Theses of the PhD dissertation

APPLICATION OF ULTRASOUND MEASUREMENT TECHNIQUE TO EVALUATE THE MEAT PRODUCING ABILITY AND CARCASS VALUE OF BEEF CATTLE

Author:

Sándor Harangi

Ph.D. candidate

Supervisor:

Dr. Béla Béri

associate professor

UNIVERSITY OF DEBRECEN

Doctoral School of Animal Husbandry

Debrecen

2013.

1. BACKGROUND AND OBJECTIVES OF THE DOCTORAL THESIS

In countries with long tradition in the field of beef cattle breeding (USA, Canada, Australia, New-Zealand) many breeding organization built in the measurement based on ultrasound images to the breeding value estimation. Studies proved that the use of data collected by real-time ultrasound (RTU) technology in genetic improvement programs the meat producing ability of beef cattle can be improved, the slaughter value of the beef cattle can be estimated in vivo and the time of reaching the optimal slaughter weight can be forecasted. These advantages can contribute to the significant improvement of the profitability of beef cattle production, not only in abroad, but also in our home country. These advantages could also provide the possibility to the subsistence and continuous development of this sector.

The possibilities provided by ultrasound technology drove my attention to learn this topic. In Hungary several publications were published concerning ultrasound measurements, but so far the method has not been tested in practice. Before the introduction of ultrasound technology into the breeding value estimation several examinations shall be performed. Learning the growing characteristics of the beef cattle genotypes most represented in our country (measure of muscle building, time of tallow production, etc.) is of great importance. For learning the connections between carcass value and the characteristics measured by ultrasound it is necessary to perform so called test cuts and the evaluation of slaughtering, deboning results. In certain countries there are already existing equations for the estimation of body composition based on ultrasound measurements, but the application of these methods in our country is difficult, because of reasons such as different breed, sex, age, feeding, housing technology, climate and other factors. The creation of estimating equations performed in domestic circumstances and based on test cuts is explained by the adaptation to domestic factors.

My study focused on the examination of the application possibilities of the real-time ultrasound technology in domestic beef cattle breeding, concerning Hungarian Simmental beef cattle and Charolais breeds. Closely related to the mentioned subject – partly providing data to the estimation of slaughter value by in vivo ultrasound data – I searched the answer for what kinds of changes can be observed in the meat producing ability of Charolais beef bulls together with the increase of slaughter weight.

<u>Major objectives of the thesis can be summarized as follows:</u>

1. Repeatability of the interpretation of ultrasound images:

- determination of the repeatability of properties that can be measured by real-time ultrasound technology (ribeye area, backfat thickness, P8 and rump fat thickness) in domestic circumstances;
- examination of the repeatability of other properties that can be measured by so called alternative ultrasound (m. gluteus medius depth, body wall thickness) The reason of the examination of the above mentioned areas is that these can be easily measured on live animals and can be easily involved in equations prepared for the estimation of lean meat ratio as alternative supplementary properties.

2. Reliability and accuracy of ultrasound measurements:

- examination of the reliability of the ultrasound measurement on the ribeye area between the 11/12th and 12/13th ribs;
- analysis of the relation between the ultrasound properties measured by ultrasound on live animals and the results of carcass classification.

3. Examination of young seedstock bulls using ultrasound technology:

- examination of the growing parameters of Hungarian Simmental beef cattle and Charolais young seedstock bulls by ultrasound measurements;
- providing data on characteristics of alternative ultrasound measurements and measurements that are widely used in the international praxis;
- examination on the relationship between ultrasound measurements that can be measured at the start and finish of on farm performance test, the age and live weight values;
- estimation of the ultrasound data expected at the end of performance test from the data measured at setting for performing the pre-selection of the individual animals.

4. Comparative analysis of the meat producing ability of Charolais bulls fattened to different weights:

- how the fattening weight endpoint influences the growth rate of Charolais beef bulls;
- how the slaughter weight affects the slaughter results of the animals;
- how the slaughter weight influences deboning results;

5. Examination of the relationship between the ultrasound parameters and slaughter value in Charolais beef bulls:

- examination of the relationship between the characteristics defined by ultrasound before slaughtering and on the carcass;
- with the help of characteristics measured by ultrasound creating equations for the estimation of slaughter value;
- involving alternative ultrasound measurement to the equations created for the estimation of weight of carcass, dressing percentage, cut out tallow, lean meat and quantity and rate of 1st class meat in order to improve estimation.

By seeking answers for the above questions I strived to compare my findings with the results mentioned in domestic and international literature. In my study I would like to introduce certain application possibilities of the ultrasound technology, for the benefit of Hungarian beef cattle sector.

2. MATERIALS AND METHODS

2.1. Assessment of repeatability by interpreting ultrasound images

2.1. Repeatability of the interpretation of ultrasound images

The repeatability of the interpretation of ultrasound images was examined in case of two ultrasound technicians on the ultrasound image of 141 young Charolais bulls. The bulls' average age was 356.7 days (CV% = 17.75%) and their live weight 462.1 kg (CV% = 21.74%) at the time of examination. Evaluation of the images was performed by myself (B) and by another experienced technician (A) in two repetitions (A: 1st evaluation, B: 2nd evaluation). In this study the repeatability of the images was analysed, performed on characteristics of ROT, HFAG, P8, a FTF, GMV and TFV.

The following examinations were performed:

- Basic statistical indicators were calculated according to data from the repeated evaluation of the images.
- The repeatability was evaluated using correlation analysis by the calculation of root mean square errors (RMSE) and error standard deviation (ESD).
- The influence of the technician and the evaluation for the examined characteristics was examined by multivariate analysis of variance (MANOVA, Type III), using SPSS 17.0 software package.

The ultrasound measurements as the basis of my study were performed by a Falco 100 type real-time ultrasound equipment (Esaote Pie Medical). For this equipment an ASP type, 18 cm, 3,5 MHz frequency linear transducer was used. The images of adequate quality were recorded on a laptop. For the recording and interpreting of the images a special software was used (Ultrasound Engineer 3.0).
During my study ultrasound images were made on different muscle groups and subcutaneous fat depots on the following way:

- Measurement of the ribeye area (hereinafter ROT) between the 12/13th ribs, parallel to the ribs. In some chapters of this study the determination of ROT size was not only performed between 12/13th ribs (signed as $ROT_{12/13}$), but also between 11/12th ribs (signed as $ROT_{11/12}$), as a supplementary, alternative measurement point (ROBINSON et al., 1992; TŐZSÉR et al., 2005).

- **Backfat thickness** (hereinafter HFAG) was determined on the sectional image made on the ROT, calculated at the 3/4 of the medial end of rib (part close to the vertebral column) (PERKINS et al., 1996).
- To determine **P8** (the subcutaneous fat thickness at the rump according to the Australian protocol; hereinafter P8) the measurement point is at the intersection point given by a perpendicular from the level of 3rd sacral vertebra and a line from the ischium parallel to the spinal column (REVERTER et al., 2000; TŐZSÉR et al., 2005c).
- To determine **rump fat** (the subcutaneous fat thickness at the rump according to the American protocol; hereinafter FTF) the measurement point is at the junction of gluteus medius and biceps femoris, at the level of point of hip, approx. 10 cm distance from this point (ROBINSON et al., 1992; PERKINS et al., 1996).
- The determination of **m. gluteus medius depth** (hereinafter GMV) is done by the image for the evaluation of fat thickness at the rump, performed by American method. The starting point of GMV measurement on the image is at the junction of m. gluteus medius and m. biceps femoris (under the subcutaneous fat) while the end point is at the intersection given by the perpendicular from the body surface and the arch of os coxae (GREINER et al., 2003; BERGEN et al., 2005).
- The measurement of **body wall thickness** (hereinafter TFV) is done between 12/13th ribs, approx. 4 cm ventrally from m. longissimus dorsi, perpendicular to body surface. During the evaluation of the image both the subcutaneous fat thickness and body wall thickness are measured, but measurement of skin thickness is excluded (GREINER et al., 2003; BERGEN et al., 2005).

2.2. Reliability and accuracy of ultrasound measurements:

I performed the studies on Charolais fattening beef bulls (n = 21). The ultrasound scanning was performed on the day before slaughtering. Images were performed on ribeye area both between the 11/12th and 12/13th ribs ($UROT_{11/12}$; $UROT_{12/13}$), then these were analysed in two repetitions. During the quartering of the carcasses the outline of m. longissimus dorsi was assessed by tracing the muscle boundaries onto a piece of clear plastic sheet. Then the values of ribeye area that can be measured on the carcass was determined by planimeter at both anatomical points ($CROT_{11/12}$; $CROT_{12/13}$).

The followings were examined:

- Evaluation of deviations measured by ultrasound of ribeye area (UROT) on the carcass (CROT) and the live animal was examined using one factor t-test.
- For the evaluation of reliability of the process a calculation of correlation (Pearson's correlation) was performed at all repetitions between CROT and UROT values.
- The level of deviation between UROT and CROT values was examined depending on CROT values and whether CROT values influence the error of ultrasound measurement.

2.3. Examination of the growth of young seedstock bulls using ultrasound technology

During my study the growth of the individuals of two dominant beef cattle types were evaluated in Hungary using RTU technology. At Petőfi Mezőgazdasági Kft, Derecske Hungarian Simmental beef cattle, at Abaúji Charolais Kft, Léh Charolais young seedstock bulls were the subject of my study. The Hungarian Simmental young seedstock bulls (n = 53) were represented in 8, while Charolais bulls (n = 96) in 5 performance tests. Hungarian Simmental bulls are generated from 14 breeding bulls, while Charolais bulls from 25 breeding bulls. Housing and feeding circumstances in both farms complied with the relevant provisions concerning the Cattle Performance Testing Code. From the day entered into performance test until slaughtering the weighing of the animals was performed on a monthly basis, using certified animal scale. During performance test, at the events of monthly scaling the values of ROT, HFAG, P8, FTF, GMV and TFV were determined by ultrasound technology.

The studies covered the following areas at both breeds:

- The ultrasound parameters of young seedstock bulls determined at the initiation and at the end of performance test were presented by simple statistical indicators.
- With the help of calculation of correlation the relations between the ultrasound results at the beginning and at the end of performance test were revealed. For the definition of correlations I used one factor linear regression.

- For the improvement of estimation accuracy the estimation of ultrasound measurements expected at the end of performance test was made by stepwise multiple linear regression. In this case an estimating equation was created using more ultrasound measurements measured at the start of performance test to forecast the values of each ultrasound measurements.
- For the correction to unified age, live weight, ribeye area, etc. of ultrasound data regression equations were created using all data collected during the duration of performance test. During the calculations several function types were examined (linear, logarithmic, quadratic, cubic, power, exponential). The curve estimation was done by SPSS 17.0 statistical program.

2.4. Comparative analysis of the meat producing ability of Charolais bulls fattened to different weight endpoints

During my study the optimal slaughter weight of Charolais beef cattle were determined based on the slaughtering and carcass dissection of beef bulls slaughtered at different weights. The exploration of differences in the weight gain, dressing percentage, EUROP qualification, lean meat production and quantity of fat was part of the analysis, concurrently with the increase in the fattening weight endpoint. The data of examined animals provided the information for the evaluation of reliability of ultrasound technology and for the estimation of slaughter value using ultrasound parameters. By the determination of the chemical characteristics of beef I searched the answer for what differences can be found in the meat quality of the same breed but different weight Charolais beef bulls.

During the fattening period the animals were kept in a stall with a yard, including a covered deep litter resting area. Fattening was performed in ordinary semi intensive farm housing and feeding technology. During the planning of examinations 500, 600 and 700 kg fattening weight endpoint was appointed (hereinafter light, medium and heavy slaughter weight).

The slaughtering and carcass dissection of the 21 beef bulls entered into the study (7-7 animals per weight category) was performed at the slaughterhouse of KO-BOR Hús Kft. in Jászszentandrás. Determination of the weight endpoint was performed on farm right before the transport to the slaughterhouse, determination of the slaughtering weight was made in the slaughterhouse.

The following parameters were determined:

Slaughter results:

- Dressing percentage I.: quotient (%) of warm carcass weight and slaughter weight;
- dressing percentage II.: quotient (%) of warm carcass weight and slaughter weight without gastro-enteric contents;
- muscle assessment and fat covering by EUROP grid: for the quantification of EUROP system a grading system from 1 to 15 has been created (Conformation: „P^{-}” = 1 score, „E^{+}” = 15 scores; Fatness: „1^{-}” = 1 score, „5^{+}” = 15 scores);
- net weight gain (g/day);
- weight of leg ends, skin, head, tongue, total fat, kidney fat, internal organs (heart, lien, liver, lung and kidney) and their ratio compared to slaughtering weight (kg and %).

Deboning results:

- Cold weight of the carcasses (kg);
- quantity of bones, lean meat, fat and tendons and their ratio compared to the weight of cold carcasses (kg and %);
- quantity of meat of class I., II, and III. and their ratio compared to the weight of cold carcasses (kg and %);
- weight of 1st class meat parts and their ratio compared to the weight of cold carcasses (kg and %).

Data were prepared by Microsoft Excel (2003) program and were evaluated by SPSS 17.0 software. During the evaluation of slaughtering, deboning results, beside basic statistical data one factor variance analysis was performed with weight category factor. During the analysis the calculation has been made on $P<0.01$; $P<0.05$ and $P<0.1$ probability levels. The difference between weight categories was demonstrated by Tukey-test.

2.5. Examination of the relationship between the ultrasound parameters and slaughter value in Charolais beef bulls

There were 21 Charolais beef bulls involved in the study, their examination by ultrasound was performed live, before the transporting to the slaughterhouse. Beside the ultrasound parameters widely used in the practice the thickness of m. gluteus medius and body wall thickness were also determined. These characteristics, as alternative measurement methods can supplement the data already applied for the estimation of body composition by ultrasound, therefore providing more exact estimation.

The determination of relationship between the estimated ultrasound parameters on live animals and different slaughtering and deboning parameters was done by calculation of correlation. The estimation of slaughter value parameters (dependent variables) based on data measured by ultrasound was performed with stepwise linear regression method, SPSS 17.0. The independent variables had to be significant ($P<0.10$) in order to remain in the regression model (WILLIAMS et al., 1997).

The following properties measured by ultrasound – as independent variables – were considered in the estimation equations: age, slaughter weight, $ROT_{11/12}$, $ROT_{12/13}$, $HFAG_{11/12}$, $HFAG_{12/13}$, P8, FTF, GMV, TFV.

In the examination the following parameters related to the slaughter value – as dependent variables – were considered: dressing percentage I. (%), dressing percentage II. (%), weight of warm carcass (kg), quantity (kg) and ratio (%) of tallow cut out at deboning, lean meat production (g/day), quantity (kg) and ratio (%) of first class meat.

3. MAJOR CONCLUSIONS OF THE THESIS

3.1. Assessment of repeatability by interpreting ultrasound images

Before the comprehensive introduction of RTU technology into the Hungarian beef cattle breeding it is essential to make sure of its proper repeatability. The repeatability of 6 characteristics measured by ultrasound were examined. Including these parameters so far there was no publication released on the measurement of the thickness of m. gluteus medius and the body wall.

Based on the results of analysis of variance in case of all ultrasound measurements – except FTF – the data lists determined by the technicians can be considered as equal. Either the personality of the technician nor the repeated evaluation did not influence the values of ROT, HFAG, P8, GMV and TFV during the evaluation of ultrasound images ($P>0.01$). Meanwhile at FTF characteristic the technician has an influence in measured values ($P<0.01$).

Among all data series (AA, AB, BA, BB) a positive, strict correlation factor has been detected ($r = 0.86$-0.99; $P<0.01$), which proves that the evaluation of different ultrasound images by the technicians is similar both between them and their own (*Table 1*). The most loose connection was found in case of HFAG and FTF, although this also shows the advantageous repeatability of ultrasound technology. Actually the FTF and P8 examinations determine the thickness of subcutaneous fat at similar anatomical area (on the rump). Notwithstanding the P8 measurement – based on the results of MANOVA and correlation analysis – has a more favourable repeatability. The reason could be the smaller depth and better resolution that allows more exact evaluation. Meanwhile the measurement of FTF is also recommended as GMV can be evaluated on the same image as FTF. Highly preferential relationship was found at GMV that can be explained by the simple evaluation of the images. Although the images are made with a large examination depth (13-16 cm), the thickness of m. gluteus medius is relatively large that greatly supports the precision of the measurements. It is highly important that reference points shall be clearly visible on the images for the easy determination of measurement point.

Table 1: Repeatability of ultrasound traits by technician and interpretation

Technician/ Interpretation	Statistical parameters	Ultrasound traits					
		ROT	**HFAG**	**P8**	**FTF**	**GMV**	**TFV**
AA - AB	**r**	**0.97****	**0.94****	**0.96****	**0.91****	**0.97****	**0.97****
	RMSE	4.30	0.0397	0.0324	0.0521	0.3697	0.1224
	ESD	3.95	0.0398	0.0314	0.0492	0.3699	0.1227
AA - BA	**r**	**0.97****	**0.93****	**0.94****	**0.91****	**0.96****	**0.96****
	RMSE	4.05	0.0444	0.0431	0.0585	0.3687	0.1538
	ESD	3.99	0.0445	0.0399	0.0476	0.3648	0.1482
AA - BB	**r**	**0.96****	**0.88****	**0.94****	**0.87****	**0.96****	**0.94****
	RMSE	4.35	0.0551	0.0428	0.0729	0.3676	0.2047
	ESD	4.24	0.0553	0.0381	0.0569	0.3627	0.1911
AB - BA	**r**	**0.98****	**0.94****	**0.94****	**0.92****	**0.95****	**0.97****
	RMSE	2.90	0.0356	0.0363	0.0476	0.1949	0.1424
	ESD	2.74	0.0356	0.0354	0.0448	0.1926	0.1377
AB - BB	**r**	**0.98****	**0.91****	**0.95****	**0.86****	**0.94****	**0.96****
	RMSE	2.75	0.0439	0.0363	0.0651	0.2146	0.1854
	ESD	2.67	0.0440	0.0346	0.0589	0.2118	0.1724
BA - BB	**r**	**0.99****	**0.94****	**0.95****	**0.93****	**0.94****	**0.98****
	RMSE	2.36	0.0360	0.0331	0.0447	0.1779	0.1298
	ESD	2.35	0.0361	0.0331	0.0433	0.1785	0.1263

** $P<0.01$; AA: 1st technician – 1st interpretation; AB: 1st technician – 2nd interpretation; BA: 2nd technician – 1st interpretation; BB: 2nd technician – 2nd interpretation

At all parameters single evaluation of the images shall be sufficient, meanwhile I draw the attention to the fact that comprehensive training and continuous maintenance of the knowledge is essential when using ultrasound technology.

At the same time the acquisition of adequate experience is also emphasised that is essential not only at the evaluation of the images but also when making them. More strict collaboration between ultrasound technicians, sharing experience between professional, organizing so called “professional coordination training” is recommended in order to exactly perform the examinations.

3.2. Reliability and accuracy of ultrasound measurements:

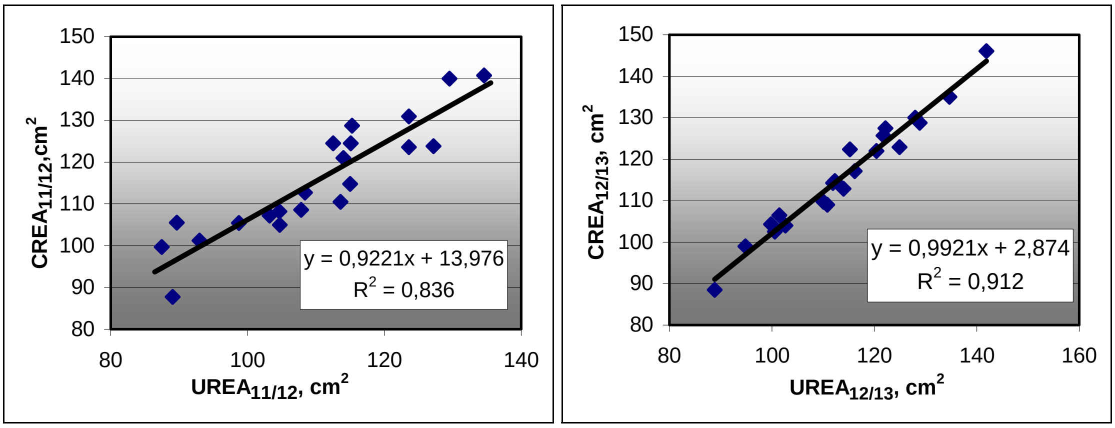
Accuracy of ultrasound technology is very important concerning its application. The accuracy of the ultrasound measurement of the ribeye area can be evaluated directly as the determination of ROT was performed on the same anatomical area also on the carcass. In international practice, in the breeding programs of different beef cattle the ribeye area values measured between the 12/13th ribs are used. Some scientists meanwhile publish data on the measurement of ribeye area between 11/12th ribs (BERGEN et al., 2005). In our domestic circumstances it is also important to examine whether there is a difference between the accuracy of ribeye area measured between 11/12th ribs or 12/13th ribs, that could be an important information in the introduction into practice.

During the accuracy of measurement technology it was proved that there was no statistically significant difference between the measured ribeye area on the carcass and in vivo by ultrasound ($P<0.05$). Between 11/12th ribs $r = 0,91$, while between 12/13th ribs $r = 0.96$ correlation coefficient was determined on the carcass and between values measured by ultrasound ($P<0.05$).

Data assessed in vivo by ultrasound and data measured with planimeter on the carcass are graphically represented in *figure 1.* and *2*. Regression equations calculated with the help of the two parameters and the determination factors of the equations were also indicated. Determination coefficient (R^2) shows the accuracy of carcass ribeye area (CROT) estimation. In case of $ROT_{11/12}$ this is 0.84, at $ROT_{12/13}$ 0.91. These high values – especially at $UROT_{12/13}$ – clearly show that with Falco 100 type ultrasound device the real size of ribeye area can be precisely rated.

By evaluating the deviation between the ribeye area values determined by ultrasound on live animals and on the carcass it can be stated that the ultrasound values measured between 12/13th ribs (2.16%) differed in a much lower measure from the values measured on the carcass than in case of the other anatomical point (5.30%). Meanwhile it can be stated that the deviations in ribeye area between in vivo estimated and determined on the carcass are independent from the carcass ribeye area values neither measured in between ribs 11/12th, nor between ribs 12/13th ($P<0.05$).

Figure 1-2: Relationship between ribeye area measured on the carcass and on live animal by ultrasound



$CROT_{11/12}$ = carcass ROT measured between the 11/12th ribs; $UROT_{11/12}$ = ultrasound measured ROT assessed between the 11/12th ribs, $CROT_{12/13}$ = carcass ROT measured between the 12/13th ribs; $UROT_{12/13}$ = ultrasound measured ROT assessed between the 12/13th ribs

Consequently the images made between ribs 12/13th are more reliable, the size of ribeye area can be estimated with a better result by ultrasound technology at this anatomical point. On my opinion it is also supported by the fact that better quality ultrasound images can be made between ribs 12/13th and evaluation is also easier at this point. Boundary surfaces of the different tissues are shown sharper on these images. This can be explained by the characteristics of the dimensions and sizes of muscle groups that can be found between ribs 11/12th and 12/13th Considering all the above mentioned facts further studies are necessary to find out how the ribeye area measured by ultrasound between ribs 11/12th can be used in the estimation of beef cattle’s slaughter value.

3.3. Examination of the growth of young seedstock bulls using ultrasound technology

In this chapter of the Study the changes in ultrasound parameters of young Charolais and Hungarian Simmental bulls are represented during performance test period. From parameters measured by ultrasound at the start of performance test the expected values of the same parameters at the end of performance test were rated using unary and multiple linear regression equations. The low-medium level reliability of one factor linear equations inspired me to try to increase the reliability of estimating equations by involving more features determined by ultrasound at the same time. The determination factor of the multiple linear regression equations in case of Hungarian Simmental breed has reached R^2 = 0,45 value in characteristics ROT, Rel. ROT, P8, HFAG, FTF, TFV, while in case of Charolais breed in Rel. ROT and GMV (*Table 2*).

Table 2: Stepwise regression to predict ultrasound traits from age, live weight and ultrasound parameters measured at the beginning of performance test

Dependent variables and equations		R^2	Constant	Age_b	$Live\ weight_b$	ROT_b	$Rel.\ ROT_b$	$P8_b$	$HFAG_b$	RF_b	GMV_b	TFV_e
ROT_e	HS	0.45*	27.096		0.100	0.513			-21.290		1.384	-1.489
	CH	0.44*	28.86	-0.015		0.909	0.737					
$Rel.\ ROT_e$	HS	0.45*	12.794	-0.011			0.307	-5.930	1.096	8.670	0.190	-0.554
	CH	0.52*	-55.25	0.016	0.15	-0.842	3.678	2.396	-1.773	4.8	-0.024	0.52
$P8_e$	HS	0.52*	0.085					0.700	0.184		0.025	
	CH	0.40*	-0.078	0.001		-0.003		0.759	0.346		0.032	
$HFAG_e$	HS	0.56*			0.001	0.002			0.257	0.191	0.017	0.053
	CH	0.44*	0.318		0.001	-0.004		-0.246	0.865		-0.018	
RF_e	HS	0.45*	0.317			0.003			0.253	0.380	-0.041	0.047
	CH	0.21*	-1.398		0.004	-0.022	0.085		0.126	0.586		
GMV_e	HS	NS										
	CH	0.51*	-6.53		0.027	-0.163	0.547	-1.819	0.717	2.761	0.913	0.51
TFV_e	HS	0.55*	0.143		0.006	0.006			-0.511			0.414

Legends: * = P<0.01; NS = non significant; HS = Hungarian Simmental; CH = Charolais
Subscript „b" means ultrasound traits measured at the beginning of performance test; subsript „e" means the same ultrasound trait measured at the end of performance test.

The equations, notwithstanding their medium reliability can help in the pre-selection of calves having adequate pedigree and characteristics before selecting them into performance test.

At both breeds the correlation between each ultrasound parameters was determined. Using regression analysis equations for the correction of data measured during performance test were created. Insertion of the equations differed between R^2 = 0.33-0.83. Therefore it is advisable to apply the equations with due discretion and further studies are necessary for increasing reliability. Meanwhile these equations can support the comparison of the performance of animals at different age and live weight.

3.4. Comparative analysis of the meat producing ability of Charolais bulls fattened to different weight endpoints

Slaughter value of beef cattle breeds has always been in focus in the selection of beef cattle. Notwithstanding there are only few actually available data available concerning the slaughter value of the beef cattle breeds and crossbred animals raised in Hungary. Beside there are different opinions concerning optimal slaughter weight. The actors of the product path: producer, processor and consumer could have a different definition concerning this question. All three participants of the product path consider this question primarily from economical aspects. For the producer above a certain weight it is only profitable to further fatten the animals when daily costs of keeping the animals do not exceed the extra profit arising from the daily weight gain. In addition at the fattening of animals with higher weight the decrease in feed gain and daily weight gain. The aim of the processor is to gain as much bony meat from the beef cattle bought as possible and that lean meat percentage and ratio of saleable cuts of meat shall be as high as possible. Meanwhile the customer would like to buy as much lean meat as possible on a reasonable price, with optimal fat content. Obviously the needs of customers differ in each part of the world.

The groups of fattening bulls involved in the study reached a weight endpoint of 523.9 kg; 626.9 kg; and 709.6 kg at the end of fattening. In the weight gain reached during fattening there was no significant difference between the groups (in order: 1 456, 1 423, 1 395 g/day) therefore even in case of fattening to heavy weight 1 400 g/day weight gain can be reached. It was observed that with the increase of age and weight dressing percentage is improved (dressing percentage I.). Between the dressing percentage of light and medium weight groups the deviation is smaller than between medium and heavy weight (*Table 3*). Significant ($P<0.01$) deviation was only found between the light and heavy weight categories (57.57% and 60.64%). The dressing percentage of the medium weight group showed no statistically significant deviation from the two other groups. The dressing percentage was calculated also predicting an empty gastro-intestinal system. In this case the dressing percentage was also improved by the increase of slaughtering weight (61.90–65.75%), and light weight group reached smaller values than medium and heavy weight groups (P<0.01). By EUROP classification system there was no significant deviation between the averages of the groups concerning muscle development, the average qualification of carcasses was category „U°”. The heavy weight group with its „2⁺” fatness proved to be more fatty than the other two, smaller weight category (P<0.05). Notwithstanding there was no deviation in the rate of kidney fat and fat produced by deboning.

Table 3: Means and standard deviations for carcass quality

Parameters	Slaughter weight			Total	Level of sig.
	Light	Medium	Heavy		
Slaughter weight (kg)	508.1±14.92[a]	603.1±18.77[b]	690.6±27.89[c]	600.6±78.95	P<0.01
Hot carcass weight (kg)	292.4±11.83[a]	359.8±12.09[b]	418.9±24.16[c]	357.0±55.35	P<0.01
Net carcass gain (g/day)	689±36.0[a]	734±34.1[ab]	782±51.8[b]	735±55.3	P<0.01
Dressing percentage I. (%)	57.57±0.91[a]	59.68±1.98[ab]	60.64±1.74[b]	59.29±2.01	P<0.01
Dressing percentage II. (%)	63.28±1.20[a]	64.97±1.74[b]	65.75±1.41[b]	64.67±1.74	P<0.01
Percentage of kidney fat (%)	0.74±0.16	0.63±0.30	0.64±0.29	0.67±0.25	NS
Total percentage of fat (%)	1.75±0.39	1.74±0.43	1.96±0.70	1.82±0.51	NS
EUROP conformation (score)	10.57±0.53	10.80±1.07	11.14±1.07	10.87±0.91	NS
EUROP fatness (score)	4.00±0.58[a]	3.86±0.90[a]	5.86±2.12[b]	4.57±1.60	P<0.05

Weight categories without the same superscript differ significantly

The ratio of four leg ends and the skin was more advantageous over the weight of 600 kg. A similar tendency can be detected in the bone ratio (relative to the warm carcasses) and in the meat/bone ratio (P<0.01). The beef bulls show the best lean meat percentage over 600 kg weight (P<0.05), and when reaching this weight the ratio of 1st grade meat parts is also more advantageous, although the deviation is not significant (*Table 4*). In practice economic circumstances will tell, if it is worth to keep the bulls until they reach the 600 kg weight.

Table 4. Means and standard deviations for carcass composition traits

Parameters	Slaughter weight			Total	Level of sig.
	Light	Medium	Heavy		
Cold carcass weight (kg)	285.1±11.10^{a}	348.9±11.48^{b}	406.0±21.87^{c}	346.7±52.71	P<0.01
Lean meat (%)	69.88±1.23^{a}	71.92±1.10^{b}	72.01±1.53^{b}	71.27±1.60	P<0.05
Fat (%)	6.80±0.56	6.76±0.75	6.86±0.89	6.80±0.71	NS
Bone (%)	19.95±0.94^{a}	17.91±0.89^{b}	18.04±0.96^{b}	18.63±1.30	P<0.01
Ratio of lean meat and fat	10.35±1.02	10.77±1.28	10.67±1.56	10.48±1.22	NS
Ratio of lean meat and bone	3.51±0.21^{a}	4.03±0.25^{b}	4.01±0.22^{b}	3.85±0.33	P<0.01
Lean meat production (g/day)	458.6±26.60^{a}	511.9±22.75^{b}	545.5±35.51^{b}	505.3±45.69	P<0.01

Weight categories without the same superscript differ significantly

3.5. Examination of the relationship between the ultrasound parameters and slaughter value in Charolais beef bulls

During the study the correlation coefficient of in vivo ultrasound characteristics and each characteristics representing the slaughter value were calculated, separately and paired. The results can help in the explanation of the connections between the characteristics determined on live animal by ultrasound and on the carcass. Through the estimating equations created by stepwise linear regression method (*Table 5*) with ultrasound parameters the dressing percentage (II.), the weight of warm carcasses, the quantity of cut-out fat, the lean meat and the quantity of 1st class meat of Charolais beef bulls can be estimated with medium-large accuracy (R^2 = 0.73-0.98). The estimating equations – within the error range used for their creation – allow the prognosis of certain slaughtering and deboning characteristics on live animals that provides the value-based qualification and pricing of slaughter animals. Obviously it is necessary to perform further studies with larger number of animals, by which estimation equations acceptable for the beef cattle sector can be created.

Table 5: Stepwise linear regression to predict some traits of slaughter value using ultrasound data (n = 21)

Dependent variables and equations	Dressing percentage I. (%)	Hot carcass weight (kg)	Fat (kg)	Lean meat (kg)	Weight of 1st grade meat parts (kg)
R^2	0.809	0.979	0.734	0.980	0.949
Constant	39.514***	-138.947***	-9.099*	-145.865***	-86.530***
Age at slaughter (day)	-	0.138*	-	0.177**	0.143*
Slaughter weight (kg)	-0.021*	0.400***	0.037**	0.187**	0.171**
$ROT_{11/12}$ (cm^2)	0.143***	-	-	-	-
$ROT_{12/13}$ (cm^2)	-	0.882***	-	0.954***	0.647**
$HFAG_{12/13}$ (cm)	-	-	-12.444	-	-
P8 (cm)	-	-	-	-	-
GMV (cm)	1.793***	7.292*	-	7.158*	-
TFV (cm)	-	-	4.856*	-	-

***P<0.001; **P<0.01; *P<0.05; P<0.10

4. NEW SCIENTIFIC RESULTS OF THE THESIS

1. During this study it was defined that the repeatability of ultrasound images made on ribeye area, backfat thickness, P8, thickness of m. gluteus medius and body wall thickness are not influenced by neither the technician nor the effect of repeated evaluation. Notwithstanding the technician has a significant effect on the results of the measurement of fat thickness at the rump.
2. Ribeye area on images made between ribs 12/13th can be estimated with a higher accuracy ($r = 0.96$; $P<0.01$), than between ribs 11/12th ($r = 0.91$; $P<0.01$).
3. Using the measured ultrasound characteristics of young bulls at their introduction into performance test their expectable values at the end of test period was estimated using multiple regression equations. The reliability of equations in case of Hungarian Simmental breed has exceeded $R^2 = 0.45$ value in characteristics ROT, Rel. ROT, P8, HFAG, FTF, TFV, while in case of Charolais breed in Rel. ROT and GMV. Equations can help in the pre-selection of bull calves having the adequate pedigree and characteristics before the introduction on performance test.
4. In beef cattle Hungarian Simmental and Charolais breeds raised in Hungary correction equations were created for the ultrasound characteristics, by which the correction for similar age or live weight can be performed for the comparability of each performances.
5. During the examination of the effect of slaughter weight it can be observed that the dressing percentage (II.) of Charolais beef bulls cut at the weight of 500 kg is far behind the animals slaughtered in weights 600 and 700 kg ($P<0.01$). The bone and lean meat ratio, the lean meat/bone ratio of Charolais beef bulls is more advantageous when slaughtering in 600 and 700 kg weight than in 500 kg ($P<0.01$; $P<0.05$).
6. It was proved that through the age, live weight and the parameters can be measured by ultrasound the dressing percentage (II.), the weight of warm carcasses, the quantity of cut-out fat, the lean meat, the lean meat production per day and the quantity of 1st class meat of Charolais beef bulls can be estimated with medium-large accuracy ($R^2 = 0.73$-0.98).

5. PRACTICAL UTILIZATION OF THE RESULTS

1. Using real time ultrasound technology on beef cattle certain characteristics that represent slaughter value (ribeye area, backfat thickness, P8, rump fat, m. gluteus medius depth, body wall thickness) can be estimated with adequate repeatability in domestic circumstances. During the examinations it was proved that the ultrasound measurement of ribeye area is reliable and accurate. The qualification of ultrasound technicians is necessary both when making and evaluating the images. The cooperation of Hungarian professionals on domestic level and their participation on foreign trainings that can contribute to the improvement of the repeatability, accuracy and exactness of ultrasound scanning.
2. Considering the domestic beef Hungarian Simmental and Charolais young seedstock bulls estimation equations were created by which – with the help of ultrasound characteristics measured at their introduction into performance test – the values expected at the end of test period can be estimated. By using these equations the individuals producing the best ultrasound results can be preselected before introducing them into performance test.
3. Improving the slaughter value of beef cattle breeds involved in the study – together with other important characteristics – is an extremely important task in domestic breeding programs. A correction equation was created for all the characteristics involved in the study, by which the correction of ultrasound parameters of individuals with different age and live weight is possible. Consequently young seedstock bulls will be comparable and ranked based on the ultrasound characteristics showing slaughter value. All these findings can be used also at reproductive performance tests. By using the method the selection made for slaughter value can be cheaper and more effective without increasing generation interval.
4. At Charolais beef bulls after reaching 600 of live weight a better dressing percentage, lean meat ratio and meat/bone rate can be reached than in smaller slaughter weight. Actual relation between fattening costs and production prices determine that farmers reach the best profitability by fattening for 600 or even 700 kg weight endpoint. For slaughterhouses it is also advisable to purchase Charolais beef bulls in a live weight over 600 kg, as within the examined slaughter

weight interval the slaughter value increasing without the significant increase of tallow production.

5. By using the data gained by in vivo ultrasound at the end of fattening period the slaughter value of Charolais bulls can be estimated with a medium-high accuracy, that allows the objective qualification of animals for slaughter at minimal cost and its application in the pricing of animals for slaughter.
6. There is a possibility to examine alternative ultrasound characteristics in domestic circumstances (m. gluteus medius depth, body wall thickness), that can be measured with the due repeatability, and are in relatively tight connection with certain parameters describing slaughter value. Thanks to this these characteristics – together with the ultrasound methods widely used in the practice – can improve the accuracy and reliability of forecasting equations estimating the slaughter value from ultrasound parameters.

5. PUBLICATIONS RELATED TO SUBJECT MATTER OF THE THESIS

Articles published in journals and foreign periodicals:

HARANGI S. – BÉRI B. – POPP J. (2013): Különböző súlyban vágott bikák hizlalási, vágási és csontozási eredményei. Gazdálkodás. 57. évf. 2. sz. pp. 147-159.

HARANGI S. – BÉRI B. – RADÁCSI A. (2009): Real-time ultrahangkészülék felhasználásának lehetősége a húsmarhatenyésztésben. Agrártudományi Közlemények - Acta Agraria Debreceniensis. 2009:(37) pp. 45-52.

HARANGI, S. – BÉRI, B. (2008): Evaluation of ultrasonic carcass traits of young seed-stock beef bulls. Journal of Agricultural Sciences. Acta Agraria Debreceniensis Supplement. Natural Resources and Sustainable Development. pp. 75-80.

HARANGI S. – BÉRI B. – CZEGLÉDI L. (2008): Ultrahangos méréstechnika reprodukálhatóságának vizsgálata növendék bikáknál. Agrártudományi Közlemények- Acta Agraria Debreceniensis. 2008:(31) pp. 43-48.

HARANGI S. – BÉRI B. – GAZDÓF K. – CZEGLÉDI L. (2008): Különböző genotípusú növendék bikák sajátteljesítmény-vizsgálat alatti teljesítményének értékelése. Animal welfare, etológia és tartástechnológia. Gödöllő, 4:(2) pp. 128-136.

Book chapter in Hungarian:

BÉRI B. – BODÓ I. – KOMLÓSI I. – CZEGLÉDI L. – RADÁCSI A. – **HARANGI S.** – SZENDREI Z. (2009): Szarvasmarha-tenyésztésünk helyzete, lehetőségeink. In: Nagy János, Jávor András (szerk.) Debreceni álláspont az agrárium jelenéről, jövőjéről. Budapest: DE AMTC, Magyar Mezőgazdaság Kft., 2009. pp. 347-378. (ISBN:978-963-88233-04)

Conference proceedings in Hungarian:

BÉRI B. – **HARANGI S.** – SZENDREI Z. (2007): A színes fajták szerepe a hazai tejhasznosításban. In: Kovács Krisztián: Ágazatspecifikus innováción alapuló projektek generálása a tejágazatban. Debrecen, pp. 93-102. ISSN: 1588-8665.

HARANGI S. – CZEGLÉDI L. – BÉRI B. (2007): Különböző genotípusú húsmarha borjak növekedési jellemzőinek vizsgálata. In: 49. Georgikon Napok. Konferencia helye, ideje: Keszthely, Magyarország, 67. p. ISBN 978-963-9639-20-1

HARANGI SÁNDOR – BÉRI B. – VARGA T. (2008): Ultrahangos felvételek értékelésének megbízhatósága szarvasmarhánál. In: XIV. Ifjúsági Tudományos Fórum. Konferencia helye, ideje: Keszthely, Magyarország, 2008.04.03 pp. 1-5.

HARANGI S. – BÉRI B. (2008): Tenyésztői döntések támogatása real-time ultrahangos technika segítségével a húsmarhatenyésztésben. In: XXXII. Óvári Tudományos Nap. Konferencia helye, ideje: Mosonmagyaróvár, Magyarország, 2008.10.09. Mosonmagyaróvár: pp. 1-6. (ISBN:978-963-9883-05-5)

Conference proceedings in foreign language:

HARANGI, S. – RADÁCSI, A. – BÉRI, B. (2009): The repeatability and accuracy of real-time ultrasound technique in measuring ribeye area of Charolais cattle. In: [European Association for Animal Production (EAAP)] (szerk.). Book of Abstracts of the 60th Annual Meeting of the European Association for Animal Production. Konferencia helye, ideje: Barcelona, Spanyolország, 2009.08.24-2009.08.27. The Netherlands: Wageningen Academic Publishers, 2009. 399. p. (Book of abstracts 15.) (ISBN: 978-90-8686-121-7)

HARANGI, S. – CZEGLÉDI, L. – BÉRI, B. (2008): Comparison of ultrasound carcass traits in young beef bulls of three breeds. In: 59th Annual Meeting of the European Association for Animal Production. Konferencia helye, ideje: Vilnius, Litvánia, 2008.08.24-2008.08.27. The Netherlands: Wageningen Academic Publishers, 2008. 161. p. (ISBN:978-90-8686-074-6)

SZENDREI, Z. – **HARANGI, S.** – RADÁCSI, A. – BÉRI, B. – BODÓ, I. (2007): Crossing with colored breeds in Hungary. In: Book of Abstracts of the 58th Annual Meeting of the European Association for Animal Production Konferencia helye, ideje: Dublin, Írország, 2007.08.26-2007.08.29. The Netherlands: Wageningen Academic Publishers, 2007. 319. p. (ISBN:978-90-8686-045-6)

SZENDREI, Z. – RADÁCSI, A. – **HARANGI, S.** – BÉRI, B. (2008): Milk production of Jersey x Holstein and Brown Swiss x Holstein crossbreds compared with their Holstein contemporaries. In: Book of Abstracts of the 59th Annual Meeting of the European Association for Animal Production. Konferencia helye, ideje: Vilnius, Litvánia, 2008.08.24-2008.08.27. The Netherlands: Wageningen Academic Publishers, 2008. 158. p. (ISBN:978-90-8686-074-6)

SZENDREI Z. – VÍGH ZS. – **HARANGI S.** – BÉRI B. (2009): Are Jerseys better keepers: body condition and ultrasonographically evaluated fat depth in Jerseys and Holsteins. In: [European Association for Animal Production (EAAP)] (szerk.). Book of Abstracts of the 60th Annual Meeting of the European Association for Animal Production. Konferencia helye, ideje: Barcelona, Spanyolország, 2009.08.24-2009.08.27. The Netherlands: Wageningen Academic Publishers, 2009. 103. p. (ISBN:978-90-8686-121-7)

Other publications:

HARANGI S. (2013): Húsmarhák vágóértékének javítása. Magyar Állattenyésztők Lapja. XLI. 3. pp. 18-19.

BÉRI B. – BODÓ I. – KOMLÓSI I. – CZEGLÉDI L. – RADÁCSI A. – **HARANGI S.** – SZENDREI Z. (2009): Debreceni álláspont; Szarvasmarha-tenyésztésünk helyzete, lehetőségeink. Magyar Mezőgazdaság. 64:(11) pp. 34-42.

HARANGI S. – BÉRI B. (2009): Ultrahang felhasználása a magyartarka fajta javítására. A magyartarka. IX. 1. pp. 12-14. ISSN 1587-9305

Abstract in Hungarian:

BÉRI B. – **HARANGI S.** (2006): A keresztezések lehetősége és eddigi eredményei tejhasznosítású állományoknál. In: Kérődző állatfajok mai helyzete és perspektívái az Európai Unióban. Állattenyésztés és takarmányozás különszám. vol. 55. Konferencia helye, ideje: Gödöllő, Magyarország, 2006.04.10-2006.04.11. Budapest: Állattenyésztési és Takarmányozási Kutatóintézet, pp. 36-37.

Abstract in foreign language:

HARANGI, S. – BÉRI, B. (2009): The use of real-time ultrasound technique to improve carcass value of Hungarian Simmental. In: 28th Congress of the European Simmental Federation. Konferencia helye, ideje: Siófok, Magyarország, 2009.09.29. pp. 58-59.