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GENDER-RELATED CORRELATIONS BETWEEN THE WEIGHT OF SELECTED MUSCLES AND CARCASS LEAN AND FAT CONTENT IN BROILER CHICKENS

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Abstract. *The objective of this study was to determine the applicability of the weight of selected wing, leg and breast muscles for estimating the content of lean meat and skin with subcutaneous and intermuscular fat in the carcasses of broiler chickens. The experimental materials comprised 40 carcasses of Ross 308 chickens (20 males and 20 females) slaughtered at 42 days of age. During carcass dissection, 17 muscles were removed from the right wing and the right leg. Breast muscles were separated from the breast portion. Coefficients of simple correlation between muscle weight and selected slaughter quality parameters were calculated. The results of the*

study indicate that carcass lean content can be evaluated based on the weight of the right and left breast muscles, and m. gastrocnemius medialis (r > 0.6) in both genders, and on the weight of m. semitendinosus (r = 0.79) and m. peroneus superficialis (r = 0.65) in females. Estimates of the weight of skin with subcutaneous fat in the carcasses of broiler chickens based on the weight of individual muscles could be inaccurate due to the low values of correlation coefficients. The highest correlation was found between breast muscle weight and the weight of skin with subcutaneous fat (r > 0.6). The weight of m. gastrocnemius medialis was also a reliable indicator of carcass fatness in male chickens (r = 0.67).

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Introduction. Poultry production and consumption have been growing steadily for many years. Consumers make their purchase decisions based on the taste and nutritional value of poultry meat and products. A short processing time is another important consideration (Nowak, Trziszka, 2010). The high demand for poultry meat has prompted intensive selection for increased muscling. The results of selective breeding programs can be evaluated based on indirect (live) and postmortem fat and lean mass measurements. A detailed tissue dissection procedure is laborious, which limits its practical applicability. A relatively simple alternative is to separate individual muscles and determine correlations between their weight vs. lean and fat percentages in the carcass. This procedure requires less time and effort, and has no significant effect on carcass quality.

Aim. Very few studies have investigated relationships between the weight of individual muscles vs. the lean meat and fat content of the whole carcass. Therefore, the present study was undertaken to determine the applicability of the weight of selected wing, leg and breast muscles for estimating the content of lean meat and skin with subcutaneous and intermuscular fat in the carcasses of broiler chickens.

Literature review. There is a need for reliable and objective methods that could be used to assess poultry carcass quality in selective breeding and improvement programs. A detailed carcass dissection combined with meat quality evaluation provides the best results. However, this method has not been widely applied by poultry breeders and producers because it is laborious and time-consuming. Thus, continuous efforts have been made to develop indirect methods for predicting lean and fat percentages in the carcass based on selected traits as indicators of carcass tissue composition. Such evaluations should be rapid, simple and accurate. Further research is needed to determine which parameters could be used for estimating carcass lean and fat content in live birds. The traits determined after slaughter cannot serve as a selection tool, but could be used in animal improvement programs. Easy-to-measure indicators showing high correlations with carcass tissue compo-

sition have been continuously searched for. The applicability of certain traits for indirect evaluation of carcass tissue composition in poultry is largely determined by their interdependences and measurement simplicity (Brzozowski, Bochno, 1998).

A detailed dissection of the whole carcass is the most reliable direct technique for analyzing carcass lean and fat content. During dissection, lean meat, fat and bones are separated. The subcutaneous fat layer is not separated from skin because it would be highly laborious. Before dissection, carcasses should be chilled and stored for no longer than 24 hours. Poultry carcasses are dissected by a standard method (Ziołecki, Doruchowski, 1989), which requires considerable time and effort, and decreases the market value of poultry carcasses.

Another method for indirect measurement of carcass lean and fat weights in poultry carcasses involves the dissection of individual muscles which are weighed to estimate percentage carcass lean yield and fat content. Wawro et al. (1984a) analyzed 16 muscles removed from goose carcasses and observed relatively high correlations between lean meat content and the weight of two leg muscles, *m. gastrocnemius medialis* and *m. gastrocnemius lateralis* (r = 0.80 and 0.83, respectively). In the cited study, the weight of *m. anconeus longus* was found to be the best predictor of carcass lean yield. This muscle can be easily separated without compromising the processing suitability of meat because the wing portion is the least valuable cut of poultry carcasses. The weight of *m. anconeus longus* showed also the highest correlation with total lean weight in the carcass (r = 0.89). The content of fat and skin in goose carcasses was most significantly correlated with the weight of leg muscles, *m. tibialis anterior*, *m. gastrocnemius lateralis* and *m. semitendinosus* (r = 0.711, 0.630 and 0.611, respectively; Wawro et al., 1984a), followed by the weight of breast muscles and *m. gastrocnemius medialis* (Wawro et al., 1984b). In an experiment performed on ducks, Wawro et al. (1984b) noted relatively high correlations between total lean weight in the carcass and the weight of *m. gastrocnemius medialis* (r = 0.76) and *m. biceps brachii* (r = 0.82), whereas the highest correlation was found between lean meat weight and the weight of the right and left breast muscles (r = 0.818 to 0.939).

Materials and Methods. The experimental materials comprised 40 carcasses of Ross 308 chickens (20 males and 20 females) slaughtered at 42 days of age. After removal of the head and feet, carcasses were chilled at +4^{o}C for around 18 hours, weighed and divided into the following primal cuts: neck, wings, legs (thigh and drumstick), breast portion, back and lumbar portion. The primal were dissected to separate lean meat, bones, and skin with subcutaneous and intermuscular fat. During carcass dissection, 17 muscles were removed from the right wing and the right leg (Komárek et al., 1986):

a) wing muscles: *m. deltoideus major*, *m. biceps brachii*, *m. triceps brachii*, *m. coracobrachialis posterior*, *m. extensor matacarpi ulnaris*, *m. indicis longus*, *m. extensor digitorum communis*, *m. flexor carpi ulnaris;*

b) leg muscles: *m. sartorius*, *m. tensor fasciae latae*, *m. biceps femoris*, *m. semitendinosus*, *m. semimembranosus*, *m. peroneus superficialis*, *m. tibialis anterior*, *m. gastrocnemius lateralis*, *m. gastrocnemius medialis*.

The muscles and tissue components were weighed within an accuracy of 0.1 g. Breast muscles (superficial and deep) were removed from the breast portion by cutting along the breastbone crest, clavicle and coracoids, and the line connecting the breast muscles to the ribs. In this article, the term "fat with skin" encompasses intermuscular fat and skin including a layer of subcutaneous fat, which are difficult to separate in poultry.

The results of the study were analyzed statistically ($\bar{x}$ and v). The significance of differences in the mean values of the analyzed parameters between genders was determined by analysis of variance (ANOVA). Coefficients of simple correlation (r) between the weights of selected muscles (x) and the weights of lean meat and fat with subcutaneous and intermuscular fat (y_i) were calculated (StatSoft, 2015).

Results and Discussion. The average body weight of broiler chickens (Table 1) was 2926.7 g in males and 2502.1 g in females, and average carcass weight was 2114.0 g and 1853.3 g, respectively. In males, the average weight of lean meat and skin with subcutaneous fat was 1451.1 g and 260.9 g, respectively. In females, the respective values were 1246.5 g and 270.8 g. Our results are consistent with the reference data provided by Aviagen for Ross chickens (ROSS 308 Broiler Performance Objectives, 2013).

Table 1 – Body weight, carcass weight, total meat weight and the weight of skin and fat in broiler carcasses

Specification	Statistics	Sex	
		♂	♀
Weight of (g): Body	$\bar{x}$ v	2926.7** 6.2	2502.1 7.7
Carcass	$\bar{x}$ v	2114.0** 9.8	1853.3 9.2
Meat	$\bar{x}$ v	1451.1** 9.6	1246.5 7.6
Fat with skin	$\bar{x}$ v	260.9 14.5	270.8 14.5

*Mean values denoted by ** are significantly different at $P \leq 0.01$*

The analyzed muscles differed in weight (Tables 2 and 3). Two wing muscles, *m. extensor digitorum communis* and *m. indicis longus*, had the lowest weight (both 1.6 g in males, 0.8 g and 1.2 g, respectively, in females). The weight of *m. coracobrachialis posterior* (2.5 g in males, 2.4 g in females) and *m. flexor carpi ulnaris* (2.9 g in males, 2.5 g in females) was also relatively low. Breast muscles were heaviest – the average weight of the right and left breast muscles reached 550.3 g in males, and 532.9 g in females. Leg muscles also had high average weight: *m. biceps femoris* (27.5 g in males, 23.1 g in females), *m. gastrocnemius lateralis* (21.8 g in males, 17.8 g in females) and *m. semimembranosus* (17.0 g in males, 16.0 g in females).

Among the analyzed muscles, carcass lean content (Tables 4 and 5) was most significantly correlated with the weight of the right and left breast muscles (r = 0.88 and 0.87, respectively, in males; r = 0.82 and 0.83, respectively, in females), *m. gastrocnemius medialis* (r = 0.72 in males, r = 0.60 in females) and *m. semitendinosus* (r = 0.79 in females). High coefficients of correlation were also noted for *m. biceps brachii*, *m. flexor carpi ulnaris*, *m. sartorius* and *m. biceps femoris* (r = 0.54 to 0.61). Relatively high coefficients of correlation were found between carcass lean weight and the weight of *m. extensor matacarpi ulnaris* (r = 0.62) and *m. tibialis anterior* (r = 0.52) in males, and between carcass lean weight and the weight of *m. peroneus superficialis* (r = 0.65), *m. deltoideus major* (r = 0.61) and *m. triceps brachii* (r = 0.52) in females. The weight of lean meat in the carcass was not correlated with the weight of *m. semimembranosus* in males, and with the weight of *m. extensor digitorum communis* and *m. indicis longus* in females. The weights of the remaining muscles were significantly correlated with carcass lean weight, but the coefficients of correlation were relatively low (r = 0.28 to 0.49).

Table 2 – The weight of breast muscles and arm muscles

Specification	Statistics	Sex	
		♂	♀
1	2	3	4
Masa mięśnia(g): *m. pectoralis* (right)	$\bar{x}$ v	291.9 14.8	268.6 11.6
m. pectoralis (left)	$\bar{x}$ v	288.3* 15.7	264.3 10.7
m. pectoralis (right and left)	$\bar{x}$ v	580.3 15.1	532.9 10.9
m. deltoideus major	$\bar{x}$ v	4.6 14.1	4.4 11.6

1	2	3	4
m. biceps brachii	$\bar{x}$ v	7.3 11.2	6.8 14.4
m. triceps brachii	$\bar{x}$ v	11.2** 12.1	9.8 11.9
m. coracobrachialis posterior	$\bar{x}$ v	2.5 20.0	2.4 21.1
m. extensor matacarpi ulnaris	$\bar{x}$ v	3.5 16.6	3.2 16.9
m. indicis longus	$\bar{x}$ v	1.6** 33.2	0.8 29.0
m. extensor digitorum communis	$\bar{x}$ v	1.6** 24.6	1.2 24.7
m. flexor carpi ulnaris	$\bar{x}$ v	2.9* 15.0	2.5 18.7

*Mean values denoted by ** are significantly different at P ≤ 0.01, * – at P ≤ 0.05*

Table 3 – The weight of leg muscles

Specification	Statistics	Sex	
		♂	♀
1	2	3	4
Masa mięśnia(g): *m. sartorius*	$\bar{x}$ v	10.1** 15.6	8.4 17.3
m. tensor fasciae latae	$\bar{x}$ v	7.1** 14.8	5.6 15.2
m. biceps femoris	$\bar{x}$ v	27.5** 20.4	23.1 17.3
m. semitendinosus	$\bar{x}$ v	14.5 19.9	11.7 13.9
m. semimembranosus	$\bar{x}$ v	17.0 31.2	16.0 20.3
m. peroneus superficialis	$\bar{x}$ v	11.3** 12.2	9.3 12.3
m. tibialis anterior	$\bar{x}$ v	12.5** 14.0	10.4 14.1

1	2	3	4
m. gastrocnemius lateralis	$\bar{x}$ v	21.8** 13.0	17.8 8.0
m. gastrocnemius medialis	$\bar{x}$ v	13.6** 13.8	11.1 13.4

*Mean values denoted by ** are significantly different at P ≤ 0.01*

In a study of geese, Wawro et al. (1984a) noted a significant correlation between carcass lean content and the weight of *m. gastrocnemius medialis* (r = 0.801), and a relatively high correlation between carcass lean content and the weight of *m. gastrocnemius lateralis* (r = 0.827). In our study, the coefficient of correlation between the above parameters was somewhat lower (r ≈ 0.4). In an experiment performed on ducks, Wawro et al. (1984b) reported the highest coefficients of correlation between the weight of lean meat in the carcass and the weight of breast muscles (r = 0.845) and *m. gastrocnemius medialis* (r = 0.759). The cited authors observed also a relatively high correlation between carcass lean weight and the weight of *m. biceps brachii*. Such correlations were also noted in broiler chickens in the present study.

Table 4 – The coefficients of simple correlation between the weight of breast and arm muscles and the weight of lean meat, skin and fat in broiler carcasses

Muscle	Sex	r_{xy} between the weight of the analyzed muscles and the weight of:	
		Meat	Fat with skin
1	2	3	4
m. pectoralis (right)	♂ ♀	0.88** 0.82**	0.69** 0.42
m. pectoralis (left)	♂ ♀	0.87** 0.83**	0.62** 0.50**
m. pectoralis (right and left)	♂ ♀	0.89** 0.84**	0.67** 0.47*
m. deltoideus maior	♂ ♀	0.42 0.61**	0.32 0.06
m. biceps brachii	♂ ♀	0.59** 0.61**	0.40 0.13
m. triceps brachii	♂ ♀	0.33 0.52**	0.07 0.55**
m. coracobrachialis posterior	♂ ♀	0.48* 0.42	0.27 0.34
m. extensor matacarpi ulnaris	♂ ♀	0.62** 0.33	0.43 0.15
m. indicius longus	♂ ♀	0.35 -0.04	0.33 0.22

1	2	3	4
m. extensor digitorum communis	♂ ♀	0.28 -0.03	0.17 0.06
m. flexor carpi ulnaris	♂ ♀	0.56** 0.54**	0.35 0.46*

*Significance of correlation coefficients (r_{xy}) at a level of α = 0.05, ** - at a level of α = 0.01*

Table 5 – The coefficients of simple correlation between the weight of leg muscles and the weight of lean meat, skin and fat in broiler carcasses

Muscle	Sex	r_{xy} between the weight of the analyzed muscles and the weight of:	
		Meat	Fat with skin
m. sartorius	♂ ♀	0.59** 0.51**	0.32 0.51**
m. tensor fasciae latae	♂ ♀	0.48* 0.39	0.40 0.26
m. biceps femoris	♂ ♀	0.61** 0.54**	0.38 0.36
m. semitendinosus	♂ ♀	0.36 0.79**	0.36 0.55**
m. semimembranosus	♂ ♀	-0.06 0.40	-0.06 0.52**
m. peroneus superficialis	♂ ♀	0.49* 0.65**	0.14 0.38
m. tibialis anterior	♂ ♀	0.52** 0.48*	0.42 0.33
m. gastrocnemius laterale	♂ ♀	0.39 0.44	0.42 0.50**
m. gastrocnemius mediale	♂ ♀	0.72** 0.60**	0.67** 0.22

*Significance of correlation coefficients (r_{xy}) at a level of α = 0.05, ** - at a level of α = 0.01*

Estimates of the weight of skin with subcutaneous fat in the carcasses of broiler chickens based on the weight of individual muscles could be inaccurate due to the low values of correlation coefficients. Carcass fat content (Tables 4 and 5) was most significantly correlated with the weight of breast muscles (r = 0.42 to 0.69). In males, the weight of skin with subcutaneous fat in the carcass was highly correlated with *m. gastrocnemius medialis* (r = 0.67), whereas in females – with the weight of *m. triceps brachii*, *m. flexor carpi ulnaris*, *m. sartorius*, *m. semitendinosus*, *m. semimembranosus* and *m. gastrocnemius medialis* (r ≈ 0.5 in all cases). No correlations or low correlations were observed between carcass fatness and the weights of the remaining muscles. Our results corroborate the findings of Wawro et al. (1984b) who noted relatively low correlations between carcass fat content and the weights of the analyzed muscles. In another study by Wawro et al. (1984a),

carcass fat weight was most significantly correlated with leg muscles: *m. tibialis anterior* (r = 0.711), *m. gastrocnemius lateralis* (r = 0.630) and *m. semitendinosus* (r = 0.611).

Summary. The results of this study indicate that carcass lean content can be evaluated based on the weight of the right and left breast muscles, and *m. gastrocnemius medialis* (r > 0.6) in both genders, and on the weight of *m. semitendinosus* (r = 0.79) and *m. peroneus superficialis* (r = 0.65) in females. Estimates of the weight of skin with subcutaneous fat in the carcasses of broiler chickens based on the weight of individual muscles could be inaccurate due to the low values of correlation coefficients. The highest correlation was found between breast muscle weight and the weight of skin with subcutaneous fat (r > 0.6). The weight of *m. gastrocnemius medialis* was also a reliable indicator of carcass fatness in male chickens (r = 0.67).

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THE INFLUENCE OF EARLY HUMAN-ANIMAL INTERACTIONS ON THE LATER BEHAVIOR OF CALVES

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Abstract. *Relations between people and animals might have a significant impact on behavior, productivity as well as their welfare. Positive relations of a human*