EVALUATION OF CARCASS COMPOSITION OF CATTLE GENOTYPES BY USE OF COMPUTED TOMOGRAPHY (CT) DATA OF RIB JOINTS

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Abstract – The aim of study was to evaluate the carcass composition of different genotypes by means of Computed Tomography (CT)-data of rib joints and to compare them with data obtained by manual dissection. The slaughter weight was 583±48 kg. The right half carcasses were dissected manually. For CT-analysis rib joints were taken between the 11-13th ribs. According to CT results, the muscle tissue proportion of Limousine bulls was the highest (79%), followed by Hungarian Simmental, Charolais, Hungarian Grey, Charolais x Hungarian Grey F_1, Holstein, Charolais x Angus, Hereford, Shaver, Angus bulls and Charolais x Angus heifers. The opposite rank order could be observed regarding fat tissue, except for Holstein. The proportion of bone in the rib joint was the highest with the Holstein (15%), and the lowest with the Hereford and Limousine genotypes (10%). The CT-data of rib joints closely correlates with dissected carcass composition (R^2=0.7-0.9). The area of *longissimus* muscle on CT-scans was greater (P<0.0001) for the Limousine than for other genotypes. The intramuscular fat level of *longissimus* muscle on CT-scans in Charolais x Angus heifers and Angus bulls were significantly higher. In conclusion, the carcass composition of various genotypes can be distinguished by use of CT-examination of rib joints.

Key Words – cattle, cross sectional imaging technique, slaughter value.

I. INTRODUCTION

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. Digital cross-section imaging techniques such as X-ray Computer Tomography (CT) and Magnetic Resonance Imaging (MRI) have been applied in Hungary with success in pigs, sheep, poultry and rabbit to predict body composition with high level of accuracy [1]. In spite of size limits, considerable effort has been made for the application of this method in cattle. A number of experiments indicate [2, 3] 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. Previous findings [4] established that the carcass tissue composition can be estimated more accurately by use of CT data from the 11-13th rib joint than that of the 9-11th rib joint. These studies also showed that CT can accurately predict the fat and lean percentage in carcasses of different types of cows. The accuracy of estimation can be improved if the equation of cold carcass weight is included. The objective of this study was to compare the tissue composition of the 11-13th rib joint by using CT-analysis *vs*. manual dissection. For this purpose, 10 different genotypes were included in this study.

II. MATERIALS AND METHODS

Altogether, one hundred fifty-one animals, Angus, Charolais, Charolais x Angus, Charolais x Hungarian Grey, Hereford, Holstein, Hungarian Grey, Hungarian Simmental, Shaver, Limousine bulls and Charolais x Angus heifers were included in the experiment. The animals were loose-housed in pens with straw bedding at the Experimental farm of University of Kaposvár. Each genotype (sex) group was fed *ad libitum* maize silage, hay and concentrate. Charolais x Angus bulls and heifers were slaughtered at a similar age. The animals were slaughtered at a commercial abattoir according to Hungarian Standards. At slaughter, animals

were stunned with a captive bolt gun and killed by exsanguination. Carcasses were assessed by trained operators for conformation (an 18 point scale: scale 1 (poorest) to 18 (best)) and fatness (a 15 point scale: scale 1 (leanest) to 15 (fattest)) according to EU beef carcass classification scheme with the use of subclasses. After 24 hrs of chilling the right half carcasses were dissected into lean meat, fat, bone, and tendon. Before dressing, the 11-13th rib portion was removed from the carcass and weighed. Rib joints were wrapped in foil and stored at 4^{o}C degrees until X-ray computer tomography analysis. X-ray Computer Tomography analysis of rib joints were made by SIEMENS EMOTION 6 at the Institute of Diagnostic Imaging and Radiation Oncology of the University of Kaposvár (Hungary). Depending on the size of rib joint, 11-18 overlapping cross sectional scans (slice thickness: 8 mm) were taken. On the CT-scan the pixels characterized X-ray density value on the Hounsfield (HU) scale. Scans were evaluated by Medical Image Processing (MIP) software. Tissues were differentiated according to the threshold values described previously by Holló *et al*. [4] as follows: fat, muscle, bone, connective tissue. From these data the proportion of tissues were calculated between the 11-13th ribs (3-rib cut); moreover the average area of *longissimus* muscle in whole rib joints was determined on CT scans. The intramuscular fat level of *longissimus* muscle in the whole rib joints was evaluated based on standard CT thresholds for fat on the Hounsfield scale. Statistical analysis was made by using the SPSS 11.5 program package. Data are expressed in tables as mean values and standard errors of mean ($MEAN_{SEM}$). Differences between group means were tested by Tukey's method (level of significance set at 5 %). Coefficients of correlation (Spearman's rank) and coefficients of determination (R) were calculated among manual dissection and CT data.

III. RESULTS AND DISCUSSION

The average slaughter weight and the age of animals were 582.93+47.71 kg and 589.31+108.31 days, respectively. According to EU classification results the Limousine (9.50) and Hereford bulls (10) had higher conformation score than the other genotypes. As a dairy type, Holstein bulls received the lowest conformation score (5). The lower fatness scores corresponded to Limousine (5) and Hungarian Simmental (6) bulls, whereas Angus bulls and Charolais x Angus heifers showed the highest scores (higher than 8). The value of carcass is determined by tissue composition. Among different genotypes there were significant differences for all tissues. As for the percentage of lean meat (Table 1), values above 70% were recorded for Limousine, Charolais, Hungarian Simmental and Hungarian Grey crossbred and purebred bulls; Angus purebred and crossbred animals ranged from 57% (Charolais x Angus heifers) to 67 % (Charolais x Angus bulls). Shaver and Holstein bulls had 69 % muscle percent in carcass.

Table 1. Lean and muscle content ($mean_{SEM}$) of different genotypes

Genotype	Lean in carcass, %	Muscle in ribs joint, %
Angus	$66.69_{0.65}^{d}$	$61.34_{1.52}^{e}$
Charolais	$72.57_{0.95}^{cb}$	$69.72_{1.21}^{b.c}$
Hereford	$67.63_{0.40}^{ed}$	$64.24_{0.50}^{c.e}$
Holstein	$68.54_{0.54}^{d}$	$67.45_{0.52}^{c.d}$
Limousine	$78.95_{0.45}^{a}$	$78.97_{0.55}^{a}$
Hungarian Grey	$71.50_{0.64}^{eb}$	$68.10_{0.96}^{b.c.d}$
Hungarian Simmental	$72.81_{0.48}^{b}$	$71.33_{0.58}^{b}$
Shaver	$68.72_{0.96}^{dc}$	$63.91_{2.24}^{d}$
Charolais x Hungarian Grey	$71.14_{0.44}^{be}$	$67.48_{0.73}^{b.d}$
Charolais x Angus	$64.55_{0.34}^{de}$	$64.87_{0.90}^{c.d.e}$
Charolais x Angus heifers	$57.39_{0.63}^{f}$	$52.76_{0.87}^{f}$

$^{a-f}$ means with different letters indicate significant differences between genotypes ($P<0.05$)

The weight of the rib joints of Limousine bulls was significantly higher (6 kg) than that of the other genotypes. The average weight of the rib joints in Holstein and Hungarian Grey purebred and crossbred animals was less than 4 kg. Muscle proportion values above 70% in rib joints were measured for Limousine and Hungarian Simmental; the rest of genotypes presented a muscle proportion ranging from 57 to 69%. The meat percentage proves the superiority of Limousine, Hungarian Simmental and Charolais; on the other hand the lowest value can be observed in Angus crossbred (heifers) and purebred (bulls) animals.

If we compare the muscle content of carcass and that of rib joints across genotypes, the rankings were almost the same. The Spearman's rank correlation coefficient was r_S=0.85 (P<0.001). Based on only one CT-datum (muscle % in the rib joint) we can accurately estimate lean content in carcass (R^2=0.82, P<0.001). At the same time, EU carcass conformation score showed no relationship with CT muscle percent and lean content in the carcass. Recently, Lambe *et al.* [5] used an ultrasound method for the estimation of carcass composition in beef cattle. Predictions of muscle proportion and conformation classes had poor accuracy.

The fat percentage of carcass (Table 2) was the highest in Charolais x Angus heifers (20.5 %). Hereford, Charolais x Angus, Angus and Shaver surpassed a percentage of 10%, whereas the other genotypes ranged from 2 (Limousine) to 8 % (Hungarian Grey purebred and crossbred animals).

Table 2. Fat content (mean$_{SEM}$) of different genotypes

Genotype	Fat in carcass. %	Fat in ribs joint. %
Angus	$12.41_{0.45}^{b}$	$17.83_{0.93}^{b}$
Charolais	$6.03_{0.65}^{d}$	$9.58_{0.67}^{d}$
Hereford	$13.03_{0.40}^{b}$	$15.60_{0.50}^{b}$
Holstein	$6.57_{0.36}^{d}$	$9.48_{0.35}^{d}$
Limousine	$1.71_{0.42}^{e}$	$4.22_{0.48}^{e}$
Hungarian Grey	$7.54_{0.48}^{c.d}$	$11.15_{0.76}^{c.d}$
Hungarian Simmental	$5.78_{0.38}^{d}$	$8.56_{0.46}^{d}$
Shaver	$10.60_{0.64}^{b.c}$	$15.27_{1.94}^{b.c}$
Charolais x Hungarian Grey	$7.79_{0.40}^{c.d}$	$11.61_{0.64}^{c.d}$
Charolais x Angus	$13.24_{0.48}^{b}$	$14.45_{0.91}^{b}$
Charolais x Angus heifers	$20.48_{0.49}^{a}$	$24.84_{0.83}^{a}$

[a-e] means with different letters indicate significant differences between genotypes (P<0.05)

The fat content of rib joints measured with CT was higher than that of manually dissected carcasses, although the associaton of CT- and dissection data was very close (R^2=0.9, P<0.001). The ranking of genotypes is similar in both cases (r_S=0.93). EU fatness score moderately correlated with carcass fat (r=0.61) and CT-fat (r=0.66). Similar to CT, ultrasound measurements tend to over predict carcass fat in leaner cattle and under-predict muscle area [6].

Concerning bone percentage, only the Holstein group (carcass: 22% rib joint: 15%) differed from the values of other genotypes (P<0.001). Limousine had less bone (P<0.05) in the carcass than Hungarian Simmental, Shaver and Charolais purebed and crossbred animals. Regarding bone percentage in the rib joint, 10 to 13% was the average for Hereford, Limousine and Hungarian Simmental. The association between bone content in the carcass and bone percent in the rib joint was lower than for lean and fat (R^2=0.80, r_S=0.77; P<0.001).

Herefords had the lowest tendon percentage values in the carcass, while the Charolais x Angus bulls had the highest. Higher connective tissue percentage was measured in the rib joints by CT for Shaver bulls, and the difference between CT connective tissue and dissected tendon proved to be significant for all genotypes except for Hungarian Grey and Angus purebred and crossbred animals. There was no significant correlation between tendon and connective tissue proportion.

Average area of *longissimus* muscle in the rib joint was 74 cm^2; Limousine excelled with an area of 118 cm^2. Charolais (89 cm^2) and Hungarian Simmental (80 cm^2) animals had significantly greater *longissimus* muscle area in rib joints than other genotypes. Holsteins showed the lowest muscle area, but differences from other genotypes (Hereford, Shaver, Hungarian Simmental, Angus/Hungarian Grey purebred and crossbred animals) were not significant.

The intramuscular fat percentage of *longissimus* muscle measured with CT exceeded 2% for Charolais x Angus heifers and Angus bulls. Marbling values of Charolais x Hungarian Grey, Shaver, Hungarian Grey and Hereford are intermediate, ranging from 1.22 to 1.89%. Holstein, Charolais, Hungarian Simmental and Limousine animals had intramuscular fat levels less than 1%.

Table 3. Area and intramuscular fat content ($mean_{SEM}$) of longissimus muscle (LD) on CT scans

Genotype	Area of LD. cm^2	Fat in LD. %
Angus	$68.88_{3.44}^{d}$	$2.26_{0.38}^{a,b}$
Charolais	$88.53_{4.71}^{b}$	$0.94_{0.15}^{c,d}$
Hereford	$72.90_{1.00}^{c,d}$	$1.89_{0.80}^{b,c}$
Holstein	$64.37_{1.11}^{d}$	$0.98_{0.08}^{c,d}$
Limousine	$117.83_{.14}^{a}$	$0.52_{0.08}^{d}$
Hungarian Grey	$74.92_{1.97}^{c,d}$	$1.50_{0.21}^{b,c,d}$
Hungarian Simmental	$80.34_{1.53}^{b,c}$	$0.88_{0.10}^{c,d}$
Shaver	$63.49_{2.18}^{d}$	$1.34_{0.14}^{b,c,d}$
Charolais x Hungarian Grey	$73.22_{3.07}^{c,d}$	$1.22_{0.18}^{b,c,d}$
Charolais xAngus	$76.35_{.97}^{c,d}$	$0.95_{0.10}^{c,d}$
Charolais x Angus heifers	$65.45_{2.16}^{d}$	$3.04_{0.35}^{a}$

[a-d] means with different letters indicate significant differences between genotypes ($P<0.05$)

IV. CONCLUSION

There were significant differences among genotypes regarding carcass composition. The fat and muscle proportion of rib joints determined by using CT-examination showed almost the same tendency as that of carcass composition of genotypes. The carcass lean content is generally higher than CT-measured muscle content of rib joints. The opposite tendency can be observed for fat proportion. Fat and muscle content of carcass based on corresponded CT-data of rib joints could be predicted with similar accuracy, while bone proportions with less accuracy. Limousine presented more muscle and less fat in the carcass, whereas Charolais x Angus bulls and heifers showed opposite characteristics. Regarding bone proportion, Holstein had the highest values. The *longissimus* muscle area showed the superiority of Limousine, Charolais and Hungarian Simmental breeds. The opposite tendency could be observed for the intramuscular fat level of *longissimus* muscle; Limousine, Charolais and Hungarian Simmental animals produced significantly lower values than Angus bulls and Charolais x Angus heifers.

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