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RELATIONSHIP BETWEEN *IN VIVO* PREDICTED AND LABORATORY DETERMINED INTRAMUSCULAR FAT CONTENT IN BULLS OF DIFFERENT BREEDS

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ABSTRACT

The possibility of *in vivo* carcass quality prediction in breeding process using ultrasound method was studied. Attention was paid to marbling and intramuscular fat content prediction and the effect of breed and age on prediction accuracy was evaluated. The study was carried out on 75 bulls (38 Slovak Simmental, 14 Beef Polled Simmental and 23 Charolais). The ultrasound machine ALOKA SSD-500 with 3.5 MHz / 172 mm probe was used. Ultrasound images were obtained from the site between 12th and 13th rib one week before slaughter. Statistical evaluation was performed using special software for computer image analysis and SAS software for statistical evaluation were performed. When data on whole dataset were considered, the correlations between marbling determined by photography (MARB) and intramuscular fat content determined by ultrasound (SONO) (0.19 – 0.41) and correlations between sonographic image values (SONO) and laboratory determined intramuscular fat content (IMF) (0.11 – 0.47) were statistically significant. The correlation between MARB and IMF (0.47) was at a very high level of statistical significance. When data on Slovak Simmental bulls group were considered, statistically significant correlations were observed between SONO and MARB values (0.35 – 0.54) and SONO and IMF values (0.50 – 0.59). The correlation between MARB and IMF (0.47) was also statistically significant. Non-significant correlation coefficients were calculated when data on Beef Polled Simmental and Charolais bulls group were considered.

Key words: *in vivo* ultrasound method; marbling; intramuscular fat; carcass quality; beef cattle.

INTRODUCTION

The accuracy of carcass traits prediction varies over studies but overall it seems to be moderately precise (Charagu, et al. 2000, Hassen et al. 1998). Very important is minimizing the factors influencing the prediction accuracy and standardizing conditions under which the particular equipment is used. Whittaker et al. (1992) showed the scattering effect and absorption to be the main factors influencing scanogram interpretation. The greater the effect of scattering captured in the ultrasonic image, higher is the marbling presumed to be present in the imaged *longissimus (MLTL)* muscle. This is due to high frequency probe used and very high ultrasound intensity applied. On the other hand the lower the ultrasound frequency and intensity applied, the higher the absorption effect (low marbling is presumed to be in the imaged muscle) is.This was proved by BLANCO ROA et al. (2002). Blanco Roa et al. (2004b) showed a trend of decreasing correlation coefficients with increasing ultrasound machine performance (60 – 70%), when ALOKA SSD-500 with 5 MHz ultrasound probe was used. Indurain et al. (2006) showed a significant correlation between marbling and grey level of ultrasonic image ($r = 0.63$; $P < 0.001$). They stated that the fatter the animal, the whiter the scanogram is. Rahim et al. (1997) found that the correlation coefficients between actual carcass traits

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and their ultrasonic estimates increase with increasing time of fattening. They ranged from 0.12 to 0.91 (10.6 – 20.4 months of age). This trend of improving accuracy was also proved by Brethour (2000). He reported that this accuracy improved from 64% while entering the intensive feeding period to 75% at 36 days to slaughter (123 days after the arrival) when the Limousine and Simmental bulls group was considered. When group of Angus and Angus x Hereford animals was considered, the accuracy improved from 74% to 81% (90 days after the arrival). These findings are in contrast to results presented by Blanco Roa (2004a). He showed statistically significant correlations between sonographic measurements and actual intramuscular fat content ($r=0.89$; $P<0.01$) in group of the youngest bulls (9 months) and statistically significant correlation $r = 0.60$ ($P<0.01$) in group of the oldest bulls. According to repeatability, Hassen et al. (1999) stated that fatter the animal (4.76% IMF and above) the higher the repeatability.

The aim of this paper is to evaluate the possible effect of breed on prediction accuracy and to prove the hypothesis that the age may influences the prediction. Additionally, the optimal intensity of ultrasound should be determined.

MATERIAL AND METHODS

Animals

The study was carried out on 101 bulls (59 Slovak Simmental, 19 Beef Polled Simmental and 23 Charolais). Following computer image analysis 26 animals were rejected because of mistaken scanograms. Finally, the two datasets were created. The first group included 38 dual purpose bulls (Slovak Simmental) and the second group comprised of 37 beef bulls (14 Beef Polled Simmental, 23 Charolais). In the whole dataset ($n = 75$) an average age at slaughter was 568 days and average live animal weight was 597 kg. When data on Slovak Simmental bulls were considered, an average age at slaughter was 599 days and average live animal weight was 568 kg. When data on Beef Polled Simmental and Charolais were considered, an average age at slaughter was 536 days and average live animal weight was 627 kg.

The total mix ratio (TMR) was balanced for average daily gain 1200 g (Petrikovič et al., 2002) and included silage, hay, alfalfa silage and concentrate in the Slovak Simmental bulls group. The total mix ratio was balanced for average daily gain 1300g and comprised of the similar components in the Beef Polled Simmental and Charolais bulls.

Data collection

The ultrasound machine ALOKA SSD-500 with 3.5 MHz (172 mm) probe was used in our experiments. Scanograms of *musculus longissimus thoracis et lumborum* (MLTL) rib eye area were obtained from the site between 12th and 13th rib 7 days before slaughter. Different ultrasound intensities were applied (75, 80, 85 and 90%) so that 4 scanograms from each bull were obtained. The ultrasound images were entitled as SONO_75, SONO_80, SONO_85 and SONO_90. The detailed dissection was performed twenty-four hours after slaughter. Then the cross sectional cut of *musculus longissimus thoracis et lumborum* was performed between 12th and 13th rib (area of ultrasound measurement). The photograph of MLTL area was obtained using Canon PowerShot 85A camera and entitled as MARB. The meat sample was taken for laboratory determination of intramuscular fat content (value was entitled as IMF). The Infratec 1265 – Meat Analyzer equipment was used.

Computer Image Analysis

The ultrasound and photographic images were digitalized (converted into the set of pixels). Each pixel was given the grey value (0 to 255). The grey value of 0 represents 100% brightness and the grey value of 255 represents 100% darkness. In the scanogram the white colour represents the intramuscular fat in rib eye area of muscle and the black colour represents the muscle fibres. Sonographic and photographic images were analyzed using LUCIA software (LIM, s.r.o., 2005) for computer image analysis (CIA). The peak detection algorithm was applied. The intramuscular fat was distinguished from muscle fibres in the whole muscle area. Then the percentage of intramuscular fat was assessed. The values were entitled as SONO_75, SONO_80, SONO_85 and SONO_90 (scanogram values for percentage intramuscular fat according to the ultrasound intensity) and MARB (photographic value for percentage intramuscular fat). The higher the MARB and SONO values assessed, the higher the level of marbling present in the muscle.

For statistical analysis SAS 8.2 software (SAS, 2002) was used. STAT (Basic Statistics) module and CORR (Correlation analysis) procedure were applied.

RESULTS AND DISCUSSION

Basic Statistics

Mean values and standard deviations for measured characteristics are summarized in Table 1. SONO values were rising as the ultrasound machine performance was increasing. When the whole dataset was considered, average marbling value (MARB) was 2.66%. When data on single group were considered, the average MARB value was 2.81% (Slovak Simmental bulls) and 2.51% (Beef Polled Simmental, Charolais bulls). The average intramuscular fat content (IMF) was 2.13% (whole dataset). When data on single groups were considered, the average IMF was 2.78% (Slovak Simmental) and 1.49% (Beef Polled Simmental, Charolais). The higher IMF value within Slovak Simmental group can be due to the longer feeding period, the higher age at the slaughter and consequent more intensive fat deposition. These values were in agreement with those obtained by Zaujec et al. (2003), who showed an average intramuscular fat content of 1 – 3% for majority of Slovak Simmental, Slovak Pinzgau and Holstein bulls. Aass et al. (2006) reported intramuscular fat content ranging from 0.4 to 2.7% for Norwegian Red dual purpose bulls (age of 12.8 months).

The effect of breed on intramuscular fat content was showed by Chambaz et al. (2003). They reported different age of the steers (Angus, Simmental, Charolais, Limousine) at slaughter when the constant intramuscular fat content was considered. Angus steers were the youngest and Limousine steers were the oldest. Also, Cuvelier et al. (2006) reported the effect of breed on the groups of Angus, Limousine and Belgian Blue bulls. The highest intramuscular fat content was observed in Angus bulls and the lowest in Belgian Blue bulls. Blanco Roa (2004a) reported average intramuscular fat content of 2.39 % (Slovak Simmental, 15 months) and 2.17 % (Holstein, 15 months).

Correlation coefficients

Calculated correlation coefficients in the whole dataset are shown in Table 2. Statistically significant correlations were observed between sonographic and photographic image values except for SONO_90. They varied from 0.19 (SONO_90) to 0.41 (SONO_80). Correlation coefficients between SONO values (determined from scanograms) and laboratory determined intramuscular fat content ranged from 0.11 (SONO_90) to 0.47 (SONO_75) and were statistically significant (except for SONO 90). The correlation between MARB and IMF (0.47) was at high level of statistical significance.

When the data on Slovak Simmental bulls were considered, the correlation coefficients between SONO values (determined from scanograms) and MARB values (determined from photographs) ranged from 0.35 (SONO_90) to 0.54 (SONO_80) and were statistically

Table 1: Basic statistics

Variable	Whole dataset (n = 75)				Slovak Simmental bulls (n = 38)				Beef Polled Simmental and Charolais bulls (n = 37)			
	Mean	StD.	Min.	Max.	Mean	StD.	Min.	Max.	Mean	StD.	Min.	Max.
SONO_75, %	0.54	0.564	0.10	2.70	0.65	0.700	0.10	2.70	0.43	0.356	0.10	1.78
SONO_80, %	1.22	1.136	0.10	4.60	1.23	1.305	0.10	4.60	1.21	0.949	0.10	3.70
SONO_85, %	1.88	1.222	0.10	5.90	2.01	1.464	0.10	5.90	1.75	0.913	0.50	3.46
SONO_90, %	3.85	2.164	0.30	10.70	3.38	2.145	0.30	10.70	4.34	2.100	0.40	9.32
MARB, %	2.66	0.892	0.67	4.82	2.81	0.946	0.67	4.82	2.51	0.817	0.72	4.39
IMF, %	2.13	1.008	0.78	5.40	2.78	0.972	0.96	5.40	1.49	0.470	0.78	2.70
AGE, days	568	69.5	430	733	599	75.6	450	733	536	44.7	430	599
LW, kg	597	51.44	480	720	568	44.09	480	670	627	40.27	522	720

SONO_75 = ultrasound measurement at 75% of overall machine performance, SONO_80 = ultrasound measurement at 80% of overall machine performance, SONO_85 = ultrasound measurement at 85% of overall machine performance, SONO_90 = ultrasound measurement at 90% of overall machine performance, MARB = predicted percentage intramuscular fat from photographs, IMF = laboratory determined intramuscular fat content, AGE = average age at slaughter, LW = live weight at slaughter

Table 2: Pearson's correlation coefficients (whole dataset, n = 75)

Variable	SONO_80	SONO_85	SONO_90	MARB	IMF
SONO_75	0.74***	0.72***	0.46***	0.36*	0.47***
SONO_80		0.74***	0.57***	0.41**	0.36*
SONO_85			0.70***	0.36*	0.39**
SONO_90				0.19	0.11
MARB					0.47***

*** - P < 0.001, ** - P < 0.01, * - P < 0.05, see Table 1 for explanation of abbreviations

Table 3: Pearson's correlation coefficients (Slovak Simmental bulls, n = 38)

Variable	SONO_80	SONO_85	SONO_90	MARB	IMF
SONO_75	0.87***	0.81***	0.70***	0.46*	0.56**
SONO_80		0.83***	0.67***	0.54**	0.59***
SONO_85			0.85***	0.51*	0.55**
SONO_90				0.35	0.50*
MARB					0.49*

*** - P < 0.001, ** - P < 0.01, * - P < 0.05, see Table 1 for explanation of abbreviations

Table 4: Pearson's correlation coefficients (Beef Polled Simmental and Charolais bulls, n = 37)

Variable	SONO_80	SONO_85	SONO_90	MARB	IMF
SONO_75	0.47*	0.44	0.24	0.10	0.04
SONO_80		0.57**	0.48*	0.22	-0.002
SONO_85			0.61***	0.07	-0.06
SONO_90				0.11	0.07
MARB					0.21

*** - P < 0.001, ** - P < 0.01, * - P < 0.05, see Table 1 for explanation of abbreviations

significant except for SONO_90 (Table 3). Correlations between ultrasound image values and IMF varied from 0.50 to 0.59 and were statistically significant. Also the correlation between MARB and IMF values (0.49) was statistically significant.

The correlation coefficients calculated in the Beef Polled Simmental and Charolais bull`s group are summarized in Table 4. Correlations between ultrasound and photographic image values ranged from 0.07 to 0.22. Correlation coefficients between SONO values and laboratory determined intramuscular fat content varied from -0.002 to 0.07. Correlation between photographic image values and IMF values was 0.21. All correlation coefficients were statistically non-significant.

Different correlations were calculated when data on Slovak Simmental bulls and beef bulls (Beef Polled Simmental, Charolais) were taken into account. According to this comparison, it can be said the breed is one of the factors influencing ultrasound method. Blanco Roa (2004a) also showed different correlation coefficients according to breed; r = 0.79 (Slovak Simmental) and r = 0.60 (Holstein).

In our experiment, correlation coefficients improved after the beef bulls (Beef Polled Simmental, Charolais) were excluded. These results are in contrast to findings of Aass et al. (2006). They stated that when whole file (dual purpose and beef bulls) was considered, correlations varied from 0.05 to 0.21 and after exclusion of Norwegian Red dual purpose bulls correlations improved from 0.23 to 0.41. Such differences in results could be caused by differences in average age and actual IMF content at measurement. In our study, the average age was 19.9 months for Slovak Simmental bulls, 17.9 months for Beef Polled Simmental and Charolais bulls and average IMF content was 2.78% (Slovak Simmental) and 1.49% (Beef Polled Simmental, Charolais), while Aass et al. (2006) reported average age of 12.8 months (Norwegian Red dual purpose bulls) and 16.7 months (beef bulls) at measurement while the average IMF content of 1.14% (Norwegian Red dual purpose bulls) and 1.35% (beef bulls). These results suggest that the age of animal and actual IMF content might be the factors influencing the prediction accuracy.

Taking into account calculated correlations (r = 0.47; P < 0.001, whole file, r = 0.49; P < 0.05, Slovak Simmental bulls) it can be said that the objective evaluation of intramuscular fat is feasible via photo images of cross sectional cut of *musculus longissimus thoracis et lumborum*. On the other hand, it must be said that this method can not be utilized for breeding organizations as the data on percentage of intramuscular fat are available after slaughter and, therefore, the breeding process is slowed.

The most authors use the marbling scales for intramuscular fat content evaluation. These methods are based on the conversion of percentage of the intramuscular fat to marbling grade (marbling score) (Drake, 2004) and should be used only for evaluation of finished cattle. Therefore, it is important to decide if the prediction of percentage intramuscular fat percentage is appropriate.

CONCLUSION

The study was carried out on two groups of animals. Different values for correlation coefficients were obtained depending on breeds. The lower values were calculated for beef breeds (Beef Polled Simmental, Charolais), the higher values were calculated for Slovak Simmental bulls.

The higher correlation values were calculated when data on older (dual purpose Slovak Simmental) bulls with higher level of IMF were considered. Further research dealing with influence of age and actual IMF on intramuscular fat content prediction is needed.

The optimal ultrasound intensity for this equipment was suggested (80 - 85%).

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