0.018	0.041	0.09	0.003	0.006

The differences between the values, indicated with identical letters on the lines are significant: b- p<0.01; a- p<0.05

We did not ascertain any clear trend in the interior indices connected to the fish live weight. VSI and HtSI were higher in the smaller fish, while HIS, GSI, SSI were higher in the heavier ones. A significant difference was observed between the groups only regarding GSI. The index was twice higher (*p<0.05*) in the larger fish.

Chemical composition and energy content of the Siberian sturgeon meat

The results we obtained demonstrate that the live weight of four-year-old Siberian sturgeons had a significant influence on the meat quality (Table 11). The meat of both weight groups was marked with a high dry matter content- 21.41-27.06%. This is one of the main parameters indicating the meat quality. The meat of the fish we studied was of good quality. The protein content in the fresh meat varied from 14.68 % in the first weight group to 17.35% in the second. The lipid content for the groups was 3.72 and 7.66% respectively. Having analysed the results obtained for the Siberian sturgeon, we ascertained that the fish from both groups could be classified as medium-fat fish. Regarding the influence of the fish weight on the chemical composition of the meat, it can be stated that its increase enhanced a range of parameters. The relative share of the dry matter in the meat went 26.4% up, and that of the protein in the fresh meat- 18.2%. Similarly, the lipids more than doubled. No significant differences were reported between the two groups in terms of the carbohydrate and mineral content in the fresh meat.

Table 11. Chemical composition and energy content of the Siberian sturgeon meat, X ± Sx

Parameters	**Groups**	
	Ab - 1	**Ab – 2**
% fresh sample		
Total dry matter	21.41±1.10	27.06±0.21
Water	78.59±1.10	72.94±0.21
Protein	14.68±0.68	17.35±0.14
Lipids	3.72±0.07	7.66±0.50
Carbohydrates	0.17±0.03	0.17±0.03
Minerals	1.00±0.06	1.02±0.01
% in dry matter		
Protein	75.01±0.79	64.12±0.16
Lipids	17.38±0.43	28.32±1.83
Carbohydrates	0.79±0.15	0.64±0.11
Minerals	4.66±0.28	3.77±0.05
Energy		
Total, kJ.100^{-1}g	2329.1±75.75	2658.1±3.75
Protein based, %	70.34±3.25	57.65±0.14

The lipid content in the dry matter displayed the same trend as that in the fresh meat. With the increase of the Siberian sturgeon live weight, the lipid levels also went up by 38.6%, while the protein decreased by 14.5%. The content of carbohydrates and minerals also fell with 18.9 and 19%, respectively. The total meat energy in our study reached 2658.08 kJ.100^{-1}g. It increased by 14.1 % with the increase in the live weight of the fish, however, the protein-based energy decreased by 18.04 %.

Amino Acid Profile

Table 12 displays the amino acid composition of the meat and the separate amino acid ratios of the Siberian sturgeons from the two weight groups. The results we obtained demonstrate that the meat of a four-year-old Siberian sturgeon cultivated in an industrial cage farm could be a good source of amino acids. Regarding the nonessential amino acids, the alanine and the histidine had the highest levels in both groups. However, it should be noted that the meat of the smaller fish was richer in these amino acids. The difference in favour of the first groups (Ab- 1) was 43.2 % for the levels of histidine and 10.6% for those of alanine. The serine, glutamine, glycine, arginine, and proline contents in the meat were lower. However, their levels were once again higher in the fish from the first group (Ab- 1) when compared with those in the fish from the second one (Ab- 2), with the difference being respectively 64.2%; 57.2%; 20%; 18.3%; 20.8%. Conversely, the cysteine and tyrosine content in the larger fish was 22.8% and respectively 16.1% higher.

Table 12. Analysed amino acid content of Siberian sturgeon from different groups, g/100 g protein

Parameters	**Groups**	
	Ab – 1	**Ab - 2**
Nonessential amino acids		
Asparagine **Asp**	12.26	4.08
Serine **Ser**	5.75	2.06
Glutamine **Glu**	8.32	3.56
Glycine**Gly**	1.35	1.08
Histidine* **His**	18.29	10.38
Arginine* **Arg**	6.51	5.32
Alanine **Ala**	10.99	9.83
Proline **Pro**	3.75	2.97
Cysteine **Cys**	2.03	2.63
Tyrosine **Tyr**	0.73	0.87
Essential amino acids		
Threonine **Thr**	5.13	4.09
Valine **Val**	2.99	2.83
Methionine **Met**	4.17	4.38
Lysine **Lys**	11.13	11.21
Isoleucine **Ile**	3.26	4.13
Leucine**Leu**	1.04	0.36
Phenylalanine **Phe**	5.58	9.24

* Conditionally essential amino acids

Intriguing results were obtained with reference to the Asparagine acid. Its content in group Ab-1 was 12.26 g/100 g protein, while in Ab-2 it was over three times lower- 4.08 g/ 100 g protein. The Siberian sturgeon meat is a very good source of lysine. In both of the Siberian sturgeon groups we studied, the lysine content significantly exceeded the content of the other essential amino acids. The lysine levels in the heavier fish insignificantly exceeded (by 0.7%) those in the fish from the first group. Regarding the group of essential amino acids, the trend observed was towards an increase of the content of methionine, isoleucine and, phenylalanine with the increase of the live weight of the fish. The difference in the phenylalanine was especially big, with the meat of the heavier fish having 39.6% more of this amino acid when compared with the fish with lower live weight. The differences in the methionine and the isoleucine levels were respectively 4.8% and 21.1%.

Protein Profile

Table 13 displays the fractional analysis of the protein in the Siberian sturgeon meat. It is clear that all protein fractions increased in parallel with the increase of the fish live weight. The most considerable increase was observed in the sarcoplasmic proteins- 15.3%, followed by the alkali-solubles- 10.9% and the myofibrillar proteins which went up by only 1.1%. The difference in the total protein content was in favour of the heavier fish and was 6.3%. Table 14 displays the share of the separate fractions in comparison with the total protein content, and fig. 2- the fraction profile.

Table 13. Fractionation of proteins in the Siberian sturgeon meat (Lowry's method, %

Proteins, %	**Groups**	
	Ab – 1	**Ab – 2**
Sarcoplasmic	5.24±0.24	6.04±0.20
Myofibrillar	10.28±0.31	10.39±0.29
Alkali soluble	1.37±0.04	1.52±0.06
Total	16.89	17.95

Table 14 Share of the separate protein fractions in comparison with the total protein content in the Siberian sturgeon meat.

Fractions, %	**Groups**	
	Ab - 1	**Ab – 2**
Proteins with molecular weight < 50 kDa (LMW)		
Sarcoplasmic	79.28	73.16
Myofibrillar	49.37	60.05
Alkali soluble	91.14	96.45
Proteins with molecular weight from 51 to 150 kDa (MMW)		
Sarcoplasmic	17.62	22.92
Myofibrillar	13.25	7.28
Alkali soluble	8.86	3.55
Proteins with molecular weight > 151 kDa (HMW)		
Sarcoplasmic	3.10	3.92
Myofibrillar	37.38	32.67
Alkali soluble	-	-

The sarcoplasmic fractions of the fish from both weight groups were composed of mostly low molecular proteins, with their share being higher in the fish with lower live weight (Ab- 1)- 79.28%. The difference between the two groups regarding this parameter was 8.4%. There has been a marked interest in the proteins in the meat with low molecular weight. Most studies are predominantly aimed at ascertaining the presence of parvalbumins in the meat as they are considered the major allergens in fish. The share of the proteins with molecular weight from 51 to 151 kDA was relatively higher in the fish with greater live weight (Ab- 2)- 22.92%. The difference between the groups was more significant- 30.1%. The sarcoplasmic fraction had the lowest share of proteins with molecular weight over 151 kDa. It was higher in the fish with greater live weight- 3.92%, which is 26.5% more than that of the fish with lower live weight. The same trend as the one we ascertained for the sarcoplasmic fraction was observed for the myofibrillar one.

The share of the low molecular weight proteins (< 50 kDa) was the highest. Unlike the sarcoplasmic fraction, however, their share was larger in the fish with greater live weight (Ab- 2). The parameter difference between the groups was 21.6%. An opposite trend was also observed in the proteins with molecular weight from 51 to 150 kDa. Unlike the sarcoplasmic fraction, their share was larger in fish with lower live weight, and the difference between the groups was significant- 1.8 times. With reference to the proteins with molecular weight > 151 kDa, once again their share was larger in the smaller fish, with the difference as opposed to the heavier fish being 14.4%.

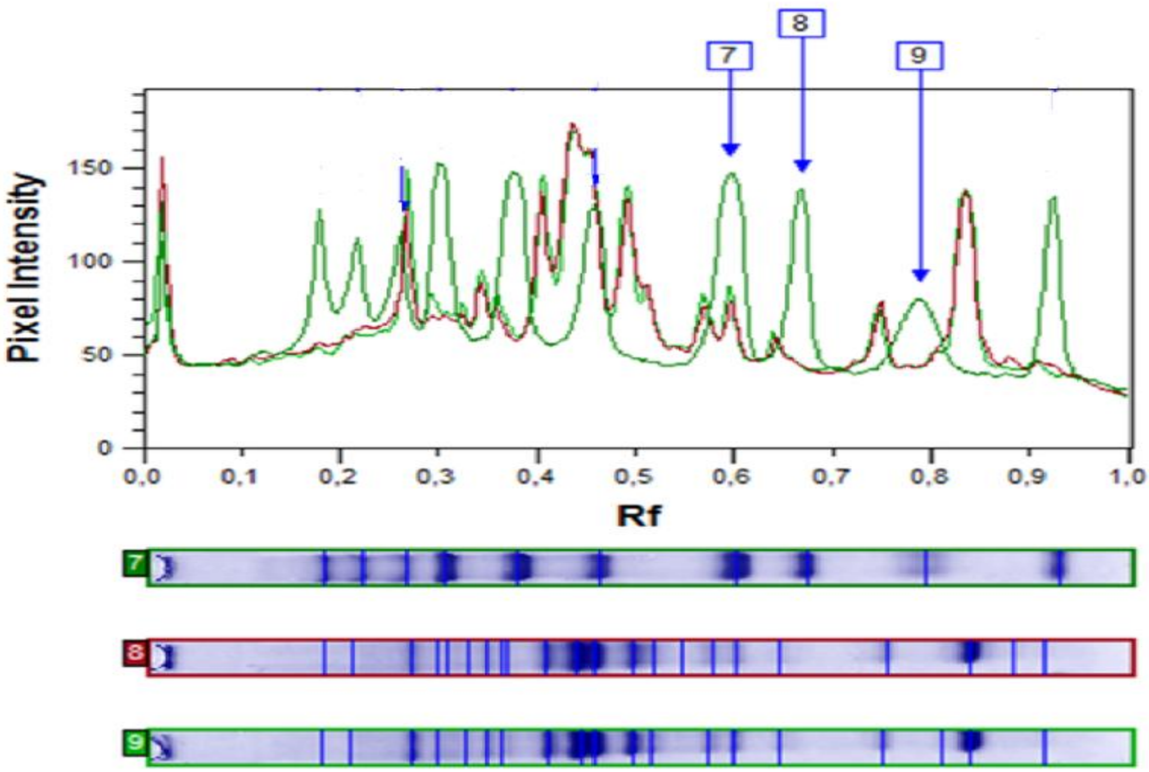


Fig. 2. Fractional profiles: 7- Marker proteins, 8- Ab- 1; 9- Ab- 2

Alkali soluble fraction was mostly presented by low molecular weight proteins (< 50kDa) and their share was the largest in the fish with greater live weight- 96.45%. The difference between the groups was 5.8%. The share of the proteins with molecular weight from 51 to 150 kDa was larger in the fish with lower live weight, and the difference with the heavier fish was 2.5 times. We did not ascertain an alkali-soluble fraction for the high molecular weight proteins (>151 kDa).

Morpho-physiological characteristics, slaughter parameters, and quality of the meat of the Russian sturgeon (*Acipenser gueldenstaedtii*).

Morpho-physiological and slaughter parameters

Table 15 displays the exterior parameters of the Russian sturgeon from different experimental groups.

Table 15. Exterior parameters of Russian sturgeon from different weight groups, cm

Group / Parameters	Ag – 1			Ag – 2		
	X	±Sx	SD	X	±Sx	SD
Total length	86.080	1.334	2.990	91.70	0.784	1.752
Дължина по Смит Smith's length	72.140	1.057	2.364	79.42	1.239	2.769
Standard length	67.700b	0.965	2.159	76.12b	1.717	3.840
Maximum body height	10.640a	0.157	0.351	13.340a	0.189	0.422
Maximum body width	10.180a	0.097	0.217	12.460a	0.378	0.844
Maximum body girth	30.880b	0.464	1.038	38.580b	1.365	3.052

The differences between the values, indicated with identical letters are significant: a- p<0.001; b- p<0.01

During the study, it was ascertained that there were significant differences between the groups, in favour of the fish with greater live weight, with reference to all exterior parameters. The heavier fish from the second group had 63.1% grater live weight; they also displayed higher percentages in their standard length- 12.4%, maximum body height- 25.4%, maximum body width- 22.4%, and maximum body girth- 24.9% more than what was recorded for the fish from the first group. The present study proves that same-age fish, cultivated under the same conditions but significantly different in their live weight, also display significant differences in some of the major exterior parameters. Tables 16, 17, and 18 display the results of the Russian sturgeon slaughter analysis which was performed. Differences, once again in favour of the larger fish, were observed in the different parts of the bodies and the organs of the fish from the different weight groups. The differences between the separate organs were slim- 0.19% were reported for the pyloric appendage, 4% for the scutes, 22 % for the chord, and 34.49% for the swim bladder. However, there were more significant differences between the other body parts and the viscera. The total viscera of the second group were more than twice as much as those of the first group, the gonads marked a difference of three times, the spleen- 1.8 times, fins and tail- 1.44 times, head without gills- 1.63 times, gills- 1.26 times. The fish from the second group had greater live weight and it was therefore logical for the absolute values of their separate parameters to be greater too. The smaller fish (Ag-1) exhibited higher values with reference to the relative share of the body parts and organs in the whole fish. It was only the swim bladder relative share value that was higher in group Ag- 2, however, the difference was negligible and insignificant- 0.02%. There were significant differences ($p<0.05$) regarding the relative whole fish share of: head without gills, gills, pyloric appendage, chord, and scutes. Overall, It can be stated that with the live weight increase of the fish, the relative shares of the pyloric appendage (38.9%) and the scutes (35.3%) significantly ($p<0.05$) decrease. In our study, we ascertained that the lower live-weight fish (Ag- 1) had significantly higher 1-Sv ($p<0.01$) and Sv ($p<0.05$)- 4 and 3.4%, respectively. No significant differences were reported between the groups in relation to 3-Sv. The significant difference between the groups regarding the first two yields was formed in connection with the head. The share of the head and the gills was significantly higher in the fish with lower live weight- by 13.8 and 23.2%, respectively.

Table 16 Weight parameters of the Russian sturgeon from different groups, g

Parameters	**Ag – 1**			**Ag – 2**		
	X	**±Sx**	**SD**	**X**	**±Sx**	**SD**
Live weight	3010.8a	72.96	163.1	4910.0a	100.3	224.3
Carcass	1931.9	73.49	164.3	2151.1	47.53	106.3
Fillet with skin	1505.2	70.03	156.6	2370.0	148.3	331.5
Fillet with skin without belly flap	1298.0	90.68	202.8	1913.6	86.89	194.3
Total viscera	288.14	10.12	22.62	652.7	42.08	94.09
Gonads	88.04	17.47	39.07	274.3	20.85	46.62
Liver	50.09	4.656	10.41	98.98	9.152	20.47
Spleen	5.51	0.538	1.202	10.17	1.882	4.208
Heart	5.07	0.548	1.226	7.51	0.845	1.890
Fins and tail	141.5	11.34	25.36	204.8	14.69	32.85
Head without gills	554.5	22.99	51.43	901.6	57.22	127.9
Gills	94.91	5.248	11.74	119.26	6.203	13.87
Scutes	145.2	14.02	31.35	151.3	25.69	57.44
Swim bladder	20.62	2.019	4.516	34.49	3.649	8.158
Pyloric appendage	5.23	0.667	1.491	5.24	0.757	1.692
Chord	62.63	4.371	9.774	76.66	7.443	16.64

The difference between the values, indicated with identical letters on the lines is significant: a- p<0.001

Table 17. Relative share of separate body parts and organs of Russian sturgeon from different weight groups, % live weight

Parameters	**Ag – 1**			**Ag – 2**		
	X	**±Sx**	**SD**	**X**	**±Sx**	**SD**
Head without gills	18.44c	0.787	1.759	15.89c	0.832	1.861
Gills	3.15b	0.167	0.372	2.42b	0.090	0.201
Fins and tail	4.68	0.355	0.794	4.16	0.262	0.585
Swim bladder	0.68	0.058	0.130	0.70	0.064	0.143
Pyloric appendage	0.18c	0.025	0.056	0.11c	0.0161	0.036
Chord	2.09b	0.158	0.353	1.57b	0.174	0.390
Scutes	4.81c	0.438	0.979	3.11c	0.589	1.317

The differences between the values, indicated with identical letters on the lines are significant: b- p<0.01; c- p<0.05

Taking into account that the head of the sturgeon fish is considered conditionally consumable, the first two yields showed that the inconsumable share of the consumable Russian sturgeon was small. It was 9.61% (fro 1-Sv) and 12.76% (for 2-Sv) with reference to the fish in the first weight group, while the values for the fish from the second weight group were respectively 13.3 and 15.7%. No significant difference was ascertained between the groups in connection with the fillet in the whole fish and the carcass. It must be noted, however, that the fish with lower weight had a higher share of the fillet (over 3%) and fillet without the belly flap (over 9%) in both the whole fish and the carcass.

Table 19 presents morphometric and morpho-physiological indices of the fish from the two weight groups examined.

Table 18. General slaughter parameters of Russian sturgeon from different groups, %

Parameters	**Ag - 1**			**Ag – 2**		
	X	**±Sx**	**SD**	**X**	**±Sx**	**SD**
Slaughter yield	90.39b	0.492	1.101	86.70b	0.853	1.908
Consumable yield	87.24c	0.539	1.206	84.27c	0.777	1.738
Carcass yield	64.11	1.244	2.783	64.21	0.601	1.344
Relative share in the whole fish						
Whole fillet	49.92	1.383	3.093	48.34	3.057	6.835
Fillet without the belly flap	42.99	2.290	5.122	38.99	1.675	3.746
Relative share in the carcass						
Whole fillet	77.83	1.105	2.472	75.25	4.656	10.41
Fillet without the belly flap	66.94	2.605	5.824	60.71	2.508	5.608

The differences between the values, indicated with identical letters on the lines are significant:- b p<0.01; c p<0.05

Table 19. Morphometric and morpho-physiological inidces of Russian sturgeon from different weight groups

Indices	**Ag – 1**			**Ag – 2**		
	X	**±Sx**	**SD**	**X**	**±Sx**	**SD**
IHB	6.37b	0.140	0.313	5.71b	0.098	0.220
IBB	15.05	0.329	0.736	16.42	0.771	1.724
IH	45.65	0.987	2.208	50.89	2.703	6.044
CFF	0.97	0.043	0.095	1.13	0.089	1.994
CFC	0.88	0.038	0.084	0.98	0.081	0.181
IC	13.55	0.287	0.637	12.60	0.435	0.968
ICR	6.19	0.206	0.462	6.42	0.433	0.968
VSI	9.61b	0.492	1.101	13.30b	0.853	1.907
HSI	1.67	0.168	0.375	2.01	0.175	0.392
GSI	2.92b	0.579	1.296	5.58b	0.374	0.836
SSI	0.18	0.016	0.035	0.21	0.038	0.085
HtSI	0.17	0.021	0.047	0.15	0.016	0.036

The differences between the values indicated with identical letters on the lines are significant: b- p<0.01

Our study indicated that CFF in the Russian sturgeon exceeded 1. A significant difference was ascertained in favour of the larger fish in the VSI (38.4%) and the GSI (91.2%) values.

Chemical composition and energy content in the Russian sturgeon meat

Table 20 displays chemical parameters and the energy content of the meat of the Russian sturgeon. The analysis showed that the six-year-old male Russian sturgeon, reared in a super-intensive cage farm, had meat with very good quality. It was rich in protein (up to 17.1%) and lipids (up to 6.8%), and the dry matter reached 26.6%. The obtained results demonstrate the influence of the live weight of the fish on the quality of their meat. The fish from the heavier weight group had higher dry matter quantity, with the difference between the two groups being 6.2%. The protein content was 1% higher in the same group. Higher mineral content was reported for the smaller fish but the difference was negligible- 0.09%. A more significant difference was ascertained for the fat and carbohydrate content. The fresh meat of the larger Russian sturgeon had 1.9 times more carbohydrates. As for the lipid content in the fresh meat, it was observed that with the increase of the live weight of same-age fish groups, their meat became considerably fattier. The larger fish (second group) had parameter values which were twice the same parameter values of the smaller fish. According to the classification specified by Babina & Koshnerov (2015), the Russian sturgeon from both weight groups could be considered medium-fat fish.

Table 20. Chemical composition and energy content of the meat of Russian sturgeon from different groups.

Parameters	**Groups**	
	Ag – 1	**Ag – 2**
% fresh sample		
Total dry matter	20.45±0.25	26.64±0.14
Water	79.55±0.25	73.36±0.14
Protein	16.05±0.44	17.05±0.33
Lipids	3.20±0.18	6.77±0.06
Carbohydrates	0.11±0.02	0.21±0.02
Minerals	1.28±0.05	1.19±0.09
% in dry matter		
Proteins	78.47±2.15	63.98±1.25
Lipids	15.65±0.87	25.42±0.21
Carbohydrates	0.56±0.09	0.78±0.09
Minerals	6.25±0.25	4.48±0.34
Energy		
Total, kJ.100^{-1}g	2497.5±51.36	2539.7±29.77
Protein based, %	75.09±2.06	60.21±1.17

The lipid content in the total dry matter of the larger fish reached 25.4%. The parameter difference between the groups was 9.77%. Unlike in the case of the fresh meat, the recalculated protein quantity in the dry matter was in favour of the smaller fish. Their protein relative share was over 78%, while for the larger fish it was 14.5% less. The smaller Russian sturgeon had a bigger mineral relative share in the dry matter, with the difference being 1.77%. The total energy content of the meat in our study was higher in the larger fish, and the difference between the groups was 1.7%. The difference could be explained by the higher fat levels of the fish with greater live weight. It needs to be pointed out, however, that the energy content of the smaller Russian sturgeon was supplied by the protein-based energy- 75%. Only 60 % of the total energy of the larger fish was protein-based.

Amino Acid profile

Table 21 displays the amino acid composition of the protein in the fish of the Russian sturgeon analysed. The results we obtained indicated that the species had meat with a very good amino acid profile. The meat was rich in lysine, with its values being high in both weight groups- from 17.86 to 19.43g/ 100 g protein. Higher lysine values were reported for the larger fish. Its content in the fish with lower live weight was 8.8% lower. The isoleucine was the essential amino acid with the highest quantity- over 22g/ 100 g protein in the smaller fish.

Table 21 Analysed amino acid content of the Russian sturgeon, g/100 g protein

Parameters	**Groups**	
	Ag – 1	**Ag – 2**
Non-essential amino acids		
Asparagine **Asp**	15.95	12.27
Serine **Ser**	5.05	5.26
Glutamine **Glu**	7.09	6.57
Glycine **Gly**	3.25	1.95
Histidine* **His**	17.70	13.15
Arginine* **Arg**	5.99	7.84
Alanine **Ala**	13.99	12.96
Proline **Pro**	4.17	4.69
Cysteine **Cys**	3.90	0.08
Tyrosine Tyr	5.60	6.76
Essential amino acids		
Threonine **Thr**	4.62	7.50
Valine **Val**	3.50	0.73
Methionine **Met**	4.10	4.35
Lysine **Lys**	17.86	19.43
Isoleucine **Ile**	22.59	7.78
Leucine **Leu**	1.59	1.46
Phenylalanine **Phe**	12.92	6.62

* Conditionally essential amino acids

Its content in the greater live weight fish was almost three times lower (7.78 g/ 100 g protein). The same trend was reported for phenylalanine, valine, and leucine. The phenylalanine content in the fish with lower live weight reached 12.92g/ 100 g protein, which is almost twice the values reported for the larger live weight fish (6.62 g/ 100 g protein). The valine quantities were lower- 3.50g/ 100 g protein in the smaller fish and 0.73 g/ 100 g protein in the heavier. The valine content difference between the groups was 4.8 point. In the case of the leucine, the difference in favour of the smaller fish which had 1.59g / 100 g protein, was considerably smaller 8.9%. The larger fish exhibited higher quantities of threonine, methionine as well as lysine. The meat of the smaller fish had 4.62g/ 100 g protein threonine, and that of those with greater live weight- 7.50g/ 100 g protein, with the difference being 62.3%. The difference in the methionine levels was smaller. The meat of the smaller fish had 4.10 g/ 100 g protein, and that of the larger- 6.1% more (4.35g/ 100 g protein). Similarly, in the non-essential amino acids, there were no clear trends related to the size of the fish. Overall, higher values were reported for the asparagine amino acid (12.27-15.95g/ 100 g protein), histidine (13.15- 17.70g/ 100 g protein), and alanine (12.96- 13.99 g/ 100 g protein). Higher values of the three amino acids were recorded for the smaller fish with the respective differences being 30, 34.6, and 7.9%. We discovered the same pattern for the glutamine amino acid, glycine, and cysteine. The first amino acid had values from 6.57 to 7.09 g/ 100 g protein, with the difference being 7.9%. The differences in the glycine and the cysteine were bigger. The glycine values were within 1.95-3.25 g/ 100 g protein, at a difference of 1.7 times in favour of the smaller fish. The cysteine values ranged from 0.08 to 3.90 g/ 100 g protein, at a difference of 48.8 times in favour of the fish with lower live weight. The larger fish had a higher content of several amino acids: serine- from 5.05 to 5.26 g/ 100 g protein; arginine- from 5.99 to 7.84 g/ 100 g protein; proline- from 4.17 to 4.69 g/ 100 g protein; tyrosine-5.60 to 6.76 g/ 100 g protein, with the respective differences in favour of the larger fish being- 4.2, 30.9, 12.5 and 20. 7 %.

Protein profile

Table 22 displays the results from the analysis of the protein fractions in the meat of the Russian sturgeon from the different weight groups. The total protein content was 12.3% more in the larger fish. The share of the myofibrillar proteins was the biggest in both groups, however, it was 3.4% higher in the heavier fish. The same trend was exhibited by the other protein fractions, with the difference between the sarcoplasmic and the alkali solubles being 35.2 and 7.3% respectively. The relative share of the separate protein fractions in relation to the total protein content in the Russian sturgeon meat is displayed in table 23. The fraction profile is illustrated in fig. 3. It can be seen that the share of the low molecular proteins with weights lower than 50 kDa in the Russian sturgeon muscles was the biggest in all protein fractions examined.

Table 22. Fractionation of proteins in the Russian sturgeon meat (Lowry's method, %).

Proteins, %	**Groups**	
	Ag – 1	**Ag – 2**
Sarcoplasmic	4.49±0.09	6.07±0.35
Myofibrillar	9.72±0.29	10.05±0.30
Alkali soluble	3.31±0.08	3.55±0.26
Total	17.52	19.67

The sarcoplasmic fraction was mostly composed of low molecular weight proteins. Their share exceeded 78%, followed by the proteins with molecular weight from 51 to 150 kDa (over 20%), and the share of the high-molecular-weight proteins (>151 kDa) was the lowest- with a maximum share of approximately 5%. The larger share of low molecular weight sarcoplasmic proteins was reported for the fish with lower live weight, with the difference in relation to the fish with larger live weight being 5.5%. The fish with larger live weight, however, had a larger share of proteins with higher molecular weight. The difference in the group of proteins with a molecular weight from 51 to 150 kDa was 9.1%, and that in the group with a molecular weight over 151 kDa reached 1.8 times.

Table 23. Share of the separate protein fractions in comparison with the total protein content in the Russian sturgeon meat.

Fraction, %	Groups	
	Ag – 1	Ag – 2
Proteins with molecular weight < 50 kDa (LMW)		
Sarcoplasmic	78.06	74.01
Myofibrillar	50.38	57.40
Alkali soluble	93.44	91.79
Proteins with molecular weight from 51 до 150 kDa (MMW)		
Sarcoplasmic	18.96	20.68
Myofibrillar	14.68	8.90
Alkali soluble	6.56	8.21
Proteins with molecular weight > 151 kDa (HMW)		
Sarcoplasmic	2.98	5.31
Myofibrillar	34.94	33.70
Alkali soluble	-	-

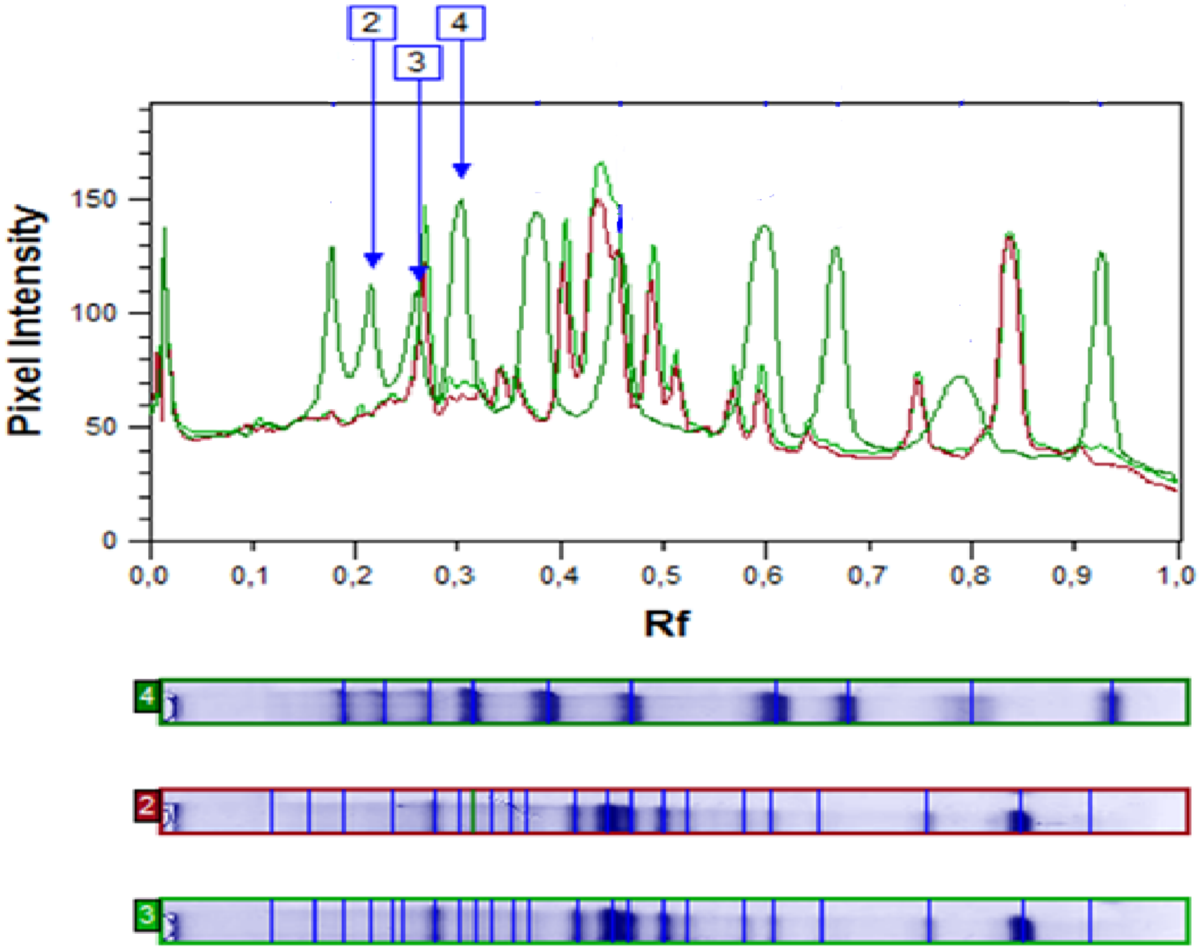


Fig. 3. Fractional profiles of sarcoplasmic fraction: 2- Ag- 1; 3- Ag- 2; 4- Marker protein.

Analysis of the results obtained for the myofibrillar fraction in the group of the low molecular weight proteins indicated that their share was higher in the heavier fish, unlike the share of the sarcoplasmic fraction which had higher values in the fish with lower live weight. The difference between the two fractions was 13.9%. In the groups of the proteins with molecular weight from 51 to 150 kDa and those of over 151 kDa, higher values were reported for the fish with smaller live weight, with the respective differences being 64.9 and 3.7%. The major part of the alkali-soluble fraction in the Russian sturgeon meat was taken by the low molecular protein. It was over 93% in the fish with smaller live weight, and more than 91% in the fish with greater live weight. The difference between the groups was small- 1.8%. The rest of the alkali-soluble proteins were from the group with molecular weight from 51 to 150 dKa. Here, higher values were reported for the fish with larger live weight, and the difference between the two weight groups was 25.2%.

Morpho-physiological characteristics, slaughter parameters, and quality of the meat of the hybrid of the Siberian and Russian sturgeon (F1 *A. baerii* x *A. gueldenstaedtii*).

Morpho-physiological and slaughter parameters

Table 24 displays the exterior parameters of the hybrid from different groups used during the analysis, and table 25 includes major weight parameters. The fish with greater live weight had significantly ($p<0.001$) longer body. The difference in the total length was 12.9 %, and the fork length and the standard length difference were respectively 12.7 and 17.8%. The live weight increase significantly influenced the body height (13.2 *($p<0.05$)*), the width (13.9 (*$p<0.05$*)), and the body girth (17.3% (*$p<0.001$*)).

Table 24. Exterior parameters of the hybrid from different weight groups, cm

Groups / Parameters	Hy - 1 (n=5)			Hy - 2 (n=5)		
	X	±Sx	SD	X	±Sx	SD
Total length	89.12a	1.483	3.316	102.42a	1.334	2.982
Fork length	77.48a	1.054	2.356	88.80a	0.644	1.441
Standard length	71.50a	1.304	2.916	87.00a	1.01	2.253
Maximum height	11.20c	1.210	2.707	12.90c	0.430	0.962
Maximum width	10.60c	0.828	1.851	12.32c	0.231	0.517
Maximum girth	30.80a	1.310	2.928	37.24a	0.214	0.477

The differences in the values indicated with identical letters on the lines are significant a - $p<0.001$; c - $p<0.05$

The viscera weight of the heavier hybrid was over twice as much as the one of the smaller fish *($p<0.001$)*. With reference to the live weight difference between Hy-1 and Hy-2, the second group had 43.3% *($p<0.001$)* higher values regarding the separate parts of the body and the internal organs, and it was only the differences in the weight of the gonads, spleen, heart and the chord that were not significant (Table 26). The relative share of the head and the fins decreased, by 16.4 % *($p<0.001$)* and 14.7 respectively, in parallel with the hybrid live weight increase. The slaughter analysis indicated that the six-year-old hybrid of the Siberian and Russian sturgeon had very good slaughter parameters (Table 27). The maximum mean values of the slaughter yield reached 89.5%, the consumable- 86.6%, and those of the carcass yield 61.5%. The share of the whole fillet in the fish body reached 50%, and that in the carcass up to 81.35%. The share of the fillet without the belly flap in the whole fish reached 42.2%, and in the carcass- up to 68.7%. The slaughter and the consumable yields were higher *($p<0.05$)* in the lower-weight hybrid (Hy-1). The differences were respectively 3.5 and 3.4%. The fish with greater live weight had(1.2%) higher carcass yield but the difference was not significant. Our study showed that the fish with greater weight had a greater share, respectively 4 and 11% *($p<0.05$),* of fillet and fillet without the belly flap in the whole fish, and a greater share of fillet and fillet without belly flap in the carcass- 2.9 and 10% more *($p<0.05$).* No significant differences between the fish from the different groups were reported with reference to any of the morphometric indices (Table 28).

Table 25. Weight parameters of the hybrid from different weight groups, g

Parameters	Hy - 1 (n=5)			Hy - 2 (n=5)		
	X	±Sx	SD	X	±Sx	SD
Live weight	2796.6a	129.84	290.33	4934.8a	86.11	192.54
Carcass	1699.0a	90.07	201.41	3035.9a	65.26	145.92
Fillet with skin	1342.1a	75.24	168.24	2470.8a	87.41	195.46
Fillet with skin without belly flap	1042.0a	49.08	109.75	2087.6a	100.2	223.94
Total viscera	296.6a	33.42	74.73	665.6a	22.344	49.96
Gonads	43.18	19.83	44.34	168.7	22.23	49.69
Liver	42.52a	4.282	9.576	96.89a	10.28	22.98
Spleen	7.08	1.417	3.168	10.08	0.560	1.253
Heart	4.18	0.558	1.249	5.97	0.530	1.186
Fins and tail	152.0a	7.560	16.90	234.6a	10.22	22.85
Head without gills	568.4a	32.86	73.48	864.6a	18.71	41.84
Gills	80.53a	7.817	17.48	134.1a	6.683	14.94
Scutes	69.99c	13.66	30.55	145.2c4	22.44	50.17
Swim bladder	19.18b	1.842	4.118	35.74b	4.329	9.681
Pyloric appendage	4.71c	0.302	0.676	9.31c	1.734	3.878
Chord	53.54	2.957	6.611	64.57	7.834	17.517

The differences between the values, indicated with identical letters on the lines are significant: a - $p<0.001$ b - $p<0.01$; c - $p<0.05$.

Table 26. Relative share of separate body parts and organs of the hybrid from different weight groups, % live weight

Parameters	Hy - 1 (n=5)			Hy - 2 (n=5)		
	X	±Sx	SD	X	±Sx	SD
Head without gills	20.41a	1.204	2.692	17.53a	0.359	0.803
Gills	2.890	0.286	0.638	2.72	0.128	0.287
Fins and tail	5.46	0.248	0.555	4.76	0.241	0.540
Swim bladder	0.69	0.060	0.135	0.73	0.090	0.200
Pyloric appendage	0.17	0.005	0.012	0.19	0.033	0.073
Chord	1.92a	0.099	0.221	1.32a	0.175	0.392
Scutes	2.49	0.461	1.030	2.96	0.477	1.066

The differences between the values indicated with the same letters on the lines are significant; a- $p<0.05$

Table 27. General slaughter parameters of the hybrid, %

Parameter	Hy - 1 (n=5)			Hy - 2 (n=5)		
	X	±Sx	SD	X	±Sx	SD
Slaughter yield	89.51a	0.848	1.897	86.51a	0.363	0.813
Consumable yield	86.62a	0.800	1.789	83.80a	0.321	0.718
Carcass yield	60.75	1.458	3.261	61.50	0.306	0.685
Relative share in the whole fish						
Fillet	48.00	1.584	3.542	50.03	1.150	2.571
Fillet without the body flap	37.55	2.320	5.188	42.24	1.530	3.422
Relative share in the carcass						
Fillet	78.97	1.211	2.707	81.35	1.930	4.316
Fillet without the body flap	61.79	3.396	7.595	68.68	2.413	5.395

The differences between the values, indicated with identical letters on the lines are significant: a- p<0.05

The SSI and HtSI indices were higher for the smaller fish, but the respective differences of 27.3 and 24.8% were not significant. Conversely, higher GSI, HIS, and VSI values were reported for the larger fish. The differences between the groups were respectively 2.3 times, 23.5 and 22.2%, but they were significant *(p<0.05)* only with reference to the last index.

Table 28. Morphometric and morpho-physiological indices of the hybrid from different weight groups

Indices	Hy - 1 (n=5)			Hy - 2 (n=5)		
	X	±Sx	SD	X	±Sx	SD
IHB	6.74	0.845	1.890	6.55	0.177	0.397
IBB	14.90	1.376	3.076	14.64	0.344	0.769
IH	43.24	2.524	5.644	44.26	0.698	1.561
CFF	0.78	0.068	0.153	0.83	0.039	0.087
CFC	0.69	0.058	0.131	0.72	0.035	0.0781
IC	11.85	1.218	2.725	12.27	0.564	1.261
ICR	5.03	0.336	0.750	5.45	0.331	0.740
VSI	10.49a	0.848	1.897	13.49a	0.363	0.813
HSI	1.50	0.091	0.202	1.96	0.196	0.439
GSI	1.47	0.654	1.462	3.43	0.462	1.032
SSI	0.261	0.065	0.144	0.205	0.014	0.311
HtSI	0.151	0.023	0.051	0.121	0.011	0.024

The differences between the values indicated with the same letters on the lines are significant; a- p<0.05

Chemical composition and energy content of the meat

Table 29 displays the chemical composition and the energy content of the meat of the hybrid (Siberian x Russian sturgeon) with different live weights. The results obtained showed that the increase of the hybrid live weight led to an increase in a range of fresh meat quality characteristics.

Table 29. Chemical composition and energy content of the hybrid meat.

Parameters	Groups	
	Hy – 1	Hy – 2
% fresh sample		
Total dry matter	20.07±0.01	22.97±0.75
Water	79.93±0.01	77.03±0.75
Protein	16.95±0.63	17.23±0.18
Lipids	2.51±0.23	4.72±0.04
Carbohydrates	0.13±0.01	0.20±0.02
Minerals	1.28±0.07	1.29±0.02
% in dry matter		
Protein	84.47±3.13	73.54±0.78
Lipids	12.52±1.15	20.55±0.16
Carbohydrates	0.98±0.08	0.86±0.07
Minerals	6.37±0.36	5.59±0.11
Energy		
Total, kJ.100^{-1}g	2516.4±74.77	2609.7±18.97
Protein based, %	80.2±2.97	68.7±0.73

The larger fish had dry matter, protein, carbohydrate, and mineral content which was respectively 12.6%, 1.6%, 35%, and 0.78% higher. The difference between the groups in terms of lipid content in the fresh meat reached 1.9 times in favour of the larger fish. The analysis of the ratios of the separate components in the dry matter indicated that, unlike the case with the fresh meat, the relative share of the proteins, carbohydrates and minerals was respectively 12.9, 12.2, and 12.2% lower in the fish with greater live weight. The lipids trend remained the same, however, as the heavier fish had 1.6 times more muscle fat when compared with the smaller ones. The hybrid from both groups analysed could be classified as a medium-fat fish. The higher lipid content also meant higher energy values. The energy content of the meat was 3.6% higher in the heavier fish, but their protein-based energy was 14.4% lower.

Amino acid profile

Table 30 displays the amino acid profile of the meat of the hybrid from the separate weight groups. It can be seen that the fish live weight had a different influence. Higher levels of some of the amino acids were reported in the smaller fish, and the other exhibited the opposite trend. Overall, the results we obtained indicated that the hybrid of the Siberian and Russian sturgeon had valuable meat, which was rich in essential amino acids, whose content was dependent on the live weight of the fish. Except for the methionine, all essential amino acid contents in the muscles decreased with the increase of the live weight of the fish.

Table 30. Analysed amino acid content of the hybrid, g/100g protein

Parameters	Groups	
	Hy – 1	**Hy – 2**
Non-essential amino acids		
Asparagine **Asp**	5.56	7.71
Serine **Ser**	1.95	3.22
Glutamine **Glu**	4.88	4.72
Glycine **Gly**	2.12	2.11
Histidine* **His**	10.92	14.86
Arginine* **Arg**	10.34	5.08
Alanine **Ala**	14.73	11.35
Proline **Pro**	4.97	3.59
Cysteine **Cys**	0.13	2.47
Tyrosine **Tyr**	6.09	0.86
Essential amino acids		
Threonine **Thr**	6.15	4.50
Valine **Val**	6.88	3.08
Methionine **Met**	2.15	2.96
Lysine **Lys**	22.98	13.18
Isoleucine **Ile**	8.48	2.70
Leucine **Leu**	1.56	0.92
Phenylalanine **Phe**	7.25	3.88

* Conditionally non-essential amino acids

Considerably high values were reported for the lysine. The different weight groups displayed a difference of 74.4% in their lysine values. Apart from the lysine, the isoleucine (8.48), phenylalanine (7.25), valine (6.88), and threonine (6.15) also had relatively higher levels (g/100 g protein) in smaller fish. The differences between the groups regarding these amino acids were respectively 3.1 times, 1.9 times, 2.2 times and 36.7%. When compared with the above-mentioned amino acid contents, the leucine (1.56 g/ 100 g protein) and the methionine (2.15 g/ 100 g protein) content in the meat was lower. With reference to the leucine, the difference in favour of the smaller fish was 69.6%. The difference of 37.7% in the methionine was in favour of the heavier fish. When it comes to the non-essential amino acid contents, it can be said that the influence of the live weight of the fish varied. Larger quantities of asparagine, serine, histidine, and cysteine were reported for the meat in the heavier fish. The opposite trend was observed for the other amino acids as their content was higher in the smaller fish, with the smallest difference reported being the one of the glycine (0.5%). In the non-essential amino acids group, we recorded considerably large quantities (g/ 100 g protein) for the histidine (10.92- 14.86) and the alanine (11.35-14.73), with group differences as follows- 36.1% in favour of the heavier fish; 29.8% in favour of the smaller fish. We also reported relatively high arginine levels (5.08-10.34 g/ 100g protein) in the meat of the hybrid we analysed; the difference in favour of the smaller fish was more than two times. Relatively high levels (g/100g protein) were also ascertained for the asparagine (5.56- 7.71) and the glutamine (4.72-4.88) amino acids, as well as for the proline (3.59- 4.97), and the respective group differences were 38.7%, 3.4%, and 38.4%.

Protein profile

Table 31 displays the fraction analysis of the proteins in the meat of the hybrid from the separate weight groups. The fraction profile is presented in fig. 4.

Table 31. Fractionation of proteins in the meat of the hybrid (Lowry's protein %).

Proteins, %	Groups	
	Hy – 1	Hy – 2
Sarcoplasmic	4.86±0.27	5.38±0.19
Myofibrillar	9.53±0.28	7.75±0.39
Alkali soluble	4.94±0.22	5.27±0.22
Total	19.33	18.40

The fish from the lower weight group had higher meat protein content. The parameter difference between the groups was 5.1%. The highest content reported was that of the myofibillar fraction. The myofibrillar proteins were more than 9% in the lower live weight fish. The difference in relation to the larger fish was almost 23% in favour of the smaller fish. The sarcoplasmic proteins had a higher share (5.38%) in the larger fish. The parameter difference in relation to the smaller fish was 10.7%. The alkali soluble proteins share was also higher in the larger fish. This fraction was 5.27% in them, while in smaller fish, it was 6.7% lower.

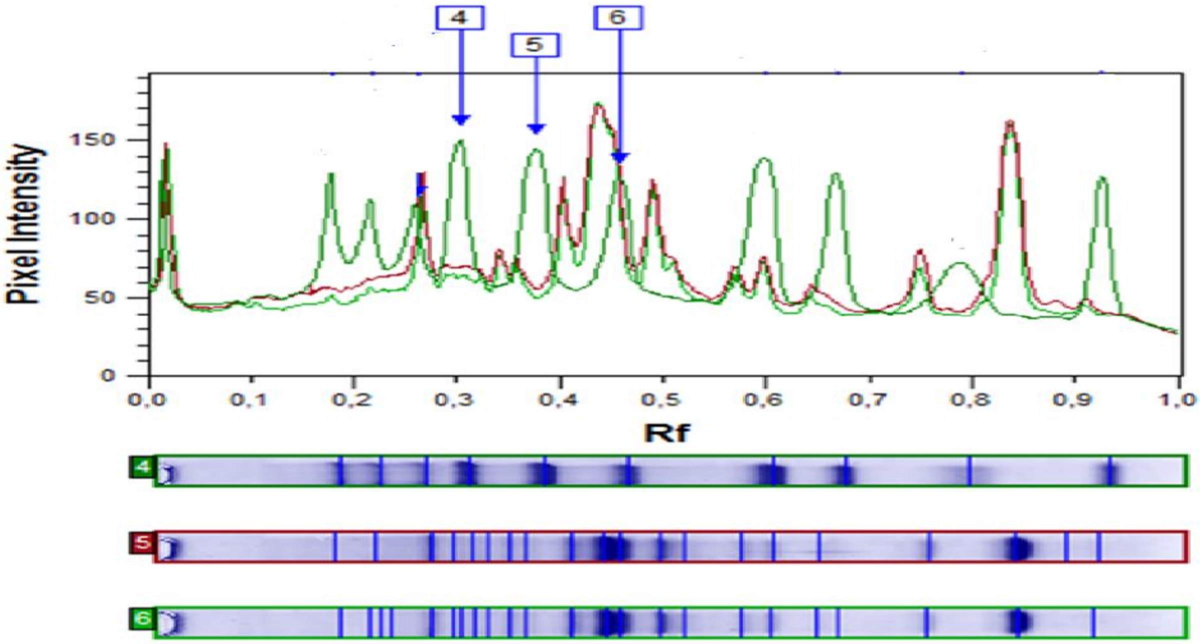


Figure 4. Fractional profiles: - Protein markers, 5- Hy-1; 6- Hy-2.

The proteins with low molecular weight (< 50 kDa) had a major share of participation in the sarcoplasmic protein fraction in the meat of the hybrid in both weight groups (Table 32). Their share was larger in the fish with lower live weight (81.99%), with the difference between the groups being 6.5%. The same was observed with reference to the myofibrillar and the alkali-soluble fractions, where once again the low molecular proteins were prevalent. The share of the myofibrillar fraction of the low molecular proteins in the total meat protein was from 53.96 to 58.22 %, and the values were higher in the fish with lower live weight. The respective share reported for the heavier fish was 7.9% lower. The respective share with reference to the alkali-soluble fraction was from 92.54 to 93.32%. The difference was in favour of the smaller fish, but it was negligible as it was only 0.8%.

Table 32. Share of the separate protein fractions in comparison with the total protein content in the hybrid meat

Fractions, %	**Groups**	
	Hy – 1	**Hy - 2**
Proteins with molecular weight < 50 kDa (LMW)		
Sarcoplasmic	81.99	76.97
Myofibrillar	58.22	53.96
Alkali soluble	93.32	92.54
Proteins with molecular weight from 51 to 150 kDa (MMW)		
Sarcoplasmic	15.45	18.43
Myofibrillar	5.67	9.91
Alkali soluble	6.68	7.47
Proteins with molecular weight > 151 kDa (HMW)		
Sarcoplasmic	2.56	4.60
Myofibrillar	36.11	36.13
Alkali soluble	-	-

The sarcoplasmic fraction of the proteins with molecular weight from 51 to 150 kDa in the total meat protein of the hybrid was from 15.45 to 18.43%, with its values being higher in the heavier fish. The same trend was also observed for the myofibrillar and the alkali-soluble fractions. The myofibrillar fraction was within the range of 5.67-9.91%. The difference in favour of the larger live weight fish was 74.8%. The alkali-soluble fraction comprised from 6.68 to 7.47%, with a difference of 11.8 % in favour of the second group. The myofibrillar fraction had the highest percentage- over 36% in the group of the proteins with molecular weight > 151 kDa; however, there was practically no difference between the two groups as it was only 0.01%. No alkali-soluble fraction was reported for this protein group. The variation in the sarcoplasmic fraction was from 2.56 to 4.60%. The difference in favour of the heavier fish was significant- over 1.8 times.

Comparative analysis of the morpho-physiological and slaughter parameters of Siberian sturgeon (*Acipenser baerii*), Russian sturgeon (*Acipenser gueldenstaedtii*), and the hybrid of the Siberian and Russian sturgeon (F_1 *A. baerii* x *A. gueldenstaedtii*) with different live weight

Table 33 displays the exterior parameters of fish with different genotypes within each of the weight groups. The analysis showed that the Russian sturgeon had the shortest body, and the hybrid- the longest. It was ascertained for all lengths measured that the group differences between the fish from the three genotypes increased with the increase of their live weight. It was also ascertained that these differences were significant ($p < 0.05$) in the second weight group.

Table 33. Influence of the genotype on the exterior parameters of the fish.

Parameter	Genotype		Weight group 1		Weight group 2	
			Diff.*	Sig.	Diff.*	Sig.
Total length	**Ag**	**Hy**	-3.040	0.232	-10.720	0.000
		Ab	-2.060	0.410	-8.120	0.000
	Hy	**Ab**	0.980	0.692	2.600	0.087
Fork length	**Ag**	**Hy**	-5.340	0.021	-9.380	0.000
		Ab	-3.980	0.070	-6.560	0.000
	Hy	**Ab**	1.360	0.510	2.820	0.058
Standard length	**Ag**	**Hy**	-3.800	0.076	-8.080	0.000
		Ab	-4.280	0.049	-4.340	0.022
	Hy	**Ab**	-0.480	0.810	3.740	0.042
Maximum height	**Ag**	**Hy**	-0.560	0.586	0.440	0.315
		Ab	0.740	0.473	2.660	0.000
	Hy	**Ab**	1.300	0.218	2.220	0.000
Maximum width	**Ag**	**Hy**	-0.420	0.559	0.140	0.733
		Ab	-0.600	0.407	0.380	0.362
	Hy	**Ab**	-0.180	0.801	0.240	0.561
Maximum girth	**Ag**	**Hy**	0.080	0.949	1.340	0.275
		Ab	-0.520	0.680	3.580	0.010
	Hy	**Ab**	-0.600	0.634	2.240	0.080

**Difference between separate genotypes within each weight group, cm*

With reference to the fish from the second weight group, the highest values in the parameters connected to the compactness were exhibited by the Russian sturgeon, with the differences in relation to the Siberian sturgeon were significant with reference to the height (*0.001*) and the body girth ($p<0.05$). A significant difference was also ascertained with reference to the height (*0.001*) and the girth ($p<0.05$) of the Siberian sturgeon and the hybrid, with the difference being in favour of the latter.

Table 34 displays the interaction between the genotype and the live weight of the fish in relation to the slaughter parameters, and Table 35- in relation to the morpho-physiological indices. In the first group, the highest values with reference to the three yields were reported for the Russian sturgeon, and the lowest- for the Siberian, while the hybrid took a middle position in relation to the parental forms. Significant differences between the fish from this weight group were ascertained in 1-Sv ($p<0.01$), 2-Sv ($p<0.01$) and 3-Sv ($p<0.05$) between the Russian and the Siberian sturgeon, and 1-Sv and 2-Sv between the hybrid and the Siberian sturgeon ($p<0.05$). The Russian sturgeon had better slaughter parameters than the hybrid. The Russian sturgeon had better consumable and carcass yield than the Siberian sturgeon, but the best slaughter yield results were reported for the Siberian sturgeon. The influence of the live weight can be seen when it comes to the relative share of the fillet, however, the trends were different from those ascertained for the yields.

Table 34. Influence of the fish genotype on the slaughter parameters.

Parameter	Group		Weight group			
			1		2	
			Diff.*	Sig.	Diff.*	Sig.
Slaughter yield	**Ag**	**Hy**	0.884	0.433	0.184	0.895
		Ab	3.993	0.003	-0.161	0.908
	Hy	**Ab**	3.109	0.015	-0.345	0.804
Consumable yield	**Ag**	**Hy**	0.621	0.616	0.478	0.729
		Ab	3.726	0.009	0.083	0.952
	Hy	**Ab**	3.105	0.024	-0.394	0.774
Carcass yield	**Ag**	**Hy**	3.361	0.212	2.711	0.115
		Ab	6.044	0.035	2.689	0.118
	Hy	**Ab**	2.683	0.313	-0.022	0.989
Whole filelt/ carcass	**Ag**	**Hy**	-1.140	0.558	-6.107	0.174
		Ab	-0.549	0.777	-7.289	0.110
	Hy	**Ab**	0.590	0.761	-1.182	0.784
Whole fillet/ live weight	**Ag**	**Hy**	1.915	0.491	-1.690	0.574
		Ab	4.313	0.135	-2.413	0.425
	Hy	**Ab**	2.397	0.391	-0.723	0.809
Fillet without the belly flap/ carcass	**Ag**	**Hy**	5.154	0.270	-7.969	0.025
		Ab	1.748	0.702	-11.020	0.004
	Hy	**Ab**	-3.407	0.460	-3.050	0.348
Fillet without the belly flap/ live weight	**Ag**	**Hy**	5.449	0.167	-3.252	0.129
		Ab	4.936	0.208	-5.052	0.026
	Hy	**Ab**	-0.513	0.892	-1.800	0.384

**Difference between the separate genotypes within each weight group,%*

There was a distinct genotype influence on the larger fish, while when it came to the smaller fish there was no clear pattern. When compared to its parents, the hybrid from the first group had the largest whole fillet in the carcass quantity, however, this trend was not the same regarding the relative share of fillet without the belly flap in the whole fish and the carcass ratio.

The Russian sturgeon showed the highest values in the last parameters. It can be clearly seen that the Siberian sturgeon in the second weight group displayed the best meat quantity results, and the Russian sturgeon from the same group- the worst. The hybrid took the middle position in relation to the relative share of the fillet.

Overall, the Russian sturgeon had the widest back, with the differences between the Siberian sturgeon and the hybrid being significant within the second weight group only. The highest IH values were reported for the Russian sturgeon, and the differences with the Siberian sturgeon and the hybrid were significant. The hybrid had worse IH index values than the Russian sturgeon and it practically did not differ from the Siberian sturgeon. The best condition index was reported for the Russian sturgeon. The respective differences between the Russian sturgeon and the hybrid and the Siberian sturgeon in the Fulton's index and the Clarc's index were 0.199 ($p<0.05$); 0.213 ($p<0.05$) and 0.188 ($p<0.05$); 0.223 ($p<0.01$) in the first weight group and 0.300 ($p<0.01$); 0.310 ($p<0.05$) and 0.262 ($p<0.01$); 0.268 ($p<0.01$) in the second weight group. The analysis showed that with the increase of the live weight, the interior indices differences between the separate genotypes also increased.

Table 35. Influence of the fish genotype on some morpho-physiological indices.

Indices	Group		Weight group			
			1		2	
			Diff.*	Sig.	Diff.*	Sig.
IHB	Ag	Hy	-0.373	0.615	-0.844	0.002
		Ab	-0.908	0.233	-1.841	0.000
	Hy	Ab	-0.535	0.474	-0.997	0.001
IBB	Ag	Hy	0.155	0.902	1.783	0.029
		Ab	0.030	0.981	1.411	0.074
	Hy	Ab	-0.125	0.921	-0.372	0.615
IH	Ag	Hy	2.412	0.337	6.631	0.014
		Ab	1.944	0.436	7.391	0.008
	Hy	Ab	-0.468	0.849	0.760	0.748
CFF	Ag	Hy	0.199	0.020	0.300	0.003
		Ab	0.213	0.014	0.310	0.003
	Hy	Ab	0.014	0.855	0.010	0.907
CFC	Ag	Hy	0.188	0.013	0.262	0.004
		Ab	0.223	0.005	0.268	0.004
	Hy	Ab	0.035	0.595	0.005	0.943
IC	Ag	Hy	1.695	0.131	0.327	0.589
		Ab	0.945	0.384	-1.605	0.019
	Hy	Ab	-0.750	0.487	-1.933	0.007
ICR	Ag	Hy	1.155	0.007	0.978	0.052
		Ab	0.678	0.084	0.242	0.603
	Hy	Ab	-0.477	0.210	-0.735	0.131
VSI	Ag	Hy	-0.884	0.433	-0.183	0.895
		Ab	-3.993	0.003	0.162	0.907
	Hy	Ab	-3.109	0.015	0.345	0.804
HSI	Ag	Hy	0.164	0.623	0.055	0.838
		Ab	-0.386	0.259	-0.254	0.353
	Hy	Ab	-0.550	0.117	-0.309	0.263
GSI	Ag	Hy	1.451	0.165	2.147	0.014
		Ab	0.739	0.467	1.209	0.132
	Hy	Ab	-0.712	0.482	-0.938	0.234
HtSI	Ag	Hy	0.019	0.517	0.032	0.068
		Ab	0.054	0.090	0.067	0.001
	Hy	Ab	0.034	0.263	0.035	0.046
SSI	Ag	Hy	-0.079	0.190	0.001	0.974
		Ab	0.039	0.502	0.052	0.233
	Hy	Ab	0.118	0.059	0.051	0.245

**Difference between separate genotypes within each weight group*

Comparative analysis of the protein profile of the meat of the Siberian sturgeon (*Acipenser baerii*), Russian sturgeon (*Acipenser gueldenstaedtii*) and the hybrid of the Siberian and the Russian sturgeon (F_1 *A. baerii* x *A. gueldenstaedtii*)

Protein content in the soluble protein fractions

The analysis of the data in our study indicated that the sarcoplasmic fraction (SP) was different in the fish with different live weights (Table 36). SP was lower in the smaller fish from all the genotypes studied.

Table 36. Fraction analysis of meat protein in different fish groups, %

Group	SP	MP	ASP	Total
Ab-1	5.24±0.24	10.28±0.31	1.37±0.04	16.89
Ab-2	6.04±0.20	10.39±0.29	1.52±0.06	17.95
Ag-1	4.49±0.09	9.72±0.29	3.31±0.08	17.52
Ag-2	6.07±0.35	10.05±0.30	3.55±0.26	19.67
Hy-1	4.86±0.27	9.53±0.28	4.94±0.22	19.33
Hy-2	5.38±0.19	7.75±0.39	5.27±0.22	18.40

SP- sarcoplasmic fraction, MP- myofibrillar fraction, ASP- alkali-soluble fraction

In the smaller fish group, the SP was the highest in the Siberian sturgeon- 5.24%, followed by the hybrid- 4.86% and the Russian sturgeon- 4.49%. However, when calculated as a percentage of the total protein content, the range changed as follows: Siberian sturgeon- 31.02%, Russian sturgeon- 25.63%, and hybrid- 25.14%. By contrast, in the group of the larger fish, the SP was the highest in the Russian sturgeon- 6.07%, followed by the Siberian- 6.04% and the hybrid- 5.38%.

The pattern remained the same after the calculation of the SP as a percentage of the total protein content and the highest values were again displayed by the Siberian sturgeon- 33.65%, followed by the Russian- 30.86% and the hybrid- 29.24%. Overall, the sarcoplasmic proteins in the muscle protein of the fish we studied were between 25.14 and 33.65%. The myofibrillar fractions (MP) of the Siberian sturgeon were between 10.28 and 10.39% which was respectively 60.86 and 57.88% of the total protein content; in the Russian sturgeon they ranged between 9.72 and 10.05% which was respectively 55.48 and 51.09% of the total protein content; and for the hybrid, the values were from 9.53 to 7.75% which was respectively 49.3 and 42.12 of the total protein content. The lowest values were reported for the heavier hybrids- 7.75%, and the highest- for the heavier Siberian sturgeons- 10.39%. When reporting the MP content as a percentage of the total protein content, a clear downward trend against live body weight increase can be clearly observed. This pattern was valid for all genotypes examined.

The ASP varied widely- from 1.37% (lower live weight Siberian sturgeon) to 5.27% (greater weight hybrid). ASP displayed a clear trend towards an increase of the fraction share in parallel with the increase of the live weight of the fish from all genotypes analysed. The lowest ASP values were reported for the Siberian sturgeon. The fish with lower live weight had 1.37% which was 8.11% of the total protein content, and those with greater live weight- 1.52% which was 8.47% of the total protein. The highest ASP values were reported for the hybrid- 4.94% for the smaller fish, and 5.27% for the larger, which was respectively 25.6 and 28.6% of the total protein content. The Russian sturgeon was in a middle position when compared with the other two genotypes. The ASP in smaller fish was 3.31% which was 18.89% of the total protein, and in the larger Russian sturgeon, it was respectively 3.55% which was 18.05% of the total protein. In conclusion, it can be stated that with the increase of the live weight of the Russian sturgeon, Siberian sturgeon, and their hybrid, the SP and the ASP fractions increased, while the MP did not follow a clearly defined pattern.

Electrophoretic profile (SDS-PAGE)

The SDA- PAGE analysis ascertained differences in the protein profiles of the SP, MP, and ASP fractions (Table 37; Fig 5. A, B, and C).

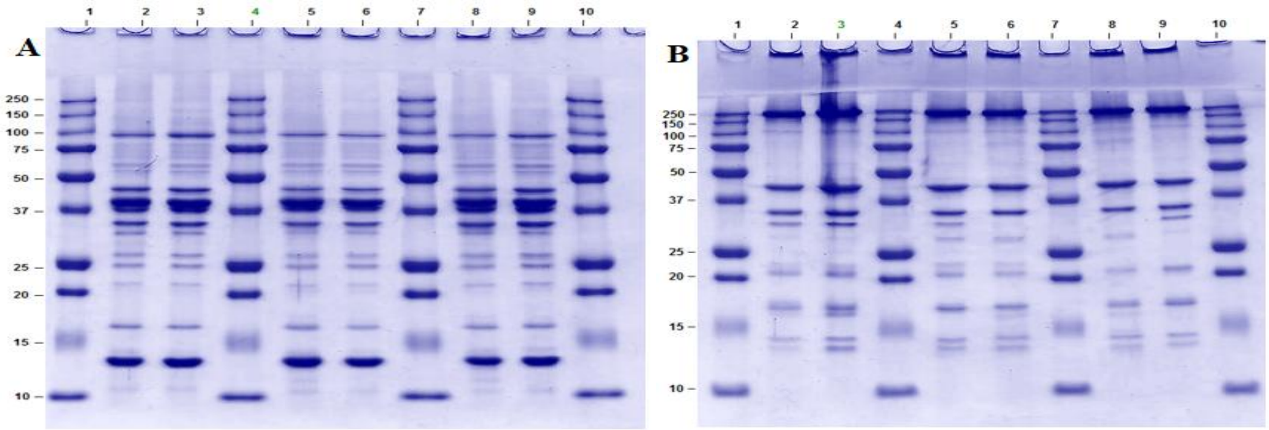
Table 37. Protein fraction share of the separate fish groups

Group	Protein fraction share compared with the total protein content, %								
	LMW (< 50 kDa)			MMW (51-150 kDa)			HMW (> 151 kDa)		
	SP	MP	ASP	SP	MP	ASP	SP	MP	ASP
Ab-1	79.28	49.37	91.14	17.62	13.25	8.86	3.10	37.38	-
Ab-2	73.16	60.05	96.45	22.92	7.28	3.55	3.92	32.67	-
Ag-1	78.06	50.38	93.44	18.96	14.68	6.56	2.98	34.94	-
Ag-2	74.01	57.40	91.79	20.68	8.90	8.21	5.31	33.70	-
Hy-1	81.99	58.22	93.32	15.45	5.67	6.68	2.56	36.11	-
Hy-2	76.97	53.96	92.54	18.43	9.91	7.47	4.60	36.13	-

LMW- proteins with molecular weight ≤ 50 kDa; MMW- proteins with molecular weight from 51 to 150 kDa; HMW- proteins with molecular weight above 150 kDa; SP- sarcoplasmic fraction, MP- myofibrillar fraction, ASP- alkali-soluble fraction.

Sarcoplasmic protein fractions

The protein fractions ascertained had molecular weight (MW) which varied from 11 to over 250 kDa, with those with low molecular weight (LMW) of up to 50 kDa being prevalent. The largest number of fractions (20) were reported for the Russian sturgeon as the protein profiles of both weight groups were similar. The protein profile in Ag- 2 had two additional fractions- 121 and 187 kDa. The respective 14, 33, 37, 40, and 48 kDa LMW fractions and the 62 and 100 kDa MMW fractions were the most intensive. Not only did the other two genotypes examined (Siberian sturgeon and the hybrid) exhibit a smaller number of fractions (19) but there were also no fractions with molecular weight > 250 kDa. All three genotypes had fractions with molecular weight of 11, 14, 16, 22, 25, 27, 33, 37, 40, 48, 55, 62, 70, 79, 100, 187 and 250 kDa. There was also a 12 kDa fraction observed in groups Ab-1, Ab-2, and Hy-1. There were large quantities of myoglobin, which is a protein with a molecular weight of approximately 17 kDa, detected in the muscle sarcoplasm of the fish. Another sarcoplasmic protein was the parvalbumin which had a molecular weight of approximately 11. kDa.



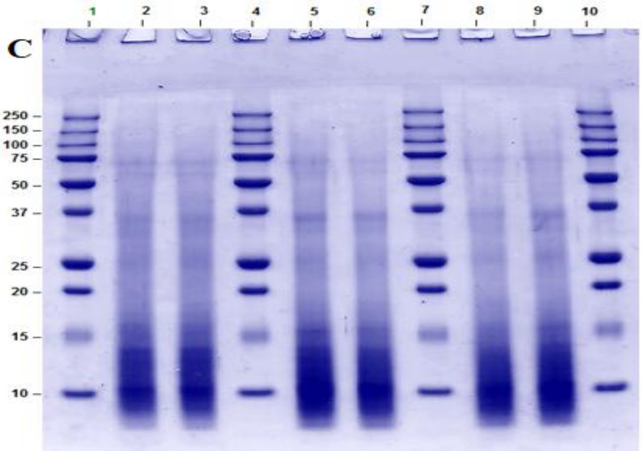


Fig. 5. SDS-PAGE of sarcoplasmic protein fractions (A), myofibrillar protein fractions (B), alkali-soluble protein fractions (C); (1, 4, 7 and 10- protein markers with molecular weight 10-250 kDa; 2 – Ag1; 3 – Ag2; 5 – Hy1; 6 – Hy2; 8 – Ab1; 9 – Ab2).

Myofibrillar protein fractions

Unlike the sarcoplasmic proteins, the myofibrillar proteins in all genotype and weight groups analysed had a fraction >250 kDa. It is worth noticing that there were only 4 identical fractions (MWs 13, 14, 17, and >250kDa) between the three genotypes examined (Table 37). The lack of a fraction with molecular weight >250 kDa for the hybrid in comparison with the Russian and the Siberian sturgeon was the most significant difference ascertained between the fish studied. In both groups and in the hybrid, its place was taken by the fraction with lower molecular weight (231 kDa) which, however, had the largest share in the total protein profile. In addition, the hybrid analysed also displayed fractions which were not reported for the Russian and the Siberian sturgeons (molecular weight 23, 29, 35, 49, 57, 84, and 103 kDa). The analysis showed that the LMW fractions (< 50 kDa) levels of all three genotypes were the highest. It was also observed that their relative share in the Russian and the Siberian sturgeon profiles increased with the increase of the live weight of the fish- (from 49.37% to 60.05% in the Siberian sturgeon and from 50.38% to 57.40% in the Russian sturgeon.) The opposite trend was ascertained with reference to the fractions with molecular weight from 51 to 150 kDa (MMW) and HMW fractions (> 151 kDa). Their share decreased (from 13.25% to 7.28% for the Siberian sturgeon and from 14.28% to 8.90% for the Russian sturgeon) with the increase of the fish live weight. The levels of the low molecular weight fractions were also higher in the hybrid, however, the trends described above for the two weight groups of the Russian and the Siberian sturgeon were not valid. The trend exhibited by the hybrid was that with the increase of the live weight, the relative share of the low molecular fractions decreased (from 58.22% to 53.96%) and the number of the fractions with molecular weight from 51 to 150 kDa increased (from 5.67% to 9.91%). The relative distribution of the HMW fractions in the two hybrid weight groups was the same (36.11% for Hy-1 and 36.13% for Hy-2).

Alkali-soluble fractions

SDS- PAGE obtained for the ASP for the separate genotypes and weight groups are displayed in table 37. The HMW fractions were not present in any of the samples tested. On the other hand, the low molecular (11 37 kDa) were prevalent (91-96%), while the medium molecular (54 and 67 kDa) constituted a negligible part of the total protein (4-9%). The fraction of the molecular weight 11 kDa formed the greater part of the LMW fractions profile. These results indicate that some of the LMW fractions of the sarcoplasmic and the myofibrillar proteins may have remained unextracted. Furthermore, during the extraction process, some of their fractions with high molecular weight were hydrolised to peptides which in turn led to the respective increase of the quantity of the ASP low molecular fractions.

CONCLUSION

The study on male sturgeon fish from the Acipenseridae family- Siberian sturgeon (*Acipenser baerii*), Russian sturgeon (*Acipenser gueldenstaedtii*), and a hybrid of Siberian x Russian sturgeon (F_1 *A. baerii* x *A. gueldenstaedtii*), cultivated in an industrial cage farm situated in Kardzhali reservoir ascertained the that the live weight influenced a range of morpho-physiological, slaughter and biochemical parameters.

Siberian sturgeon. The fish from different weight groups (2.823 and 4.273 kg on average) did not differ significantly in basic exterior parameters. The lower live weight fish had significantly lighter carcasses, fillet, viscera, gonads, liver, fins and tail, head without the gills, gills, swim bladder and chord. All slaughter value parameters were better in the fish with greater live weight, however, a significant difference was only ascertained with reference to the relative share of the fillet in the carcass (4.16%, $p<0.001$). All condition indices were also higher for the heavier fish, with the difference with the lighter fish being significant in IC ($p<0.01$) and ICR ($p<0.05$). No clear trend in the interior indices was ascertained in terms of changes related to the live weight. The viscerosomatic and the cardiosomatic indices were higher in the smaller fish, while the hepatosomatic, spleenomatic and the gonadosomatic ones were higher in the heavier fish, however, there was a significant difference ($p<0.05$) only regarding the latter. The Siberian sturgeon fish had high dry matter content- 21.41- 27.06% in the fish from the lower and respectively greater weight groups. The mineral content was around 1% and the carbohydrates were 0.17%. The Siberian sturgeon fresh meat contained 14.68-17.35% protein and 3.72-7.66% lipids. Based on the lipid content, the meat could be categorized as medium fat. The total energy of the meat was within 2329.1-2658.1 $kJ.100^{-1}g$, and the protein-based energy was respectively 57.65- 70.34%. The amino acid profile of the meat showed that the highest levels reported for the non-essential amino acids were the ones of the alanine and the histidine, and for the essential- the ones of the lysine. The live weight of the fish influenced the meat quality. When compared with the lighter fish, the heavier ones exhibited dry matter relative share values which were 26.4% higher. The protein in the fresh meat was 18.2% more, and the lipids were over twice as much. The lipid content in the dry matter of the heavier fish was also higher (by 38.6%), however, the protein content was 14.5% lower. No significant differences in terms of carbohydrate and mineral content in the fresh meat of the fish with different live weights were ascertained. By contrast, their content was found to be lower in the dry matter of the heavier fish: it was 18.9% and 19.0% more in the lighter fish. The total meat energy of the greater weight group was 14.1% higher and the protein-based energy – 18.04% lower. The different live weight fish had different amino acid meat profiles. The smaller fish displayed higher content of the non-essential amino acids alanine (43.2%), histidine (10.6%), serine (64.2%), glutamine (57.2%), glycine (20%), arginine (18.3%) and proline (20.8%). They also exhibited a particularly big difference in their favour, with reference to the asparagine acid content which was over three times more. The larger fish had higher cysteine and tyrosine levels of respectively 22.8% and 16.1%. They had higher levels of the non-essential amino acids lysine (0.7%), methionine (4.8%), isoleucine (21.1%), and phenylalanine (39.6%). The essential amino acids share was 67.2% of the total quantity. The fish with different live weights also differed in their protein profiles. The heavier fish had 6.3% higher total protein content. The values of all protein fractions were higher. The most significant differences were reported for the sarcoplasmic and the alkali-soluble proteins- 15.3% and 10.9% respectively, and the least- for the myofibrillar- 1.1%. The sarcoplasmic fraction of the Siberian sturgeon mostly comprised low molecular proteins, with their share being 8.4% higher in the fish with lower live weight. The heavier fish had 30.1% higher values for the proteins with molecular weight from 51 to 150 kDa and 26.5% for the proteins with molecular weight above 151 kDa. The myofibrillar fraction mostly comprised low molecular protein whose share was 21.6% higher in the fish with greater live weight. The smaller fish had a greater share of proteins with molecular weight from 51 to 150 kDa- 1.8 times and of proteins with molecular weight above 151 kDa- 14.4%. The alkali-soluble fraction mostly comprised low molecular proteins (<50 kDa) whose share was higher (5.5%) in the fish with greater live weight. The smaller fish had 2.5 times larger share of proteins with molecular weight from 51 to 150 kDa. No alkali-soluble fraction was found in the proteins with a molecular weight of over 151 kDa.

Russian sturgeon. The fish with different live weights (3.011 и 4.910 kg on average) differed in their exterior measurements. The fish with greater live weight had significantly higher values for their standard length (*p<0.01)*, height *(p<0.001)*, width *(p<0.001),* and body girth (*p<0.01)*. The differences in the total length and the fork length were also in favour of the larger fish, however, they were insignificant. The fish from the greater live weight group had significantly (*p<0.05)* lower relative share of the head, gills, pyloric appendage, and scutes. The fish with the lower live weight had significantly higher slaughter (1-Sv) and consumable (2-Sv) yields, but there was no significant difference reported between the groups with reference to the carcass yield (3-Sv). The relative share of the meat in the whole fish and the carcass was lower in the larger fish, but the differences between the groups were insignificant. The only significant difference *(p<0.01)* in the exterior indices ascertained was that in the body height index. The IHB values were higher in the fish group with lower average weight, which proves that the body height increased with the increase of the live weight. At the end of the vegetation period, the Russian sturgeon reared in an industrial cage farm exhibited good condition, and the maximum CFF value, which was reported for the larger fish, exceeded 1. No significant differences were ascertained in the condition indices of the different live weight fish.

In terms of the interior indices, significant difference *(p<0.01)* in favour of the larger fish was reported in the VSI (38.4%) and the GSI (91.2%). These fish also exhibited higher values in all the other interior indices, with the exception of HtSI, but the differences were insignificant. The Russian sturgeon meat had 20.45- 26.64% dry matter share in the fish from the lower and respectively- the greater live weight groups. The carbohydrate and mineral content in the fresh meat was respectively 0.11-0.21% and 1.19-1.28%. The meat contained 16.05-17.05% protein, 3.20-6.77% lipids and was classified as medium fat. The total meat energy was within 2497.5-2539.7 kJ.100^{-1}g, and the protein-based energy was respectively 75.09-60.21%.

The highest non-essential amino acid levels were reported for the asparagine acid, histidine and alanine, and the highest essential amino acid levels- for the isoleucine, lysine and the phenylalanine. The live weight of the Russian sturgeon influenced the meat quality. The heavier fish had larger dry matter (6.2%) and fresh meat protein (1%) content. The lipid content was twice as high in the dry matter (9.77%), but the protein and the minerals had values which were respectively 14.5 and 1.77% lower. The heavier fish had 1.7% higher meat total energy content, and the protein-based energy was 20% lower. No clear trend related to the different live weight was ascertained for the essential and non-essential amino acid content in the Russian sturgeon meat. The essential amino acids with higher contents in the meat of the heavier Russian sturgeon were lysine (8.8%), threonine (62.3%), and methionine (6.1%), with the share of the essential amino acids comprising 47.9% of the total amino acid content. Valine, isoleucine, phenylalanine, and leucine were the amino acids with higher content in the fish with lower live weight, and the differences between the separate weight groups were respectively- 4.8 times, 2.9 times, 2 times and 8.9%.With reference to the non-essential amino acids, the lighter fish displayed higher asparagine acid (30.0%), histidine (34.6%), alanine (7.9%), glutamine acid (7.9%), glycine (1.7 times) and cysteine (48 times) levels. There were larger serine (4.2), arginine (30.9), proline (12.5), and tyrosine (20.7%) levels in the meat of the larger fish. The analysis of the influence of the live weight on the protein profile displayed that the heavier fish had (12.3%) higher total protein content, and higher protein fraction values, with the difference between the groups in their sarcoplasmic, myofibrillar and alkali-soluble fractions being respectively 35.2%, 3.4%, and 7.3%. The share of the low molecular proteins with weight <50kDa was the largest in all protein fractions examined. The influence of the live weight on the share participation of the separate protein fractions was divergent. The low molecular protein share was higher 5.5% in the smaller fish sarcoplasmic fraction. The heavier fish exhibited 1.8 times higher protein share for their proteins with molecular mass >151 kDa and 9.1% higher share of the proteins with weight from 51 to 150 kDa. The fish with greater live weight had 13.9% more low molecular proteins in the myofibrillar fraction. Higher values were reported for the proteins with molecular weight from 51 to 150 kDa (64.9%) and those with weight > 151 kDa (3.7) in the smaller fish. The low molecular protein (<50 kDa) share in the alkali-soluble fraction was 1.8% larger for the fish with lower live weight. The larger fish had 25.2% higher levels of proteins with molecular weight from 51 to 150 kDa. No alkali soluble fraction was reported for the proteins with molecular weight >151 kDa.

The hybrid of the Siberian and Russian sturgeons with different live weights (2.797 and 4.935 kg on average) differed in their exterior measurements. The larger fish had significantly longer ($p<0.001$) and higher ($p<0.05$) body, width ($p<0.05$) and girth ($p<0.001$). The weight of the separate body parts and the internal organs was also greater, and the total viscera weight difference with the smaller fish was more than double ($p<0.001$). The differences between the two groups were insignificant only with reference to the weight of the gonads, spleen, heart, and chord. The lower-weight hybrids had significantly ($p<0.05$) higher slaughter (1-Sv) and consumable (2-Sv) yields. The difference in 3-Sv was in favour of the larger fish but it was insignificant. The latter had a significantly (*p<0.05)* higher share of the whole fillet and the fillet without the belly flap in the whole fish and the carcass. No significant influence of the live weight on the morphometric and condition indices examined was ascertained. The only interior index with reference to which a significant difference *(p<0.05)* was reported was VSI, with the total viscera being generally better developed in the heavier fish. The meat of the hybrid of Siberian and Russian sturgeon had high dry matter content – 20.07-22.97% respectively for the fish of the lower and higher weight groups. The carbohydrate and mineral content in the fresh meat was respectively 0.13- 0.20 and 1.28- 1.29%, the protein quantity was 16.95-17.23%, and that of the lipids- 2.51 and 4.72%. Based on the latter parameter, the meat can be classified as medium fat.

The total energy content of the meat was 2516.44 – 2609.72 kJ.100^{-1}g and the protein-based was respectively 68.70-80.22%. The non-essential amino acids with the greatest levels were the histidine and the alanine, and the essential amino acid with the highest values was the lysine. The live weight of the hybrid influenced the chemical composition of the meat. The heavier fish displayed higher dry matter (12.6%) protein (1.6%), carbohydrates (35%), minerals (0.78%), and 1.9 more lipids in their fresh meat. The relative shares of protein (12.9%), carbohydrates, and minerals 12.2% each were lower in the dry matter of this weight group. However, the lipid levels remained high (1.6 times), and as a result, the meat energy was 3.6% higher and the protein-based energy – 14.4% lower when compared with the hybrid from the group with lower live weight. The relative share of the amino acids in the meat of the fish from the two weight groups was different. The non-essential amino acids with high values were the histidine and the alanine, with the former being 36.1% higher in the heavier fish, and the latter- 29.8% higher in the lighter ones. Apart from the histidine, the heavier fish also exhibited higher values for the asparagine acid, the serine, and the cysteine. The hybrid meat was rich in essential amino acids. Except for the methionine, the essential amino acid content was lower in the fish with greater live weight. The difference in the methionine content was 37.7%. The hybrid meat also had higher lysine levels, with the difference in favour of the smaller fish reaching 74.4%. The latter displayed higher isoleucine (3.1 times), phenylalanine (1.9 times), valine (2.2 times), threonine (36.7%), and leucine (69.6%) content. The essential amino acid share was 55.5% of the total quantity. The analysis of the protein profile showed that the lower live weight hybrids had higher total protein content at a difference between the groups of 5.1%. The larger live weight hybrids had a higher relative share of sarcoplasmic (10.7%) and alkali-soluble (6.3%) fractions and lower myofibrillar (23%) fractions. The share of the low molecular proteins with weight < 50 kDa was major in all protein fractions, however, larger share was reported for the fish with lower live weight.

The share of the proteins with molecular weight from 51 to 150 kDa was higher in the heavier fish with reference to all protein fractions. The same held true with reference to the proteins with molecular weight > 151 kDa in the sarcoplasmic and the myofibrillar fractions, with the group difference in the latter being negligible. No alkali-soluble fraction was reported for this protein group.

The comparative analysis indicated that the fish with larger live weight from all three genotypes studied had significantly ($p < 0.05$) higher body length than that of the fish with lower weight. In the larger fish, the Russian sturgeon significantly surpassed the Siberian sturgeon in height ($p<0.001$) and girth ($p < 0.05$). The hybrid was significantly superior to the Siberian sturgeon in the same parameters. All sturgeon species had good slaughter parameters, and the live weight of the fish had influence on them. The highest slaughter yields in the smaller fish were reported for the Russian sturgeon, the lowest- for the Siberian, and the hybrid took a medium position in relation to the parental species.

There were significant differences between the Russian and the Siberian sturgeons reported with reference to all yields (1-Sv ($p<0.01$), 2-Sv ($p<0.01$) и 3-Sv ($p<0.05$)). The hybrid, on the other hand, displayed significant differences ($p<0.05$) only in 1-Sv and 2-Sv in relation to the Siberian sturgeon. The worst results in all yields calculated were reported for the larger hybrids, which were not the same with reference to the smaller fish; the best results- under 1-Sv were reported for the Siberian sturgeon, and for 2-Sv and 3-Sv- for the Russian sturgeon. Influence of the fish live weight was also ascertained with reference to the relative share of the fillet but the patterns were different from those reported for the yields. No significant differences were reported for the fish with lower live weight (the first weight group) in all parameters related to the meat quantity. In the larger fish, the Russian sturgeon displayed a significantly lower relative share of fillet in the carcass in relation to the hybrid ($p<0.05$) and the Siberian sturgeon ($p<0.001$) and significantly lower relative share in the fillet in the whole body in relation to the Siberian sturgeon ($p<0.05$). The exterior indices were also affected by the live weight but significant differences between the genotypes were reported only for the heavier fish (the second weight group). The Russian sturgeon exhibited the highest values for the CFF and CFC condition indices, with the coefficient differences between the hybrid and the Siberian sturgeon being significant in both weight groups. The best results for the IC condition index were reported for the Siberian sturgeon but only with reference to the heavier fish (second weight group). The influence of the live weight on the interior indices was divergent. No significant differences were ascertained between the heavier fish of the separate genotypes with reference to the viscerosomatic index, but a significant difference was reported between the lighter group Russian sturgeon and the hybrid. The Russian sturgeon and the hybrid from the second weight group significantly differed in their GSI, with the Russian sturgeon marking higher values. Furthermore, the Russian sturgeon also had the best developed heart, with the parameter differences with the Siberian sturgeon and the hybrid being significant regarding the heavier fish group, while in the lighter fish group, the cardiosomatic index difference was significant only for the two parental forms. When compared with the Siberian sturgeon from the first weight group (that with lower live weight), the hybrid from the same group exhibited a significantly better developed spleen. The analysis showed that the protein profile was influenced by both the live weight of the fish and their genotype. The sarcoplasmic fraction in each genotype studied was smaller in the smaller fish. The relative share of the fraction in the total protein was the highest in the Siberian sturgeon in the group of the smaller and the heavier fish- 31.02 and 33.65% respectively, followed by the Russian- 25.63 and 30.86%, and the hybrid whose share was 25.14 and 29.24%. The lowest myofibrillar fraction values were reported for the heavier hybrids and the highest for the heavier Siberian sturgeons. However, when the results were calculated as a percentage of the total protein, it was indicated that the MP was lower in heavier fish from all genotypes examined. The relative share of the fraction in the lower weight group was the highest in the Siberian sturgeon- up to 60.86%, followed by the Russian sturgeon- up to 55.48% and the hybrid- up to 49.3%. The alkali-soluble fraction in all genotypes analysed was higher in the fish with larger live weights. The relative share of the fraction in the total protein content was the highest in the hybrid- up to 5.27%, followed by the Russian sturgeon- up to 18.89% and the Siberian sturgeon- up to 8.47%. In conclusion, it can be stated that with reference to the Russian sturgeon, Siberian sturgeon and their hybrid, the fish with larger live weight had higher SP and ASP fractions, and the MP followed no clearly defined pattern. The SDS-PAGE analysis revealed distinct differences in the protein profiles of the SP, MP, and ASP fractions of the separate genotypes.

INFERENCES

1. The Siberian sturgeon (*Acipenser baerii* Brandt, 1869) the Russian sturgeon (*Acipenser gueldenstaedtii* Brandt et Ratzeburg, 1833) and their hybrid (F_1 *A. baerii* x *A. gueldenstaedtii*), with different yield weight, cultivated in super intensive cage farm in the conditions in Southern Bulgaria, had good slaughter parameters and meat quality.
2. The weight group influenced the morphological and slaughter parameters as well as on the chemical and biochemical composition of the meat. However, the influence in the separate genotypes with reference to a range of parameters was specific.
3. The Russian sturgeon from the lower weight group exhibited better slaughter parameters. It had higher slaughter (90.4% against 86.7% in the larger weight group, $p<0.01$) and consumable (87.2% against 84.3%, $p<0.05$) yields, and a higher relative share of the fillet in the whole body (49.9% against 48.3%) and in the carcass (77.8% against 75.3%).
4. Both Siberian sturgeon weight groups had similar slaughter parameters, which were insignificantly higher in the heavier fish: slaughter yield- 86.9% against 86.4% for the lighter fish, consumable yield- 84.2% against 83.5%, carcass yield- 61.5% against 58.1%, relative share of the fillet in the whole fish- 50.8% against 45.6% respectively. It was only the difference in the relative share of the fillet in the carcass that was significant (82.5% against 78.4%, $p<0.001$).
5. The lower weight hybrid group had higher slaughter (89.5% against 86.5%, $p<0.05$) and consumable (86.6 against 83.8%, $p<0.05$) yields. The relative shares of the fillet in the whole fish (50.0% against 48.0%) and in the carcass (81.4% against 79%) as well as the carcass yield (61.5% against 60.8%) were higher in the greater weight group.
6. The Russian sturgeon from the lower weight group excelled over the lower-weight Siberian sturgeon and the hybrid in the three slaughter yields and in relation to the fillet in the whole fish. The Siberian fish from the greater weight group had the highest relative share of the fillet in the whole fish and in the carcass. When compared with the parental forms, the hybrid took a medium position, only displaying insignificantly higher values for the fillet share in the carcass with reference to the group of the smaller fish.
7. The highest protein content in the dry matter was reported for the fish of the lower weight group: hybrid- 84.5%, the Russian- 78.5%, and the Siberian- 75.0% sturgeons. The greater weight group had a protein content of respectively- 73.5%, 64.0% and 64.1%. The meat of the fish analysed was classified as medium fat. The fat content in the dry matter of the fish from the lower weight group was 12.5%, 15.7% and 17.4% respectively for the hybrid, the Russian sturgeon and the Siberian sturgeon, while in the larger weight group, it was 20.6%, 25.4%, and 28.3%, respectively. The difference between the groups with reference to the water content was insignificant and the protein and fat content in the fresh meat had a similar arrangement.

8. The meat of the Russian sturgeon and the hybrid from the lower weight group had the most essential proteins in which the essential amino acids comprised respectively 67.2% and 55.5% of the total quantity. The second place was taken by the Russian sturgeon from the larger weight group with 47.9% essential amino acids, and the other groups had essential amino acid content from 31.2% to 36.2%. The differences were mostly attributed to the high isoleucine, lysine, and phenylalanine content in the lower weight group of the Russian sturgeon, and that of the lysine in the same weight group of the hybrid. The lysine was the amino acid with the highest content in the meat of the other groups.
9. The protein electrophoresis models could be used to differentiate the different sturgeon fish species.

RECOMMENDATIONS

1. The Siberian sturgeon, the Russian sturgeon, and their hybrid can be successfully cultivated in industrial cage farms in Southern Bulgaria.
2. Sturgeon fish with lower live weight is more suitable for improving the protein value of people's diets.
3. SDS-PAGE should be used for the identification of species of hybrids and sturgeons as it is a quick and reliable method allowing the identification of genotypes on the basis of the presence or the absence of different striations in the SP and the MP soluble fractions.

PUBLICATIONS RELATED TO THE DISSERTATION.

1. **Nikolova L., G. Georgiev, 2021.** Slaughter Yield And Morpho-Physiological Characteristics Of Siberian Sturgeon (*Acipenser baerii*) Reared In Net Cages, ***Agricultural Sciences****, 13(28): 34-43.*

2. **Georgiev G., L. Nikolova, 2022.** Slaughter yield and morpho-physiological traits of Russian sturgeon (*Acipenser Gueldenstaedtii*) with different live weight cultivated in industrial aquaculture, ***Bulgarian Journal of Agricultural Science*****,** 28 *(Supplement 1):139-145***.**

3. **Ivanova P., V. Chalova, L. Nikolova, G. Georgiev, 2022**. Comparative analysis of protein profile of Siberian sturgeon (*Acipenser baerii*), Russian sturgeon (*Acipenser gueldenstaedtii*), and hybrid (F1 *Acipenser baerii x Acipenser gueldenstaedtii*) grown on an aquaculture farm, ***Bulgarian Journal of Agricultural Science***, 28 *(Supplement 1): 119-128*

4. **Stoyanova M., P. Ivanova, V. Chalova, G. Georgiev, L. Nikolova, 2022.** Comparative biochemical characterization of Siberian sturgeon (*Acipenser baerii*), Russian sturgeon (*Acipenser gueldenstaedtii*), and hybrid (F1 *Acipenser baerii* x *Acipenser gueldenstaedtii*) reared in net cages, ***Bulgarian Journal of Agricultural Science*****,** 28*(Supplement 1): 146-153*.