Relationships between breast muscle thickness measured by ultrasonography and meatiness and fatness in broiler chickens

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Abstract

The objective of this study was to determine relationships between breast muscle thickness measured by ultrasonography and meatiness and fatness characteristics in broiler chickens. The experiment was conducted on 80 Ross 308 chickens aged 42 days. Breast muscle thickness was determined before and after slaughter, using an ultrasonic diagnostic apparatus (Dramiński Animal Scanner with an abdominal, sector mechanical probe). The chickens were weighed and carcasses were subjected to detailed dissection.

In males breast muscle thickness measured before slaughter was found to be statistically correlated with the weight of a carcass, meat and breast muscles as well as with the percentage content of breast muscles in the carcass. The same measurement taken after slaughter showed a high correlation with all analyzed traits except for the percentage content of fat with skin in the carcass. The coefficients of correlation between the analyzed traits, characterizing meatiness in females, were in most cases slightly higher than in males.

Keywords: broiler chickens, breast muscle thickness, fatness, meatiness, ultrasonography

Zusammenfassung

Vergleich der mittels Ultraschall gemessenen Brustmuskeldicke und einzelnen Schlachtmerkmalen von Broilern

Ziel der Untersuchung bestand im Vergleich der mit mittels Ultraschall gemessener Brustmuskeldicke und einzelnen Schlachtmerkmalen bei Broilern. Einbezogen waren 80 Ross 308 Broiler mit gleichen Geschlechteranteilen im Alter von 42 Tagen. Nach der Wägung erfolgte die Ultraschallmessung der Brustmuskeldicke (Dramiński Animal Scanner) und nach der Schlachtung eine weitere Brustmuskeldickenmessung mit Ultraschall und einer Nadelsonde sowie die Zerlegung der Schlachtkörper. Bei den männlichen Tieren ergaben sich positive, mittlere Korrelationskoeffizienten für die Lebendmessung zum Fleisch und Brustmuskelfleischgewicht sowie dem Brustmuskelanteil. Die Ultraschall-messungen an geschlachteten männlichen Tieren waren fast zu allen erfassten Merkmalen hochsignifikant. Das galt auch für die Sondenmessungen. Die Beziehungen sowohl der Lebend- als auch der Schlachtkörpermessungen mit Ultraschall oder Sonde

bei weiblichen Tieren waren, mit Ausnahme bei Beinmuskulatur sowie Haut mit Fett, zu allen wesentlichen Schlachtmerkmalen hochsignifikant.

Schlüsselwörter: Broiler, Brustmuskeldicke, Fettanteil, Fleischanteil, Ultraschall

Introduction

Carcass meatiness is reflected primarily in the content of breast and leg muscles (BERRI *et al.* 2005, DUCLOS *et al.* 2006, STRAKOVA *et al.* 2006). As demonstrated in numerous studies, breast muscle thickness is a good indicator of the content of the above elements in carcasses of chickens (MICHALIK *et al.* 1999, RYMKIEWICZ and BOCHNO 1999).

BOCHNO (1983) analyzed research results concerning indirect methods for slaughter quality estimation in birds, and concluded that the measurement of breast muscle thickness may be a useful tool in breeding work aimed at increasing carcass meatiness in poultry. An high correlation between those traits was also observed in broiler chickens (MICHALIK *et al.* 1999, 2000).

Numerous studies described non-invasive methods to recording meat and fat content in poultry, for example magnetic tomography (KALLWEIT *et al.* 1994) or computer tomography (ANDRASSY-BAKA *et al.* 2003).

The ultrasonic measurement of breast muscle thickness is a quick, easy and – which is particularly important – non-invasive method, and therefore it can be successfully applied for the purpose of poultry carcass evaluation. The use of various ultrasonic devices for measuring breast muscle thickness has been described by MICHALIK *et al.* (1999), RÉMIGNON *et al.* (2000), SŁOWIŃSKI (2005). KÖNIG and GRASHORN (1997) and KÖNIG *et al.* (1997, 1998) proposed to use a 2D image obtained by ultrasound scanning to determine *in vivo* breast muscle yield in broiler chickens.

Since previous findings in this area were somewhat ambiguous, the objective of the present study was to determine relationships between breast muscle thickness measured using ultrasonography and meatiness and fatness traits in broiler chickens.

Material and methods

The experiment was conducted on 80 Ross 308 chickens aged 42 days (sex ratio 1:1). Breast muscle thickness was determined before and after slaughter, using an ultrasonic diagnostic apparatus (Dramiński Animal Scanner with an abdominal, sector mechanical probe, filtration of the signal – 7 MHz, penetration depth – 7 cm). The measurement was performed on the right breast muscle of hanging birds, at the point situated 3 cm from the beginning of the breast-bone crest and 1.5 cm from its edge (Figure 1). Breast muscle thickness was also estimated *post mortem* with a needle catheter (Figure 2). This invasive method involves inserting a needle into the breast muscle, so it is not recommended for live animals.

The chickens were fasted for 12 h, and then they were weighed and sacrificed. The carcasses (without head and feet) were chilled at +4°C. On the next day they were weighed and cut into pieces (neck, wings, legs, breast, back). The pieces were weighed and then they were subjected to detailed dissection into meat, bones, skin with

subcutaneous fat, and intermuscular fat. Breast muscles (*superficialis* and *profundus*) were also dissected. The term »skin with fat« refers to both intermuscular fat and skin including a fat layer situated underneath, which are joined together and thus extremely difficult to separate.

Numerical data were processed statistically, calculating arithmetic means ($\bar{x}$), standard errors of the mean (*SE*), standard deviations (*SD*) as well as the coefficients of simple correlation (r_{xy}) between breast muscle thickness (x) and the characteristics of meatiness and fatness (y_i) in broiler chickens (males and females was analysed separately). The significance of differences between the mean values of traits for males and females was determined by a one-factorial analysis of variance (males and females was analysed together; StatSoft 2001).
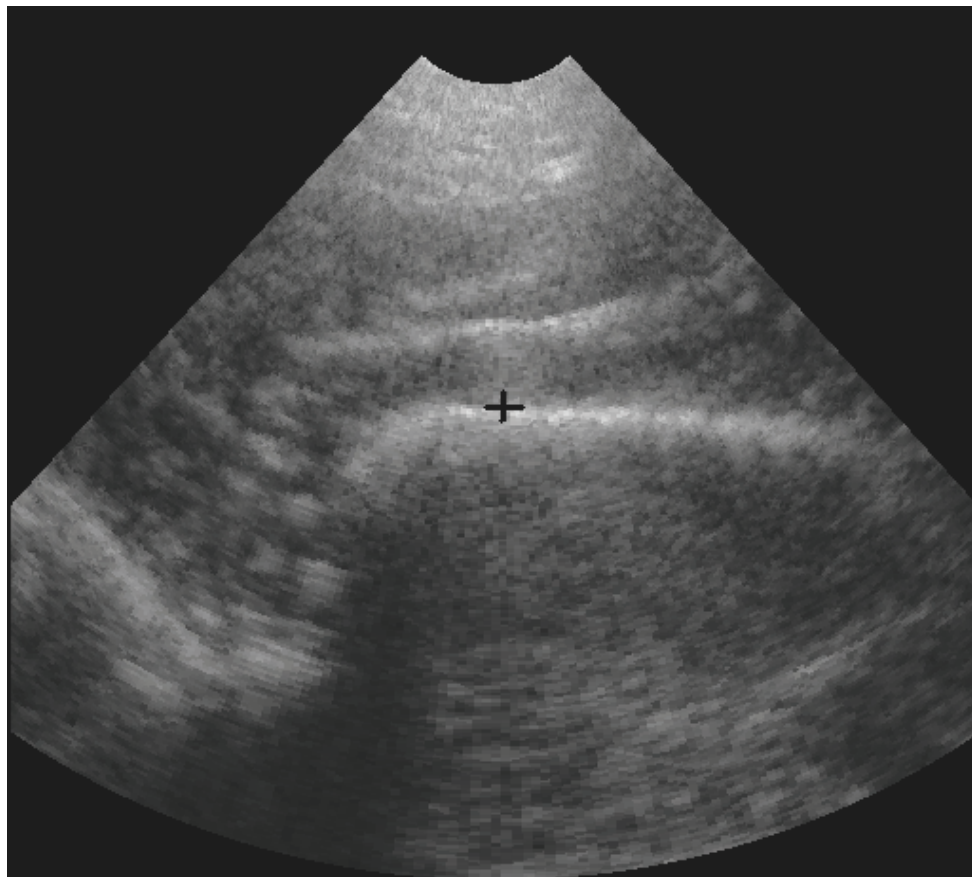

Figure 1
Image with apparatus ultrasound scan. Marked place with cross – cursor on the breast-bone crest.
Bild mittels Sonografie erhalten. Das Kreuz zeigt die Anlage des Cursors an dem Brustbein, das die Messung der Brustfleischdicke ermöglicht.

Figure 2
Needle catheter
Die Nadelsonde

Results

At the completion of the experiment the body weights of males were higher than the body weights of females (2 775 g vs. 2 355 g, Table 1), which resulted in significant differences in carcass weight (1 943 g and 1 646 g respectively) as well as in the weight of the other tissue components except for skin with fat. As regards the percentage content of particular tissue components, the proportion of breast muscles and skin with fat was higher in females, while the proportion of leg muscles was higher in males (Table 1).

In males breast muscle thickness measured before slaughter was found to be significantly correlated with the weight of a carcass, meat and breast muscles as well as with the percentage content of breast muscles in the carcass (r_{xy} from 0.38 to 0.47, Table 2). The same measurement taken after slaughter showed a high correlation with all analyzed traits except for the percentage content of skin with fat in the carcass (r_{xy} from 0.33 to 0.71, Table 2). The highest correlation was observed between this measurement and the weight and percentage content of breast muscles in the carcass (r_{xy}=0.71 and 0.61 respectively), followed by total meat weight (0.58), while the values recorded for leg muscles were substantially lower (0.35 and −0.34 respectively). Breast muscle thickness may be also a good indicator of the weight of skin with fat in carcasses of broiler chickens (r_{xy}=0.49). However, it is not significantly correlated with the percentage content of skin with fat (r_{xy}=0.24).

Table 1
Arithmetic means ($\bar{x}$), standard deviations (*SD*) and standard errors of the mean (*SE*) for the investigated traits of broiler chickens
Mittelwerte, Standardabweichung und Standardfehler der erfassten Merkmale

Specification	Males			Females		
	$\bar{x} \pm SE$		SD	$\bar{x} \pm SE$		SD
Breast muscle thickness (mm) measured with						
Ultrasound scanner before slaughter	27.8	± 0.5	3.0	27.6	± 0.5	3.2
Ultrasound scanner after slaughter	31.0	± 0.4	2.7	30.4	± 0.5	3.5
Needle catheter after slaughter	30.1	± 0.4	2.7	30.1	± 0.65	3.3
Weight of, g						
Body	2 775.0**	± 39.2	260.0	2 355.0	± 29.4	193.1
Carcass	1 943.0**	± 27.1	179.6	1 646.0	± 24.0	157.1
Total meat	1 278.0**	± 19.8	131.1	1 073.7	± 16.8	110.3
Breast muscles	498.0**	± 9.6	63.4	436.2	± 8.9	58.6
Leg muscles	452.8**	± 7.3	48.4	361.0	± 5.3	34.8
Fat with skin	271.7	± 5.6	37.0	258.5	± 6.2	40.4
Percentage in a carcass of						
Breast muscles	25.58	± 0.24	1.61	26.45**	± 0.31	2.01
Leg muscles	23.30**	± 0.17	1.11	21.96	± 0.15	0.99
Total meat	65.91	± 0.24	1.57	65.35	± 0.28	1.81
Fat with skin	14.0	± 0.19	1.27	15.70**	± 0.26	1.68

Means followed by ** are significantly different at $\alpha = 0.01$.

Table 2
Coefficients of simple correlation between breast muscle thickness (*x*) and the investigated traits in males (y_i)
Korrelationskoeffizienten zwischen Brustmuskeldicke und Schlachtmerkmalen männlicher Tiere (y_i)

Dependent variables (y_i)	Coefficients of simple correlation r_{xy}		
	Ultrasound scanner		Needle catheter
	before slaughter	after slaughter	after slaughter
Weight of, g			
Body	0.19	0.47**	0.38*
Carcass	0.38*	0.56**	0.52**
Total meat	0.38*	0.58**	0.54**
Breast muscles	0.47**	0.71**	0.67**
Leg muscles	0.23	0.35*	0.33*
Skin with fat	0.24	0.49**	0.41**
Percentage in a carcass of			
Breast muscles	0.40*	0.61**	0.57**
Leg muscles	−0.20	−0.34*	−0.31
Total meat	0.16	0.33*	0.28
Skin with fat	−0.01	0.24	0.14

ultrasound scanner   breast muscle thickness measured with ultrasound scanner,   needle catheter   breast muscle thickness measured with needle catheter,   coefficients of correlation (r_{xy}) significant at *α=0.05, **α=0.01

The values of coefficients of simple correlation between the measurement of breast muscle thickness performed with a needle catheter and the investigated traits were at an intermediate level in relation to those obtained during ultrasonic measurements taken before and after slaughter (Table 2). The coefficients of correlation between the analyzed meatiness traits were in most cases slightly higher in females than in males (Table 3). The

ultrasonic measurement of breast muscle thickness in live female birds was found to be considerably correlated with the weight of a carcass, meat and breast muscles (r_{xy}=0.62, 0.62 and 0.67 respectively). The respective values of r_{xy} obtained for the same measurement performed on carcasses were similar, although somewhat higher (Table 3). Just like in males, also in females the values of coefficients of simple correlation obtained for breast muscle thickness measured with a needle catheter *post mortem* were at an intermediate level, compared to the results provided by ultrasonography before and after slaughter (Table 3).

Table 3
Coefficients of simple correlation between breast muscle thickness (*x*) and the investigated traits in females (y_i)
Korrelationskoeffizienten zwischen Brustmuskeldicke und Schlachtmerkmalen weiblicher Tiere (y_i)

| Dependent variables (y_i) | Coefficients of simple correlation r_{xy} | | Needle catheter |
| | Ultrasound scanner | | |
	before slaughter	after slaughter	after slaughter
Weight of, g			
Body	0.46**	0.45**	0.44*
Carcass	0.62**	0.63**	0.61**
Total meat	0.62**	0.68**	0.61**
Breast muscles	0.67**	0.75**	0.64**
Leg muscles	0.44**	0.44**	0.45**
Skin with fat	0.53**	0.39*	0.44**
Percentage in a carcass of			
Breast muscles	0.45**	0.59**	0.43**
Leg muscles	−0.38*	−0.38*	−0.31
Total meat	0.21	0.41*	0.26
Skin with fat	0.24	0.03	0.12

ultrasound scanner   breast muscle thickness measured with ultrasound scanner,   needle catheter   breast muscle thickness measured with needle catheter,   coefficients of correlation (r_{xy}) significant at *α=0.05, **α=0.01

Discussion

The possibility to determine meat content in live birds is essential in breeding work directed towards improving carcass meatiness. Rapid estimation of both meatiness and fatness is also a key element of carcass quality evaluation, and it is best performed by non-invasive techniques.

In birds carcass meatiness is greatly dependent on breast muscle content. Thus, particular attention should be paid to the measurement of breast muscle thickness, especially that some authors (MICHALIK *et al.* 1999, RYMKIEWICZ and BOCHNO 1999) have stressed a significant correlation between breast muscle thickness and the content of breast muscles and meat in poultry carcasses. RYMKIEWICZ and BOCHNO (1998) postulated that breast muscle thickness in ducks may be a much better predictor of the weight of these muscles than body weight (*r*=0.905 and 0.634 respectively).

The present study indicated that the measurement of breast muscle thickness performed on carcasses showed a slightly higher correlation with the weight of meat (including breast muscles) than the same measurement taken on live birds. The values of the coefficients of correlation between this measurement carried out on live birds and the weight of breast muscles, both in males and females, were found to be high, reaching

0.71 and 0.75 respectively (Tables 2 and 3). The findings of OVIEDO-RONDON *et al.* (2007) are also interesting. These authors studied relationships between the surface area of breast muscles determined based on an ultrasonic image, and breast muscle weight and total meat weight in broiler chickens. This measurement was correlated to a higher degree with the above meatiness traits when taken on the right breast muscle, compared to the left breast muscle.

The overall quality of poultry carcasses is affected not only by meat content, but also by fat content. It should be noted here that in birds subcutaneous fat is usually dissected together with skin. The fat content of poultry carcasses is characterized by high variation, which makes it difficult to assess fatness by indirect methods (SHAHIN and ABD EL AZEEM 2005, 2006). In the current experiment the coefficients of simple correlation between the ultrasonic measurement of breast muscle thickness performed before and after slaughter and the fat content of carcasses of both males and females were generally low and non-significant. In males this measurement proved to be more useful for fatness determination when taken *post mortem* (r_{xy}=0.49), whereas in females – when performed *in vivo* (r_{xy}=0.53, Tables 2 and 3). Certain problems with an accurate indirect assessment of carcass fatness were also encountered in studies on other poultry species (BOCHNO 1983).

In conclusion in males breast muscle thickness measured before slaughter was found to be statistically significantly correlated with the weight of a carcass, meat and breast muscles as well as with the percentage content of breast muscles in the carcass. The same measurement taken after slaughter showed a high correlation with all analyzed traits except for the percentage content of skin with fat in the carcass. The coefficients of correlation between the analyzed meatiness traits were in most cases slightly higher in females than in males. The values of coefficients of simple correlation between the measurement of breast muscle thickness performed with a needle catheter and the investigated traits were at an intermediate level in relation to those obtained during ultrasonic measurements taken before and after slaughter.

An analysis of relationships between meatiness traits and breast muscle thickness measured with a needle catheter (invasive, but precise method) revealed that meatiness can be also determined in broiler chickens with an ultrasound scanner (non-invasive technique), both *in vivo* and *post mortem*.

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