ABSTRACT

Sturgeons (*Acipenseridae* family) are among the elder fishes which populate the world waters nowadays; their spreading areas are the waters from the Nordic hemisphere. At the same time is known that from all fish breeds, sturgeons are the most valuable ones, renowned especially, for their gustative qualities of meat and roe, but mainly by their uncommon size face to breeds which live in Romanian and world waters (*Manea Gh., 1985*).

Spreading and development of sturgeons entered into a new phase at the same time with the great of hydraulic works and especially with dumping the rivers fact that restrain the migration of the sturgeons to their natural areas for reproduction. The technical and scientific effects put a mark also on the development of these breed, evolution strong connected with the great danger represented by the problems created by water pollution (*Manea Gh., 1985*).

Introduction in Romanian pisciculture of *Polyodon spathula* breed took place in 1992 when were imported directly from USA, larvae of *Polyodon spathula* (5,000 - 20,000 pieces/year), at Fishing Research Station from Nucet and also adult individuals from Republic of Moldova (Ivancia farm) at S.C.D.A.E.A. Iaşi (*Costache Mioara, 2004*).

Polyodon spathula is a breed of sturgeons with natural spreading area in North America, in the Mississippi river basin. These sturgeon breed, which is the subject of the current paper, present a minimal risk for the Romanian pisciculture. Having in view the plankton feeding regime – a resource quite rich and uniform spread in the aquatic basins of Romania, the concurrence with the indigenous breeds is very small, and the "phylogenetic distance" face to the indigenous acipenseridae make impossible the phenomenon of intogression.

Banning of sturgeons fishing created very favourable premises for developing of aquaculture for *Polyodon spathula* breed in Romania, breed with a large waist (at maturity could reach the length of around 1.5 - 2.0 m and a mass of 50 - 70 kg), with two important characteristics: is *a plankton eater* fish and *have a very high growing rate*.

Besides the evident economic advantages, the extension in crop of *Polyodon spathula* allochthonous sturgeon will have a positive impact also on protection and preservation of

indigenous sturgeons. Each kilogram of meat or caviar obtained from *Polyodon spathula* grown in poly-culture will reduce the pressure on industrial fishing (especially on poaching) on the sturgeons from Danube (*Costache Mioara, 2004*).

Having in view the fact that *Polyodon spathula* sturgeon breed became important for Romanian aquaculture and due to the fact that research carried out in 1992 - 2002 period were made only in two geographical areas of Romania (Moldova, at Iaşi and Muntenia, at Nucet), we consider opportune the realise new research, more extended, in the geographical area of Moldova, to know the morph-productive characteristics of this sturgeon breed and also the quantitative and qualitative features of the meat provided from this breed.

By the current paper we aimed to study, for the first time in Romania, sensorial, physic-chemical, microbiological and technological features of the meat obtained from *Polyodon spathula* sturgeon breed. Also we have as a target the superior capitalization possibilities of the meat provided from those sturgeons.

Raising of *Polyodon spathula* sturgeons, which were the subject of the present research, were carried out in fishery exploitation S.C. Pirania S.R.L. Hudeşti – Botoşani County, unit in which is applied a semi-intensive growing system. Maintenance of sturgeons of different ages (1^{st} summer – P.s.$_{0+}$; 2^{nd} summer – P.s.$_{1+}$; 3^{rd} summer – P.s.$_{2+}$ and 4^{th} summer – P.s.$_{3+}$) was made in monoculture respectively in poly-culture with the following breeds: carp (*Cyprinus capio*), white amur (*Ctenopharingodon idella*), silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Aristichthys nobilis*).

To track the evolution of physic-chemical parameters of the waters from the investigated basins, monthly, during growing period, were made chemical analyses in according with the methodology described by STAS 4706/1988. Were analysed several parameters from which we mention: water temperature, solvate oxygen, pH, calcium, magnesium, chlorides, phosphates, nitrates, nitrites and organic matter.

For each of the analysed parameters the obtained values were between the limits admitted by the current legislation for 2^{nd} waters category, considered to be optimal for pisciculture.

Hydro-biologic analyse of the water from the studied aquatic basins show the existence of equilibrium between the main phyto-plankton and zoo-plankton groups which are developing in the stagnant freshwaters.

In according with the measured plankton deposit (seston volume) we can say that water from the analysed fishery basins were in the category of waters rich in plankton (15 – 30 ml/l).

Having in view the trophic spectre of the breed, mainly represented by zoo-plankton, aquatic insects and phyto-plankton, we could appreciate that *Polyodon spathula* breed capitalize efficiently the natural food from the studied aquatic basins.

After the study of feeding behaviour of 1st summer paddlefishes we notice the fact that those ones alternate feeding through filtration with individual capturing of zoo-plankton.

The study of feeding behaviour of paddlefish with the age of two summers show that this one capitalize efficient the natural resources from the basins studied by us, fish feeding mainly through filtration, filtration system being sufficient developed at this age, and selectivity regarding zoo-plankton species being lower in comparison with 1st summer paddlefishes.

For paddlefish with the age of three and four summers we could say the nutritive spectre is generally the same as at the younger ones, domination of a certain group or another being function of its abundance in raising basin.

The total average of mass gain of the 1st summer paddlefishes ($P.s._{0+}$) was of 110.44 g, and daily average gain was of 3.68 g.

The recorded values for paddlefish with the age of two summers ($P.s._{1+}$), shown a total average mass gain of 1620 g and a daily average gain of 12 g, gain which was with 126.08% better that those of the 1st summer paddlefish.

In the 3rd summer of growing, the realised gain was with 242.11% higher than the one of 1st summer paddlefish and with only 4.91% higher than the paddlefish with age of two summers.

At paddlefishes with the age of four summers ($P.s._{3+}$), growing rhythm was lower than in the cases of paddlefish with age of two and three summers (with 36.65% face to the paddlefishes of second summer and with 35.90% face to the ones of third summer), but higher in comparison with the ones from first summer (with 119.29%).

The presented data are in according with the ones found in the literature, describing a very well rhythm of growing in second and third summer and a little bit less while fishes are getting older.

The number of the losses from the studied batch of *Polyodon spathula* sturgeons was of 341 individuals which represent 17.57% from a total of 1940 individuals having a total survivor rate of 82.43%.

The causes of the losses were: stress caused by repeated manipulations (stocking, control fishing, production fishing); ichthyophagous predators and poaching.

After the effectuated body measurements at individuals from first and second summer and also to the ones from third and fourth summer we obtain close values to the ones presented in the literature fact that prove that the studied individuals had an appropriate development.

The obtained values resulted from concretion of indices and growing coefficients are between the values established by the literature, resulting that the analysed fish material had a good state of maintenance. The studied paddlefishes had a normal growing, capitalized efficiently the food from the growing ponds having a good state of health and maintenance.

Growing and development of the individuals from *Polyodon spathula* breed is in the standard of the breed fact which reflects a good adaptability to the specific conditions of the area.

During the whole period of growing paddlefishes and other breeds from the studied growing ponds weren't recorded mass illness phenomena at the studied fishes.

At examination of the individuals of studied *Polyodon spathula* (P.s.$_{0+}$; P.s.$_{1+}$; P.s.$_{2+}$; P.s.$_{3+}$) at the end of the analysed period we observed that these ones were clinically healthy and well developed.

For evaluating the health state and adaptability at environment conditions of the fishes from the working unit we analyse some haematological indexes such as packed cell volume and the quantity of haemoglobin.

The obtained results regarding the level of packed cell volume and haemoglobin didn't show any ill state at the studied *Polyodon spathula* individuals.

At the analysed sturgeons individuals the efficiency at hot slaughter was placed between 55.27 and 57.78%. The best efficiency for hot slaughter was calculated for the sturgeons of fourth summer – 57.78%, with 4.34 higher that the one for sturgeons of first summer, with 2.87% higher that the one for sturgeons of second summer and with 0.72% face to the ones of third summer.

Efficiency at cold slaughter (after refrigeration) at analyse *Polyodon spathula* sturgeons was between 54.12 and 56.68%. The best efficiency for cold slaughter was calculated for the paddlefishes of fourth summer – 56.68%, with 1.09 till 4.51% higher that the efficiency at cold slaughter calculated for the sturgeons of first, second and third summer. By calculating the efficiency at cold we observed that after refrigeration of the carcasses those ones lost from their weight between 1.67% (at paddlefishes of second summer) and 2.24% (at paddlefishes of third summer).

The calculated values for the three summers of growing of *Polyodon spathula* sturgeons are between the limits cited in the literature (55 – 58%).

Data regarding the weight of the gathered muscles and their participation at carcass formation and anatomical area of origin showed that at *Polyodon spathula* of second summer the epaxial muscles have a mean weight of 372.26 g and a rate of 34.80% form carcass, respectively 39.69% from election anatomic area (side muscles). Regarding hipaxial muscles at paddlefishes of the same age we noticed that they had an average weight of 565.63 g and a rate of 52.87% from carcass and 60.30% from side muscles.

For *Polyodon spathula* sturgeons of third summer concretion rate of the analysed muscles showed the fact that participation rate of the epaxial muscles was 35.89% from carcass and 38.98% from anatomic region and the proportion of hipaxial muscles was 56.17% from carcass

and 61.01% from anatomic region.

Participation rate of the head at *Polyodon spathula* breed was: 25.78% for the sturgeons of first summer, 26.34% for the ones of second summer, 27.04% for third summer and 26.85% for fourth summer. The calculated values for the four studied ages were very close.

Proportion of the fins at *Polyodon spathula* breed was between 2.76-3.27%, the highest share was obtained at paddlefishes of third summer (122.53 g).

Carcass proportion at *Polyodon spathula* breed was: 55.28% at sturgeons of first summer, 56.12% for the second summer, 57.36% for third summer and 57.78 % for fourth summer, fact that show that the share is in the favour of eatable parts, being higher of 50% and indicate the fact that *Polyodon spathula* breed is a valuable fish regarding meat quantity production.

Fillet proportion at the studied paddlefishes was between 27.25-31.19%, values higher face to the ones presented in the literature for paddlefishes (27%). The highest value – 1509.76 g (31.19% from weight) was obtained at sturgeons of fourth summer. From the above presented data we can conclude that at the same time with growing in age, at *Polyodon spathula* breed, muscular mass have a more significant rate, fact also shown through concretion of slaughter efficiency.

Analysing the weight of five internal organs studied by us (liver, spleen, heart, kidneys and bronchi) was observed that the highest rate is represented by bronchi. So their proportion was between 6.20 and 6.80% from the whole organism of the studied paddlefishes.

In a decreasing classification regarding the rate in organism formation were liver, this one having a share of 1.00 – 2.99%; livers with a rate between 0.41 and 0.46%; spleen with a share of 0.30-0.40%, while heart have a rate of only 0.10-0.15%.

The visceral mass weight of the studied sturgeons was of 61.67–513.34 g; comparing these values with weight of studied fishes we remark a visceral mass proportion of 10.6-12.78%.

Water content of filet (side muscles) gathered from *Polyodon spathula* sturgeon breed, for the all four growing summers, had close values between 75.41% for Ps_{3+} and 78.37% for Ps_{0+}; these values are in according with the limits cited in the literature.

Protein content of filet (side muscles) from *Polyodon spathula* breed for the all four summers of growing had values between 18.08% for Ps_{0+} and 19.89% for Ps_{3+}, values similar with the ones from the literature.

Lipids content of filet (side muscles) at analysed *Polyodon spathula* sturgeons was between 2.45-3.96%, values which placed those sturgeons in the category of fishes with low lipid content. Also in this case the obtained data was between the limits from literature.

Energetic value of studied filet was between 97.39 kcal/100 g at $P.s._{0+}$ and 114.31 kcal/100 g at $P.s._{3+}$, wit 17.37% higher face to $P.s._{0+}$. In according with the presented data the

nutritive value of *Polyodon spathula* sturgeon meat increases together with age. In comparison with nutritive values of other sturgeon meat (105 kcal/100 g), the calculated values were close.

Establishment of chemical composition of epaxial muscles group (dorsal and coastal) and hipaxial muscles group (coastal and abdominals) was made to put in light the existence of some differences under this aspect. Statistical analyse of the obtained data underline the fact that exist very significant differences for content in water, dry matter, lipids and ash between the abdominals hipaxial muscles (HA) and the others analysed muscles (dorsal epaxial – ED, coastal epaxial – EC and coastal hipaxial – HC) for the all analysed ages. As regarding protein content were didn't find significant statistical differences at the first two ages (first summer and second one), but for the sturgeons of third summer were found significant statistical differences between abdominals hipaxial muscles and dorsal epaxial muscles, and for the ones of fourth summer were observed significant statistical differences between the abdominals hipaxial muscles and all the rest of the studied muscles.

Quantity of *saturated fat acids* was higher in hipaxial muscles in comparison with the epaxial muscles for all four analysed summers of growing, maximal values being recorded at P.s.$_{2+}$ of 0.926 g/100g at hipaxial muscles and of 0.896 g/100g at epaxial ones. As proportion the quantity of saturated fat acids varied between 25.45 – 25.97%.

As regarding the *mono-unsaturated fat acids* the higher quantity was also found in hipaxial muscles in comparison with the epaxial muscles for all four analysed ages. The highest values were recorded also at P.s.$_{2+}$ of 1.965 g/100g at hipaxial muscles and of 1.897 g/100g at epaxial muscles. Proportion of mono-unsaturated fat acids was between 53.93 – 54.78%.

Quantity of *poly-unsaturated fat acids* was also higher in hipaxial muscles for all four summers of growing, the higher values being found at P.s.$_{2+}$, 0.747 g/100g for hipaxial muscles and of 0.699 g/100g for epaxial muscles. Poly-unsaturated fat acids had a proportion between 19.48 – 20.61%.

The pH level of side muscles (dorsal epaxial, coastal epaxial, coastal hipaxial and abdominal hipaxial), was determined on fresh meat respectively at 24 hours after slaughter. Meat pH value oscillated between: 6.90 and 7.11 for all the four analysed ages and 6.77 and 6.89 for all analysed ages, after 24 hours from slaughter.

For establishment of the proportion between muscular and connective tissues in meat of *Polyodon spathula* breed, were made previously histological studies. So in the case of side muscles gathered from paddlefishes of fourth summer, mean diameter had values between 38.78 μ and 47.07 μ, calculating an intermediate value of 43.42 μ. These data lead to obtain a mean area on transversal section of 1485.74 μ^2.

Mean diameter of muscular fiber at paddlefishes of fourth summer (43.42 μ)

characterize a meat with a soft texture. Profile on transversal section in muscular fibers had an ellipsoidal shape; this fact was underline by the ratio between great diameter and small diameter (DM/Dm) which varied from 1.35/1 to 1.61/1.

Regarding the proportion of the main tissue categories in forming the side muscles at *Polyodon spathula* sturgeon breed (fourth summer), was noticed that the mean proportion of muscular tissue was 70.47%, while mean proportion of connective tissues was of only 29.52%.

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

Paddlefish meat processing through flouring and frying recorded mean loses of 33.11%, with 12.17% lower that in the case of frying (without flouring) and with 7.29% higher face to boiling.

Analysing the recorded loses for the three types of processing, function of age, we notice the fact that younger fishes (first and second summer) had higher loses that older fishes (third and fourth summer).

The loses resulted through frying and boiling were due to water and fat content, so paddlefishes with younger age but with a high water content recorded higher loses in comparison with older aged paddlefishes. Also the differential loses function of age could be explain by the fact that at older ages was recorded a higher content in lipids and through thermo applied methods a great part of these lipids melt and passed in processing environment (water, oil).

After wet salting process with two different concentrations (16% NaCl and 26% NaCl), the obtained meals modified their texture and sensorial characteristics. So the meat is tight, taste and smell being characteristic to salty products; colour is modified becoming soft dark.

Content in salt of the obtained meals was variable function of the brine concentration. So at a brine concentration of 16%, the final content of the product was of 8.64 g NaCl, and in the case in which brine concentration increased at 26%, salt content of the product had a directly increase (with 49%).

Modification study of sensorial features of *Polyodon spathula* meat (with ages between one summer Ps_{0+} and 4 summers $Ps_{3+)}$, were analysed just after fish capturing and on refrigeration storage during a period of 15 days at a temperature of $+2 \div +4^{o}C$, in fridge. The first sensorial indicators which suffered modifications during refrigeration storage appeared after 4 days of keeping in cold air (refrigeration), and were: skin, meat and abdomen aspect and smell. So, after 15 days, the total sum of the points for analysed parameters was 24, fact that show that paddlefishes aren't proper for human consumption; after only 6 days when the sum of parameters' points reached the value of 10, it is the maximum score till which fishes are

considerate optimal to be consumed.

Between the four summers of growing could be noticed the fact that for fishes of first and second summer the analysed sensorial indicators indicate an optimal period of storage by refrigeration of 4-5 days, while for fishes of third and fourth summer the analysed sensorial indicators indicate an optimal period for storage by refrigeration (+2 ÷ +4^{o}C) of 6-7 days.

Appreciation of freshness state of paddlefishes (*Polyodon spathula*) by analysing pH, easy hydrolyze nitrogen, Eber/Nessler reaction and reaction with sulphide hydrogen, was made also on a period of 15 days in refrigeration conditions at +2 ÷ +4^{o}C temperatures.

The acidity values of paddlefishes meat analysed during 15 days of storage (initial, after 4 days, 8 days, 12 days, 15 days) had a decreasing evolution from 6.91 for paddlefishes of first summer (initial) and 7.10 for paddlefishes of fourth summer (initial) to 6.41 for paddlefishes of first summer (day 15) and 6.51 for paddlefishes of third and fourth summer (day 15).

During storage period, the values of easy hydrolyze nitrogen were modified indicate a depreciation of the features of the analysed paddlefishes, so those ones being uneatable after 8 days of storage at +2 ÷ +4^{o}C temperatures, when the values of content in easy hydrolyze nitrogen varied between 34.54 mg/100g at P.s.$_{3+}$ and 35.16 mg/100g at P.s.$_{0+}$.

At the end of storage period in refrigeration conditions, the content values of easy hydrolyze nitrogen indicate an altered meat, not suitable for human consumption, the values of this parameter being between 37.15 mg/100g at P.s.$_{3+}$ and 38.44 mg/100g at P.s.$_{0+}$.

Analyse of Eber, Nessler and sulphide hydrogen reaction revealed the fact that this meat could be stored in refrigeration conditions 3-4 days after that becoming uneatable.

Analysing five type of cuttings (body, filet, cod, „plast without head", „Klipp fisch") applied at the studied paddlefishes, we observe that the most efficient way of capitalization was recorded at "Klipp fisch" cut type, where was recorded a mean efficiency of 58.44% while the capitalization under the form of filet was the less efficient one because was recorded a mean efficiency of only 29.90%.

As a result of our research we notice that *Polyodon spathula* sturgeon breed represent an interesting breed for Romanian fish growing. By applying of some optimal growing technologies could be obtained a *quantitative and qualitative* increase of fish production and an efficient capitalization of eco-system.