Asian-Aust. J. Anim. Sci.
Vol. 20, No. 12 : 1901 - 1908
December 2007
www.ajas.info

Application of X-ray Computer Tomography (CT) in Cattle Production

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ABSTRACT : The aim of this series of experiments was to examine the opportunity for application of X-ray computer tomography (CT) in cattle production. Firstly, tissue composition of *M. longissimus dorsi* (LD) cuts between the 11-13th ribs (in Exp 1. between the 9-11th ribs), was determined by CT and correlated with tissue composition of intact half carcasses prior to dissection and tissue separation. Altogether, 207 animals of different breeds and genders were used in the study. In Exp. 2 and 3, samples were taken from LD cuts, dissected and chemical composition of muscle homogenates was analysed by conventional procedures. Correlation coefficients were calculated among slaughter records, tissues in whole carcasses and tissue composition of rib samples. Results indicated that tissue composition of rib samples determined by CT closely correlated with tissue composition results by dissection of whole carcasses. The findings revealed that figures obtained by CT correlate well with the dissection results of entire carcasses (meat, bone, fat). Close three-way coefficients of correlation (r = 0.80-0.97) were calculated among rib eye area, volume of cut, pixel-sum of adipose tissue determined by CT and intramuscular fat or adipose tissue in entire carcasses. Estimation of tissue composition of carcasses using equations including only CT-data as independent variables proved to be less reliable in prediction of lean meat and bone in carcass (R^2 = 0.51-0.86) than for fat (R^2 = 0.83-0.89). However, when cold half carcass weight was also included in the equation, the coefficient of determination exceeded R^2 = 0.90. In Exp. 3 tissue composition of rib samples by CT were compared to the results of EUROP carcass classification. Findings revealed that CT analysis has higher predictive value in estimation of actual tissue composition of cattle carcasses than EUROP carcass classification. (**Key Words :** Cattle, X-ray Computer Tomography, Carcass Composition, 9-11th Ribs, 11-13th Ribs)

INTRODUCTION

Similar to other farm animals one of the main objectives of cattle production is to improve beef production traits. At the present time increasing emphasis is laid on selection of meat production traits, carcass value, carcass composition and beef quality due to change of consumer expectations as it is the case in other beef producing animal species. The slaughter value of cattle means the main quantitative and qualitative parameters of carcass, from which lean and fat proportions, lean and bone ratio and saleable meat yield are the most important ones. The carcass composition can be measured accurately by full carcass dissection, but this is time consuming, destructive and expensive process and cannot easily be included in the commercial slaughter line. Therefore, animal breeders and scientists have had a strong desire to find methods for *in vivo* estimation of body and/or carcass composition in animals after slaughter without the need for complete dissection for a long time. Recently, various methods (ultrasonic-, NIR-technique, TOBEC, VIA) have been used for this purpose. Application of those methods in practice and accuracy may differ largely. Digital cross-section imaging techniques such as X-ray computer tomography (CT) have been applied with success in human medicine for diagnostic purposes for decades. The results of Hungarian experiments carried out in species such as swine, sheep, poultry and rabbit (Repa et al., 2002) reveal that these *in vivo* techniques are suitable to predict body composition with high level of accuracy. Due to the size of adult cattle, only calves of the live weight up to 80-100 kg can be analysed. Maybe this is the reason why, according to our present knowledge, X-ray computer tomography technique cannot be used in the cattle for the time being. Despite of practical limitations, in spite of successful results attained in other animal species of smaller body size, the aim of this study was to pave the way for application of CT imaging technology in cattle.

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Received March 13, 2007; Accepted June 11, 2007

A number of experiments (Küchenmeister et al., 1990; Robinson et al., 1992; Bozó et al., 1995) indicate that the tissue composition of intact carcasses can be determined by dissection of various cuts. Rib samples are identified as the most likely candidates for predicting whole carcass composition. The application of the above mentioned method for the determination of the carcass composition by dissection of rib samples is time-consuming, but it seems to be an obvious possibility to replace full dissection of rib samples by CT analysis. Measurements can easily be made fast and tissue composition of samples can be calculated within 8-10 minutes.

Taking into consideration the factors mentioned above objectives of this study were to establish relationship between the tissue composition of 9-11th ribs (Exp. 1) and 11-13th ribs (Exp. 2) determined by CT and that of the intact carcass and to estimate slaughter value from data of CT imaging for selected cattle breeds and gender (Exp. 2). In addition to in Exp 3. was aimed to survey the validity of the EUROP-carcass classification system in relation to findings gained through CT analysis in beef cattle fed with different feeding regimes.

MATERIALS AND METHODS

Animals, feeding and housing

In a series of experiment cattle of different breeds, gender, and age (N = 207) were investigated within a period lasting from1995 until 2005 as follows:

In Exp. 1 Hungarian Holstein growing-finishing bulls (N = 31) were fed kept under same environmental conditions, fed maize silage and hay *ad libitum* with moderate concentrate supplementation and slaughtered at around 530 kg final weight.

In Exp. 2 Purebred Hungarian Holstein (HH), Hungarian Simmental (HS) and crossbred young bulls (N = 21) cows (N = 93) and heifers (N = 22) were used. Feeding regimen consisted of maize and hay based diets with moderate concentrate supplementation. The average final live weight of animals was 504 kg.

In Exp. 3 the Hungarian Grey (HG) (N = 20) and Hungarian Holstein (HH) (N = 20) growing-finishing bulls were fed either extensively on grass silage based diets and concentrates with linseed meal supplementation in the last month of fattening or intensively on concentrates based diets with maize silage supplementation according to a 2×2 experimental design. The animals were fed until 555 kg final weight on the average.

Slaughter and dissection

Animals were slaughtered under commercial conditions using Hungarian standard procedure in the Meat Processing Plant Pápa (Exp.1) and in Zalahús Abattoir, Zalaegerszeg (Exp. 2 and 3), (Hungary). Prior to and on the slaughter line slaughter weight, weight of four feet, the hot and cold carcass weight were recorded. After 24 h chilling the right half carcasses were dejointed and dissected: lean meat, fat and bone were separated. In Exp. 1 rib samples were taken from *M. longissimus dorsi* cut between the 9-11th ribs, whereas in Exp. 2 and 3 rib samples were taken between the 11-13th ribs and weights were taken. Rib samples were wrapped in foil and stored at 4°C degrees until X-ray computer tomography analysis.

X-ray computer tomography analysis

X-ray computer tomography analysis of rib samples were made at the Institute of Diagnostic Imaging and Radiation Oncology of the University of Kaposvár (Hungary). In Exp. 1 and 2 SIEMENS Somatom DRG type (SIEMENS, Germany) was used in Exp. 3 SIEMENS Somatom Plus S-40 (SIEMENS, Germany) equipment. Scans were made with zoom of 1:1.5, the slice thickness was 10 mm in all cases. The number of scans varied from 16 to 36 depending on the size of the rib samples analysed.

Evaluation of CT-scans

The CT scan taken was actually a 256×256 matrix in case of the DRG, and 512×512 matrix in case of the Somatom equipment, of which each element, the pixels characterized X-ray density value on the Hounsfield (HU) scale. The numbers are set on scale in which -1,000 represents the attenuation of air and 0 is the attenuation of water. Tissues were differentiated as follows: fat, (-20 ~ -200) muscle (20 ~ 200), bone 200<), connective tissue (-201 ~ -400) and water like materials (-19 ~ 19). Scans were evaluated by either CTPC or Medimage image processing software.

Determination of the tissue composition of rib samples

Subsequently, in Exp. 2 and 3 samples were transported to the Analytical Laboratory of the University, where the tissue composition (muscle, bone, fat, connective tissue) was determined by dissection.

Statistical analysis

For data processing softwares of SPSS 8.0 Statistical Program Package were used. For estimation of linear association among slaughter, dissection and CT data Person multi- and bivariate regression and correlation analysis was applied. In Exp. 2 statistical significance for the effects of breed and gender, in Exp. 3 that of breed and diet LSMs were calculated at $p<0.05$ level of probability. In multiple regression analysis to attain at maximum Coefficients of Determination (R^2) forward model of linear multiple

Table 1. Means and SD for traits recorded after dressing and tissue separation of bovine carcasses

Item	Exp. 1 (N = 31)	Exp. 2 (N = 136)	Exp. 3 (N = 40)
Live weight prior to slaughter (kg)	527±49.99	504.29±86.18	554.95±32.79
Cold carcass weight (kg)	306.95±32.21	252.46±50.77	255.60±39.18
Dressing percentage (%)	58.24±5.72	51.94±4.65	54.25±2.12
Four feet (kg)	10.01±0.87	9.64±1.21	9.95±1.16
Four feet (%)	3.27±0.21	3.84±0.57	2.08±0.18
Lean meat (kg)	202.42±29.08	168.73±31.33	175.04±26.62
Lean meat (%)	65.74±3.65	67.07±3.70	68.01±2.72
Fat (kg)	30.61±4.08	31.16±18.44	28.52±11.78
Fat (%)	9.97±1.16	11.74±4.57	7.21±3.08
Bone (kg)	56.20±4.08	52.44±8.19	51.42±6.34
Bone (%)	18.31±0.96	21.15±0.16	20.15±2.22
Weight of rib samples (kg)	3.93±0.46*	2.79±0.69	2.80±0.56

* 9-11th ribs.

Table 2. Bivariate coefficients of correlation (r) between tissues in whole carcasses and CT analysis of 9-11th ribs (Exp. 1, N = 31)

Dependent variables	CT		
	Muscle	Fat	Bone
Carcass			
Lean meat (kg)	0.73***		
Fat (kg)		0.86***	
Bone (kg)			0.54*

* p<0.05, ** p<0.01, *** p<0.001.

regression model was used in prediction of carcass tissue weight and percentage as dependent variables and all CT data and the cold half carcass weight as independent ones. For each model presented in tables contained regression coefficients, multiple R and standard error of the estimate.

RESULTS AND DISCUSSION

Mean and the standard deviation of slaughter and dressing data recorded in Exp. 1, 2 and 3 are shown in Table 1, respectively. The average slaughter weight was 529 kg, dressing percentage varied between 52-58%. The lean meat % was the highest and the fat content (%) was the lowest in Exp. 3. Highest value for weight of rib samples was recorded in Exp. 1 in between 9-11th ribs compare to 11-13 ribs in Exp. 2 and Exp. 3.

Experiment 1

First, Hankins and Howe (1946) proposed to analyse the 9-11th rib cut as an estimator of the physical composition of the whole animal carcass. Later, Alhassan et al. (1975) estimated empty body composition of cattle from the chemical composition of the 9-11th rib composition and warm carcass weight. De Campeneere et al. (1999) evaluated carcass chemical composition by using only the 8th rib instead of a three rib sample taken from 18 bulls.

In this preliminary experiment the tissue composition of carcass determined by dissection and that of the 9-11th rib samples measured by CT were compared. The muscle and bone percentage in 9-11th rib samples determined by CT and the corresponding tissue component of carcass were similar (67 vs. 65, 17 vs. 18%, respectively). These results are the same, as those Paulino et al. (2005) who noticed in case of the lean and bone tissue, but not fat in dressed Zebu carcasses and the estimated 9-11th rib cut. In this experiment the fat and tendons together were separated causing higher fat level by dissection (9.97%), than by CT determined fat volume and percentage (3.6%). These results correspond with the findings of Marcoux et al. (2005) and Mercier et al. (2006) by dual energy X-ray absorptiometry (DXA) measurements on pig and sheep carcasses, where also differences between the DXA fat and the corresponding dissection value were found. On the contrary, Mitchell et al. (1997) measured significantly higher amount of fat by DXA than by dissection of 9-11 rib sections. In spite of this, the CT fat and fat content of carcass highly correlated (Table 2). The closest correlation was between the fat tissue volume and the fat quantity of carcass (r = 0.86, p<0.001), whereas the coefficient of correlation of the lean meat is slightly lower (r = 0.73, p<0.001). Previously, Nour and Thonney (1994) obtained high correlations between the chemical composition of the soft tissue (water, protein and lipid) of the 9-11th rib and that of the carcass in Angus and Holstein steers (r = 0.89, 0.82 and 0.91, respectively).The bone tissue volume of rib samples determined by CT moderately correlated with the bone content of carcass and also the weight of four feet (r = 0.65, p<0.001, r = 0.54, p<0.01). Similar results were observed by Marcoux et al. (2005) using DXA for prediction of bone weight of pork carcasses (R^2<0.66). According to the results, it can be established that the lean and fat content of carcass closely correlated with the tissue composition of 9-11th rib samples determined only by CT.

Experiment 2

In this experiment the aim to gain figures on the accuracy of CT analysis when 11-13th rib cuts were used in

Table 3. Means and SD for the tissue composition of 11-13th ribs by dissection and CT (Exp. 2, N = 136)

Tissues	Dissection		CT-data		
	g	%	cm^2	cm^3	pixel sum
Muscle	1,557.05±367.52	56.02±4.99	75.36±13.91	1546.64±365.38	83,039.68±26,241.89
Bone	650.07±150.00	23.81±4.77	18.87±3.80	385.91±103.68	11,540.07±4,764.39
Fat	379.98±324.11	12.47±7.65	14.19±11.53	305.78±270.71	16,037.04±12,241.76
Connective tissue	207.89±75.31	7.70±2.68	5.20±1.14	114.88±80.49	18,835.03±1,548.75
Water like materials	-	-	7.04±3.27	147.63±78.46	7,563.83±4,093.39

Table 4. Coefficient of correlation (r) between tissues (1) in whole carcasses and rib samples, (2) in rib samples and CT analysis and (3) tissues in whole carcasses and CT analysis

Dependent variables	Muscle (g)	Fat (g)	Bone (g)
	------ Rib samples ------		
Carcass			
Lean meat (kg)	0.84***		
Fat (kg)		0.92***	
Bone (kg)			0.76***
	------ CT ------		
Rib samples			
Lean meat (kg)	0.74-0.92***		
Fat (kg)		0.85-0.94***	
Bone (kg)			0.78-0.86***
	------ CT ------		
Carcass			
Lean meat (kg)	0.64-0.80***		
Fat (kg)		0.80-0.91***	
Bone (kg)			0.65-0.76***

* $p<0.05$. ** $p<0.01$. *** $p<0.001$.

relation to the tissue composition of carcasses. The data were completed with the dissected composition of rib samples (Table 3). The 11-13th rib samples can be cut more easily from the carcass because the cut of carcass behind the 13th rib according to EU standard and these samples are less valuable than the 9-11th rib joint. Zembayashi (1999) reported that in addition to the morphometric measurements from the cross sectional measurements of three, the 6th, 9th or 12th thoracic vertebra, the latter is the best predictor for the meat and fat tissue weight in the carcass. Previously, Holló et al. (2001) analysed the influence of breed, slaughter weight and gender on chemical composition (fatty acid profile) of homogenised 11-13th rib samples.

As Jones et al. (2002) established, the majority of research has focused on the use of CT only being used relatively recently for *in vivo* scanning but previously used only for scanning carcasses. The coefficients of correlation r among tissues in carcasses and rib samples determined by dissection and by CT are presented in Table 4.

First, the tissue composition (muscle, fat, bone) of rib samples and the dissected carcass composition were compared. The coefficients of correlation were ranged from 0.76-0.92. These findings reveal that the composition of 11-13th rib joint is suitable for the estimation of the entire carcass composition. Correlations between all CT data and the weight of dissected tissue composition of 11-13th rib cuts were positive which low variation depending on pixelsum, volume or area measured by CT. Considering the muscle and bone, the highest coefficient of correlation was found in CT volume. On the other hand, fat pixelsum and fat weight in 11-13th rib samples showed the highest value (r = 0.94). It seems that CT analyses describe well the actual composition of rib samples. The closest three-way coefficients of correlation (r = 0.80-0.94) were found between the rib eye area, volume, pixel-sum of adipose tissue determined by CT of 11-13 ribs, and the percentage of fat in the entire carcasses. The coefficients of correlation between tissue composition of rib samples determined by CT and the tissue composition of dissected rib samples were also high in lean meat, fat and bone content.

The results reveal that the tissue composition of carcass can be estimated well by CT examination of rib samples. This is one opportunity of application of CT in the cattle production. Thus, for selection purposes equations developed can be used and may have added value to improve traits of economic importance in cattle. In Table 5 best predictors of tissue composition of carcass, the non adjusted coefficient of determination and the standard error of estimation are summarized.

For the estimation of *lean meat* weight the volume of muscle tissue (MV) determined by CT was the most suitable predictor in all cases. Coefficients of determination (0.56-0.76) is not high enough to predict when using muscle volume in rib cuts by CT. Inclusion of fat volume (FV) into

Table 5. Coefficients of determination (R^2) by regression analysis and standard errors of estimate (SE) in different breeds and genders in estimation of meat, fat and bone of carcass

Dependent and independent variables		Full database (N = 136)	Holstein (n = 84)	Simmental (n = 48)	Cows (n = 93)	Heifers (n = 22)	Young bulls (n = 21)
Meat (kg)							
MV	R^2	0.63	0.56	0.76	0.68	0.70	0.66
	SE	19.10	22.00	13.51	15.96	23.58	18.63
MV+FV	R^2	0.71	0.68	0.76	0.73	0.86	0.73
	SE	17.15	18.86	13.48	14.95	16.55	17.3
CCW+MV+FV	R^2	0.95	0.96	0.98	0.96	0.98	0.99
	SE	6.93	6.87	4.47	6.02	5.90	3.94
Fat (kg)							
FP	R^2	0.83	0.84	-	-	-	0.50
	SE	7.60	8.38	-	-	-	4.74
CCW+FP	R^2	0.87	0.90	-	-	-	0.77
	SE	6.68	6.46	-	-	-	3.32
FV	R^2	-	-	-	0.89	0.84	-
	SE	-	-	-	4.86	11.32	-
CCW+FV	R^2	-	-	-	0.90	0.95	-
	SE	-	-	-	4.59	6.31	-
FA	R^2	-	-	0.88	-	-	-
	SE	-	-	4.60	-	-	-
CCW+FA	R^2	-	-	0.90	-	-	-
	SE	-	-	4.36	-	-	-
Bone (kg)							
BP	R^2	0.60	0.60	-	0.51	0.53	-
	SE	5.40	5.55	-	5.31	5.77	-
CCW+BP	R^2	0.72	0.76	-	0.61	0.86	-
	SE	4.34	4.36	-	4.77	3.18	-
BV	R^2	-	-	0.55	-	-	0.80
	SE	-	-	4.36	-	-	3.83
CCW+BV	R^2	-	-	0.72	-	-	0.92
	SE	-	-	3.51	-	-	2.48

CCW = Cold carcass Weight, MV = Muscle volume, FV = Fat volume, BV = Bone volume.
MP = Muscle pixelsum, FP = Fat pixelsum, BP = Bone pixelsum, FA = Fat area.
$p<0.001$ in all cases.

the equation the accuracy of estimation improved in Holsteins, cows, heifers and growing-finishing bulls. Lean meat content in carcasses could be better predicted with higher more accuracy based on CT data in Simmental breed and heifers. When the cold carcass weight (CCW) was also included in the equation the accuracy exceeded even 95%.

The *fat content* of carcass based only on CT analysis can be estimated with the highest reliability except for bulls. The inclusion into the equation of further CT data such as muscle or bone did not improve the coefficients of determination. Fat weight can be estimated by fat volume (FV) rather than fat pixelsum (FP) in cows and heifers. At the same time the fat area (FA) by CT seemed to be the better predictor in Simmental breed (R^2). The variables on fat by CT analysis and the cold carcass weight (CCW) enhance prediction accuracy. *Bone weight* of carcasses can generally be estimated with the low accuracy. However, the accuracy improved when the cold carcass weight (CCW) was included in the model for coefficients of determination only in bulls (R^2 = 0.92).

Summing up the results, the estimation of tissue composition of carcasses based on exclusively CT data proved to have less reliable prediction value than the model which includes also the cold carcass weight (CCW). These results agree with the findings of Sehested (1984). Young et al. (1999); excellent predictions of carcass composition of sheep have been achieved by using the area of tissues in cross section scans and live weight in prediction equation. Similar results from Mitsuhashi et al. (1990) reported *in vivo* estimation of fat thickness and in Sekine et al. (1992) studies the prediction of body water content improved the precision of regression equation if the live weight was added into the model as independent variable. Estimation of tissue composition of carcasses using equations with only independent variables of CT-analysis proved to be a less reliable prediction for lean meat and bone content in carcasses (R^2 = 0.51-0.86) than for fat content (R^2 = 0.83-0.89) in all animals but growing finishing bulls. On the contrary, Monziols et al. (2006) findings resulted in a good prediction of muscle content (R^2 = 0.97-0.99) with slightly

Table 6. Mean and SD of actual meat and fat content in half carcasses classified by EUROP* classification scheme

Treatments		Distribution of carcasses across muscularity categories							
Diet[1]	Breed[2]	R n	Muscle (%)	O n	Muscle (%)	P n	Muscle (%)	R+O+P N	Muscle (%)
e	HG	4	72.06±2.21	5	70.26±1.42	1	70.08±0.00	10	70.96±1.85
i	HG	-	-	3	68.09±2.24	7	67.17±3.13	10	67.45±2.80
e	HH	3	68.49±1.49	7	67.58±1.39	-	-	10	67.84±1.41
i	HH	-	-	4	64.70±1.41	6	66.54±1.73	10	65.80±1.79
Overall		7	70.53±2.61^{b}	19	67.76±2.41^{a}	14	67.11±2.55^{a}	40	68.01±2.72

Diet	Breed	Distribution carcasses across fatness categories							
		2 n	Fat (%)	3 n	Fat (%)			2+3 N	Fat (%)
e	HG	8	4.65±0.92	2	5.50±1.60	-	-	10	4.82±1.04
i	HG	9	10.42±1.77	1	12.18±0.00	-	-	10	10.60±1.76
e	HH	1	3.67±0.00	9	4.29±0.90	-	-	10	4.23±0.87
i	HH	3	9.72±0.81	7	8.94±2.04	-	*	10	9.18±1.75
Overall		21	7.80±3.17	19	6.55±2.92	-	-	40	7.21±3.08

[a, b] The same superscript means no different significant deviations according to LSD-test ($p>0.05$).

[1] Diets: e = extensive fattening; i = intensive fattening. [2] Breeds: HG = Hungarian Grey; HH = Holstein-Friesian.

* Council regulation 1208/81. Commission regulation 2930/81, cit. Lebert. 2000.

Conformation categories for muscularity E. U, R. O. P. Fatness categories: 1, 2. 3, 4, 5.

less accuracy for total fat (R^2 = 0.95-0.99) in pig carcasses using magnetic resonance imaging (MRI) in comparison with CT. Based on our data (N = 136) can be concluded that using of non-invasive CT-analysis of 11-13th rib samples for estimation of tissue composition of entire carcass might provide good accuracy and could replace the traditional, complicated, time consuming and expensive complete dissection technique.

Experiment 3

In Exp 3 EUROP grades and the tissue composition of dissected carcasses and that of the rib samples determined by CT analysis were compared in Hungarian Grey (HG) and Hungarian Holstein (HH) growing-finishing bulls fed either extensively (e) on grass silage based diets and intensively (i) concentrates with linseed meal supplementation in the last month of fattening. The results of EUROP-classification and the actual tissue composition of carcasses are presented in Table 6. It is a well known fact that EUROP-classification is based on the subjective evaluation of the conformation (muscularity, fatness) of carcasses (Council Regulation 1208/81, Commission Regulation 2930/81, cit. Lebert, 2000).

Thus, the lean meat and fat content of carcasses were compared to muscularity and fatness classes respectively. In lean meat content of carcasses more than 5% difference was found within muscularity class P, whilst in class O the lean meat content in both breed equalled only by 3% lower in intensively fed groups. Neither breed nor diet effects would have been expected on lean meat content of respective classes. Within nutrition groups-except for the intensively fed Holsteins (HH)-means reveal higher lean meat and fat, but the differences between the neighbouring classes are not significant. It was inconsistent if only the results of the two breed had been analysed independently from the effect of the diet. Among muscularity classes no significant differences were present.

In Norway Johansen et al. (2006) examined the accuracy of the EUROP classification system in lambs. It was established that the EUROP system predicted lean meat percentage poorly and over-classify conformation class whereas under-classify fat class. In the present study significant differences were established in fat classes of Hungarian Grey (HG) animals. 17 were assigned into the 2nd class and 3 animals to 3rd class, opposite to Holstein, where 16 animals were ranked to 3rd class and 4 to 2nd class, saying that the Holsteins were fatter. Hungarian Grey (HG) carcasses contained higher amount of fat based on the dressing data between the groups with different feeding regimen. In further experiments in Hungary Bozó et al. (1999), Sárdi et al. (2001) indicated that the EUROP cattle classification system would not reflect the actual carcass composition. Thus, the authors suggested, as it is the case in pigs, to develop objectively measurable methods (Berg et al., 2002). Lee and Kim (2004) recommended that the Real Time Ultrasonic Measurements would provide an alternative to estimate carcass value measurements for genetic evaluation in Korean beef cattle. Lee et al. (2006) established the selection of Hanwoo (Korean Native cattle) cows based on ultrasonic scans of live animals may be helpful in reducing the generation interval and cost of selection procedure. Further application area of ultrasound scanner monitoring system in a dairy herd reported by Takagi et al. (2005). Other authors (Kong et al., 2006) suggested the joint application of the Real Time Ultrasound and Marker Assisted Selection for improvement of a cow

Table 7. Bivariate coefficients of correlation (r) between tissue composition of half carcasses, rib samples and CT-estimations

	CT-estimations		
	Muscle	Fat	Bone
Half carcass dissected			
Muscle (kg)	0.88***		
Fat (kg)		0.93***	
Bone (kg)			0.81***
Rib sample dissected			
Meat (g)	0.97***		
Fat (g)		0.82***	
Bone (g)			0.96***

*** p<0.001.

population of Hanwoo.

The tissue composition of whole carcasses from samples taken from carcasses has been estimated in many studies. The lean meat yield in carcass can be estimated by determination of eye muscle area (Szücs, 2002). For the estimation of the fat content of the carcass the kidney fat proportion can be used (Sárdi et al., 2002), while the bone content of carcass can be estimated by the four feet weight. However, as Bozó et al. (1999) stated the coefficients of correlation vary between (r = 0.40-0.75). Thus, the reliability of these methods is not adequate.

On the contrary to the EUROP muscularity grades the lean meat content of rib samples of the same slaughter cattle analysed by CT showed a close correlation (r = 0.97) with the actual lean meat content of carcasses (Table 7). The same tendency can be seen in the amount of fat and bone in the carcass. As both the dissection and CT-data showed animals in the extensively fed groups deposited more lean meat and bone and less fat. These results are in agreement with those of Brown et al. (2006). They investigated that the mean lean and bone were greater for pasture fed steers, while the fat was lower than that of feedlot animals. It was established, that as compared to EUROP classification carcass quality grading system the CT-analysis is of higher predictive value in estimation of the actual carcass composition in cattle.

IMPLICATIONS

Certainly, the CT analysis can hardly applied in commercial breeding practice due to the relatively high costs associated with CT and technological problems. However, it seems to be an obvious opportunity to use CT technology for selection to develop genetic progress in cattle production. Application areas of CT analysis of rib cuts can be on the one hand in progeny testing of different breeds for upgrading of meat yield, on the other hand the carcass value qualification can be achieved more objectively with the incorporation of CT data into the EUROP carcass grading system in the future.

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