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CERTAIN TEXTURAL PROPERTIES OF CHICKEN MEAT, INVESTIGATED THROUGH HISTOLOGY AND PHOTONIC MICROSCOPY TECHNIQUES

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Abstract: *This study is included within a wide range of researches regarding poultry meat quality, consisting in some comparative researches referring to the sensorial features of the skeletal musculature as well as to the nutritional value of the meat produced by several modern broiler brands: Cobb 500, Ross 308, Shaver Starbro, Hybro-PG. The results in the paper reveal some of the poultry muscles histological parameters: myocytes (muscle fibers) thickness and cross-section area, muscular fibers density, and, finally, the proportion of main tissues (pure muscular and connective) in whole muscle structure. 100 broilers (50♂ + 50♀), selected from a shelter accommodating 9500 Cobb 500 chickens of 42 days old, served as biological material in order to elect the samples from five representative muscles: Pectoralis profundis et superficialis, Biceps brachii, Semimembranosus, Gastrocnemius medialis. The tissue samples were used to obtain histological smears on cross-section, which were then analyzed using photonic microscopy. White muscles (breast fillet) were found to have the highest values for the myocytes' thickness (41.11µ), while the contractile cells of the red muscles were thinner (the thinnest within the brachial biceps – 27.9µ) and more dense per surface unit (≈1062 myocytes/mm^2 of muscle). The highest proportion of pure muscular tissue has been found in males' Pectoralis superficialis muscles (65.22%).*

Keywords: *chicken broiler, myocytes, density, texture, meat quality*

1. Introduction

Scientific literature, mainly those publications dealing with human nutrition and customer safety, emphasizes on some aspects which pass over the quantitative side of meat production in poultry. While most of the data spread by the companies producing high value commercial broilers refers to some technological and economical features of their product (microclimate, nutritional requirements, weight gains, feed conversion ratio, slaughtering efficiency), this paper brings some partial results from a study onto the textural quality of the meat produced by high performance hybrids. One of the curiosities among scientists and practitioners in poultry industry is how carcass cuts develop in

superintensive muscle growth during the normal 42 day rearing period – basing on muscle cell hypertrophy or on myocytes "hyperplasia" (increase of muscle cells amount per cross section tissual surface unit) [1]?. From poultry meat quality traits, texture is a useful parameter for food scientisits, because is straightly reşated to tenderness or toughness of meat. Usually, instrumental methods are used to assess tenderness on cooked meat (Warner-Bratzler, tensile tests, or Allo-Kramer Shear Press) [2, 3]. Other relevant parameter for meat tenderness in pre-rigor and post-rigor stages is the sarcomere length [4], also assessed through histological methods. Such techniques could also be applied in differentiating pale soft exudative (PSE) meat from normal meat and to determine the best ante mortem treatments for broilers in order to avoid PSE occurrence [5] Why not using histological techniques to assess the development tendency in meat structure, related to chickens age, genotype and rearing technique, in order to predict the tissual and textural features of the meat prior to commercial broiler choosing for intensive farming or prior to slaughterhouse options in relation with products needed to be processed starting from raw meat? The paper aims to reveal those histological techniques that might be used to predict textural and other technological properties of the meat.

2. Experimental

A group of 100 „Cobb 500" broilers (50 males + 50 females), issued from a shelter accommodating 9500 chickens, have been used as biological material to sample five studied muscles: *Pectoralis superficialis et profundis, Biceps brachii, Semimembranosus and Gastrocnemius medialis*. The feed consisted in classical corn-soymeal diet (3012Kcal ME and 24% CP - starter; 3175Kcal ME and 22.5% CP - grower; 3226Kcal ME and 20% CP - finisher). Muscular samples have been processed after techniques specified in literature [6, 7] through formalin 10% fixation, paraffin impregnation at +56° C, acid fuchsine and Evans blue coloration, resulting histological smears. These have been studied at a Motic DMWB1-223 photonic microscope, calibrated for three OBXOC associations: 10X10; 20X10 and 40X10. An ocular micrometer served to run the assessments, while an 8MP digital camera has been used to take microphotography shots, which were subsequentially processed in the Motic Images Plus ML software. The studies comprised cytometric and histometric measurements of myocytes and muscular fascicles, whose results have been introduced in several mathematical relations, in order to achieve some histological indexes: fibers mean thickness, cross section areas, myocytes density per muscular tissue unit, proportions of pure muscular/connective tissues. The formulas are listed below:

**mean thickness*: $D\bar{x}(\mu) = (D + d)/2$, meaning: D=large diameter, D=small diameter;

**cross section area*: $S(\mu^2) = D \times d \times \pi / 4$, meaning: π = 3.1416;

**myocytes density*:

$$\text{M. dens. (myocites/ mm}^2\text{of muscle)} = \frac{n\ m.f. \times 1.000.000}{MFI\ area},$$

meaning: n m.f. = amount of muscular fibers per 1st order muscular fascicle (MFI), MFI area = area of the measured 1st order muscular fascicle (mm^2);

* *tissual categories proportion*:

$$MT\,(\%) = n\ m.f. \times m.f.\ area \times 100 / MFI\ area$$

$CT\,(\%) = 100\text{-}MT\,(\%)$, meaning: MT (%) proportion of pure muscular tissue; CT (%) proportion of connective tissue, m.f. area= myocytes area (μ^2).

The achieved average values of the studied parameters have been statistically processed running the ANOVA single factor algorithm.

3. Results and Discussion

Figure 1 presents screenshots from microscopic field, while Table 1 and

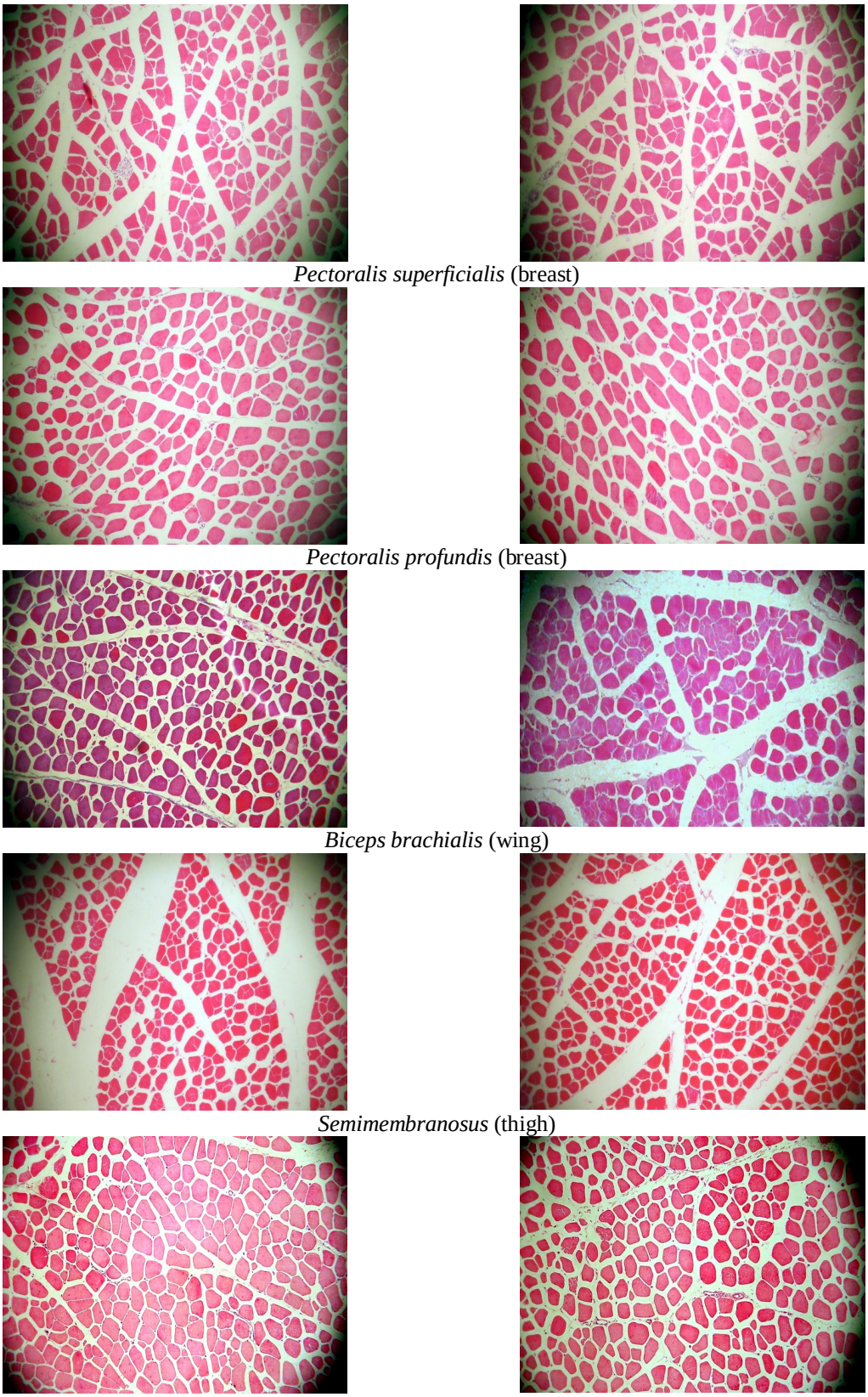
Figures 2-4 reveal data concerning dimensional features of the muscular fibers, their density within muscles an also the proportion of pure muscular and connective tissues. Mean myocytes diameter in the *Pectoralis superficialis* muscles has been found of 35.22±0.46μ at cockerels and of 35.29±0.29μ at pullets. Muscular fibers were thicker into the profound pectoral muscles, both in males and females (41.11±0.56μ and 36.51±0.45μ) and distinguished statistical significance occurred. The homogeneity was average (V=10.91-13.63%). As compared to breast fillet (white muscles), the texture of red studied muscles proved to be thinner. The lowest values for muscular fibers diameter were measured within the *Biceps brachialis* samples (26.51±0.34μ at pullets and 27.90±0.38μ at cockerels) (v% varied between 12.72-13.72%).

Table 1

Myocytes thickness, density and proportion of main tissual categories within some of the breast, wings, thighs and drumsticks muscles

Studied muscles	Broilers gender	Statistics	Myocytes mean thickness (μ)	Myocytes density (myocytes /mm^2 of muscle)	Pure muscular tissue (MT%)	Connective tissue (CT%)
Pectoral is superficialis	♂	$\bar{x}$	35.22	683.90 ^{d}	65.22 ^{d}	34.78 ^{a}
		$\pm s_{\bar{x}}$	0.46	18.02		
		V%	12.93	13.18		
	♀	$\bar{x}$	35.29	583.73 ^{a}	56.12 ^{a}	43.88 ^{d}
		$\pm s_{\bar{x}}$	0.39	20.12		
		V%	10.91	17.24		
Pectoral is profundis	♂	$\bar{x}$	41.11 ^{d}	407.51 ^{a}	53.49 ^{a}	46.51 ^{b}
		$\pm s_{\bar{x}}$	0.56	18.18		
		V%	13.63	22.31		
	♀	$\bar{x}$	36.51 ^{a}	604.46 ^{d}	62.56 ^{b}	37.44 ^{a}
		$\pm s_{\bar{x}}$	0.45	36.60		
		V%	12.28	30.28		
Biceps brachii	♂	$\bar{x}$	27.90 ^{c}	838.25 ^{a}	50.43 ^{a}	49.57 ^{b}
		$\pm s_{\bar{x}}$	0.38	27.42		
		V%	13.72	16.36		
	♀	$\bar{x}$	26.51 ^{a}	1061.94 ^{d}	58.19 ^{b}	41.81 ^{a}
		$\pm s_{\bar{x}}$	0.34	47.72		
		V%	12.72	22.47		
Semi-membranosus	♂	$\bar{x}$	30.89 ^{a}	801.63 ^{d}	59.16	40.84
		$\pm s_{\bar{x}}$	0.32	28.06		
		V%	10.41	17.50		
	♀	$\bar{x}$	32.44 ^{b}	722.01 ^{a}	58.81	41.19
		$\pm s_{\bar{x}}$	0.28	15.70		
		V%	8.64	10.88		
Gastrocnemius medialis	♂	$\bar{x}$	29.77 ^{a}	810.15 ^{d}	56.20	43.80
		$\pm s_{\bar{x}}$	0.41	32.31		
		V%	13.88	19.94		
	♀	$\bar{x}$	37.38 ^{d}	518.34 ^{a}	56.49	43.51
		$\pm s_{\bar{x}}$	0.38	19.59		
		V%	10.15	18.90		

ANOVA test – applied to each studied variable and muscle, as compared between genders, per column: ^{ab} significant differences ($\hat{F}>F_{\alpha\ 0.05}$); ^{ac} distinguished significant differences ($\hat{F}>F_{\alpha\ 0.01}$); ^{ad} high significant differences ($\hat{F}>F_{\alpha\ 0.001}$)



Pectoralis superficialis (breast)

Pectoralis profundis (breast)

Biceps brachialis (wing)

Semimembranosus (thigh)

Gastrocnemius medialis (shank – drumstick)

Figure 1. Muscle fibers (myocites) and 1st order muscular fascicles in skeletal muscles of chicken broilers (100 x magnification, OC 10xOB 10, sampling: left-males, right-females)

The ANOVA test applied to red muscles cytometric values revealed various levels of statistically significance between genders: significant differences for thighs muscles (*Semimembranosus*, thicker fibers in females); distinguished significance for wings muscles (*Biceps brachialis*, thicker fibers in males) and high significant differences between drumsticks muscles (*Gastrocnemius medialis*, thicker fibers in females).

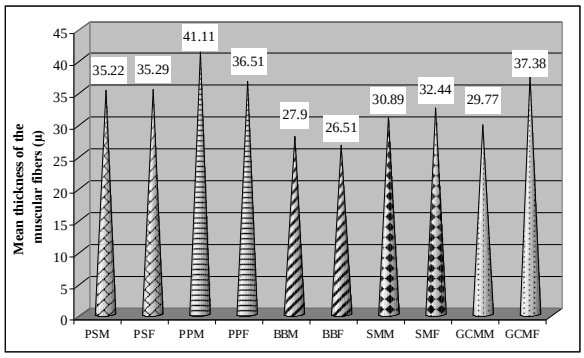


Figure 2. Mean thickness of the myocytes (µ)

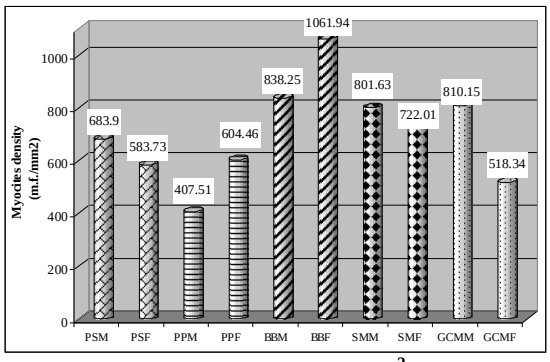
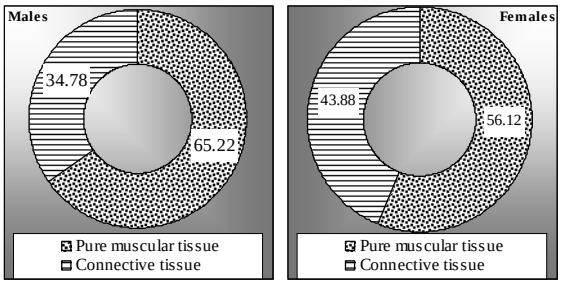
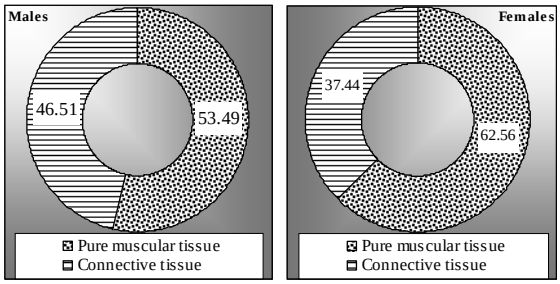


Figure 3. Myocytes density (m.f./mm^2 of muscle)

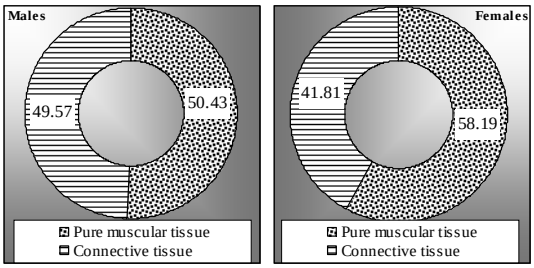
(PS = *Pectoralis superficialis*; PP = *Pectoralis profundis*; BB = *Biceps brachii*; SM = *Semimembranosus*; GC = *Gastrocnemius medialis*; M=muscles from males, F=muscles from females)



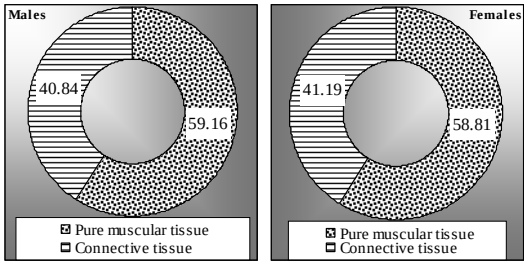
Pectoralis superficialis muscles



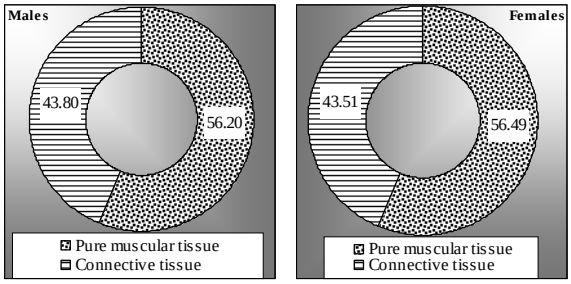
Pectoralis profundis muscles



Biceps brachii muscles



Semimembranosus muscles



Gastrocnemius medialis muscles

Figure 4. Proportions of pure muscular and connective tissues within breast, wing, thigh and drumstick muscles (%)

Myocytes density values varied conversely than those obtained for the average diameter. Thus, the lowest density could be observed into the males *Pectoralis profundis* muscles (407.51±18.18 m.f./mm^2), while highest amount of muscular fibers has been found into the pullets *Biceps brachialis* muscles (1061.94 m.f./mm^2). Very significant differences occurred for all studied muscles, when both genders were compared. Widest variation amplitude of the differences between cockerels and pullets was observed in *Gastrocnemius medialis* muscles (513.84 m.f./mm^2 in females and 810.15 m.f./mm^2 in males). The calculated variability showed high heterogenic characteristics (V=10.88-30.28%). The acquired data are consistent with those previously reported by other scientists [8], which showed higher myofibres density in males, in most analysed skeletal muscles of commercial broiler strains.

Proportions of main tissual categories in muscles structure revealed that highest amount of pure muscular tissue was found into the superficial pectoral muscles at males (65.22%) and into the profound pectoral muscles at females (62.56%). Very high significant differences occurred between genders when *Pectoralis superficialis* muscles have been compared, while other significant differences have been observed for cockerels vs. pullets *Pectoralis profundis* and *Biceps brachialis* comparisons.

Thinnest texture has been observed in *Biceps brachialis* muscles, while the thickest fibers have been measured within the *Pectoralis profundis* muscles, fact also observed during mastication. These results confirm that those myocytes having mainly glycolitical metabolism, usually found in white muscles (pectorals) are thicker than those with oxidative preponderant metabolism (red muscles – limbs) which have higher density [9, 10]. As compared to chicken broilers, in waterfowl domestic species (duck and goose), all skeletal muscles are mainly made of red fibers, which are thicker in wings [11, 12, 13].

Although previous researches recommend pectoral muscles as high qualitative, mainly concerning the physical, chemical and nutritional features (pH value, high protein content, low energy level) [14, 15, 16, 17], these researches showed that, for COBB-500 broilers, textural features are better in red muscles (especially in wings and thighs ones), which have, consequently, improved tenderness.

4. Conclusion

The quality sensorial features of meat (texture, tenderness, flavour) are influenced by the dimensional myocytes features, as well as by the proportion between main tissual categories and by lipids content, hence the possibility and usefulness in applying histological and microscopy methods in assessing them.

Further researches have to be carried on, in order to elect those components of the connective tissue which affect tenderness (eg. % of collagen, % of adipous tissue etc.), as another goal to reach in commercial broilers meat quality knowledge.

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6. References

[1]. VELLEMAN S.G., NESTOR K.E., COY C.S., HARFORD I., ANTHONY N.B., Effect of Posthatch Feed Restriction on Broiler Breast Muscle Development and Muscle Transcriptional Regulatory Factor Gene and Heparan Sulfate Proteoglycan Expression. *International Journal of Poultry Science*, 9(5).417-425, (2010).

[2]. LYON B.G., LYON C.E. Meat quality: sensory and instrumental evaluation, in: SAMS A.R. (Ed.) *Poultry meat processing*, pp. 97-120, CRC Press, New York, NY, (2001).
[3]. CAVITT L.C., MEULLENET J.F., GANDHAPUNENI R.K., YOUM G.W., OWENS C.M., Rigor Development and Meat Quality of Large and Small Broilers and the Use of Allo-Kramer Shear, Needle Puncture, and Razor Blade Shear to Measure Texture. *Poultry Science*, 84(1).113-118, (2005).
[4]. PETRACCI M., BAÉZA E., Harmonization of methodologies for the assessment of poultry meat quality features. *World's Poultry Science Journal*, 67.137-153, (2011).
[5]. GUARNIERI P.D., SOARES A.L., OLIVO R., SCHNEIDER J.P., MACEDO R.M., IDA E.I., SHIMOKOMAKI M., Preslaughter handling with water shower spray inhibits pse (Pale, Soft, Exudative) broiler breast meat in a commercial plant. Biochemical and ultrastructural observations. *Journal of food biochemistry*, 28.269-277, (2004).
[6]. DIACONIŢĂ G., Eskenasy A., Hagi-Paraschiv A., *Tehnica histopatologică*, Editura de Stat pentru Literatură Ştiinţifică, Bucureşti (1953).
[7]. BANCROFT J.D., GAMBLE M., *Theory and practice of histological techniques*, 6th Edition, Elsevier Ltd., (2008)
[8]. SCHEUERMANN G.N., BILGILI S.F., HESS J.B., MULVANEY D.R., Breast Muscle Development In Commercial Broiler Chickens. *Poultry Science*, 82.1648–1658 (2003).
[9]. PICCARD B., JURE C., CASSAR-MALEK I., HOCQUETTE J.F., LEFAUCHEUR L., BERRY C., DUCLOS M. J., ALAMI-DURANTE H., RESCAN P.Y., Typologie et ontogenèse des fibres musculaires chez différentes espèces d'intérêt agronomique. *INRA Productions Animales*, 16(2).115-120, (2003).
[10]. BERRI C., DUCLOS M.J., Typologie et ontogenèse des fibres musculaires chez les oiseaux. *INRA Productions Animales*, 16 (2).137-143, (2003).
[11]. RADU-RUSU R.M., TEUŞAN V., VOICU P., Researches concerning the thickness and the cross-section area of the miocytes in the domestic waterfowl's pectoral muscles, *Lucr. Ştiinţ. U.S.A.M.V. Iaşi, Seria Zootehnie*, 49.156-164, (2006).
[12]. RADU-RUSU R.M., TEUŞAN V., TEUŞAN A., Comparative researches concerning some histometric features of the miocytes in somatic musculature of the domestic chicken and waterfowl (I). Pectoral muscles. *Lucr. Stiint. U.S.A.M.V. Iasi, Seria Zootehnie*, 50.115-120, (2007).
[13]. RADU-RUSU R.M., TEUŞAN V., VACARU-OPRIŞ I., Comparative researches concerning some histometric features of the miocytes in somatic musculature of the domestic chicken and waterfowl (II). Wing and thigh muscles. *Lucr. Stiint. U.S.A.M.V. Iasi, Seria Zootehnie*, 50.107-114, (2007).
[14]. BANU C. et al., *Quality control of food products*, Agir Publishing house, Bucharest, Romania, (2002).
[15]. RADU-RUSU R.M., BOIŞTEANU P.C., Acţiunea unor factori asupra metabolismului muscular in-vivo şi influenţa acestora asupra calităţii finale a cărnii de pasăre, *Revista de Zootehnie*, 1.75-82, (2007).
[16]. RISTIC M., Meat quality of organically produced broilers, *World Poultry*, 20(8).30-31, (2004).
[17]. SUCHY P., JELINEK P., STRAKOVA E., HUCL J., Chemical composition of muscles of hybrid broiler chickens during prolonged feeding. *Czech Journal of Animal Science*, 47(12).511-518, (2002).