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PREDICTABILITY OF ROUND WEIGHT BY SOME BODY MEASUREMENTS, AGE AND ULTRASOUND MEASUREMENTS IN AUBRAC AND CHAROLAIS FATTENING BULLS

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SUMMARY

Authors' aim was to find factors determining round weight in Aubrac (n= 18) and Charolais (n= 8) fattening bulls. Experiments were carried out in 2007, at Italian fattening farm (n= 26, live age (LA): 570±6.41 days, live weight (LW): 621±60.76 kg). The main body measurements (height at withers (HW), height at rump (HR), chest girth (CG) and slanting body length (SBL)) were measured. Ultrasound images of rib eye area (REA) and rump fat thickness (P8) were taken with Falco 100 Pie Medical ultrasound equipment. The mean values of body measurements were as follows: HW: 122.9 cm, HR: 130.5 cm; CG: 201.9 cm, SBL: 149.1 cm. REA, P8 and weight of round were 96.2 cm^2, 0.70 cm and 133.5 kg, respectively. Correlations between LW and the different body measurements were: HW: r= 0.57 (P<0.001), HR: r= 0.55 (P<0.01), CG: r= 0.60 (P<0.001), SBL: r= 0.18. A very close correlation was revealed between LW and weight of round (r= 0.93, P<0.001). Stepwise regression analysis (backward method) was used to examine how the weight of round (y) is affected by LA (x_1), HW (x_2), HR (x_3), CG (x_4), SBL (x_5), REA (x_6) and P8 (x_7). In the 1st of the 7 models all parameters existed as independent variables, multiple correlation coefficient (R) was 0.70 (P<0.10, r_{sxy}= 11.65 kg). In the 4th model, LA, HW, CG and REA remained as independent variables, resulting an R value similar to that of the 1st model (R= 0.69, P<0.01, r_{sxy}= 10.88 kg). The last model contained only CG (R= 0.62, P<0.001, r_{sxy}= 11.11 kg). It was confirmed that the weight of round was determined in 38 % only by CG. It seems to be worth combining some body measurements with LA and ultrasound REA results for in vivo estimation of round weight of fattening bulls.

Keywords: Aubrac and Charolais, fattening bulls, body measurements, ultrasound images, prediction

INTRODUCTION

Since the domestication of cattle, an important aim of breeding has always been the improvement of beef production traits. Although the number of beef type herds is growing all around the world, the main part of beef is produced by dairy animals.

Nowadays, in selection programs of beef cattle, slaughter- and beef quality traits have been becoming more and more important. The reason for this is the changing demand by customers towards beef quality preferring lean meat.

It is widely known that slaughtering value of cattle is determined by quantity and quality traits of carcass, out of which the tissue composition, meat-bone-fat ratio and quantity are the most important. This can be evaluated well by slaughter trial. Slaughtered, and boning is a hard work that does not fit easily in the usual slaughterhouse technology. That is why it has become an aim of breeders to work out methods for examining body composition of live breeding and fattening animals and carcasses without boning.

Many methods have been developed, but their adaptability in practice and accuracy of prediction are different. Generally applied methods of evaluating an animal's traits in vivo are type classification and body condition scoring which are more or less involved in selection programs of most beef breeds. Experiments show that in evaluation of different cattle types, taking body measurements is also useful. Results from Hungarian authors concerning body measurements and body conformation indices are summarised as (1) Growth speed of different body measurements (Bartosiewicz *et al.*,1987), (2) Evaluation of body measurements and body conformation in performance tests (Tőzsér *et al.* ,1995 and Polgár and Szabó, 1997), (3) Body measurements and body measurement ratios of cows from different breeds (Nagy *et al*. 2007) and Body measurements and body measurement ratios of weaned calves and fattened cattle (Szabó *et al*. ;1993 and Tőzsér *et al*. ,1998) .

In the last decade, image analysing techniques (ultrasound, Rontgen-beam, magnetic resonance) were experienced and introduced in practice of cattle breeding (Holló, 2001). Ultrasound measurements were first taken in domestic animals, - for the first time in cattle - by Temple *et al*. (1956), and Claus (1957). Since then, many researchers have advised the use of ultrasound equipment in practice of beef cattle breeding and fattening, to determine optimal date for end off fattening period and to predict carcass yield (Robinson *et al*., 1993, Herring *et al*., 1994, Wilson *et al*., 2000).In the same time, attention was drawn to importance of experienced technicians and technical requirements. Details are not described in this article since they were introduced in an earlier study (Holló *et al*., 2005). Results of international research (i.e., Simm *et al*., 1983; Miller *et al*., 1988; Waldner *et al*., 1992; Hassen *et al*., 1999 and Wolcott, 2003) show that regression models containing ultrasound measurement results combined with different other traits, although with different determination coefficients (R^2), are appropriate to predict carcass composition (e.g. lean meat %, marketable meat %, protein content between ribs 9-11, etc., and ranged from 0.56 to 0.83).

Aim of the present study was to estimate how age, body measurements (height at withers, hip height, chest circumference, and diagonal body length) and ultrasound measurement results of rib eye area and rump fat thickness (P8) affect round weight of Charolais and Aubrac fattening bulls.

MATERIALS AND METHODS

Source of data and management :

A part of the experiment was carried out in February, 2007 by Institute of Animal Breeding, Szent István University and Hungarian Association of Charolais Breeders on 18 Aubrac (age: 570±5.91 days, live weight: 609.2±66.70 kg) and 8 Charolais (age: 568±7.57 days, live weight: 647.5±34.96 kg) fattening bulls in Italy. Age and live weight at end of fattening was 570±6.41 days and 621±60.76 kg for the two groups, respectively. Feeding system of the two groups was the same, they were fed at lib., during fattening on balance feed with the following components:

- Maize silage 6.00 kg
- Maize grout. 2.80 kg
- Dry sugar beet slices. 2.00 kg
- Wheat straw. 1.20 kg
- Soya grout. 1.10 kg
- Wheat meal. 1.00 kg
- Barley. 0.70 kg
- Glutinated meal. 0.60 kg
- Bovimix mineral premix. 0.20 kg
- Saturated plant fat (dehydrated, grout consistence) 0.15 kg

Body measurements were taken using the traditional method (stick and tape) described by Horn (1976), before slaughtering, together with weighing:

b- Body and Ultrasound measurements

Four body measurements are taken (1) height at withers, cm : distance between floor and highest point of withers, (2) hip height, cm : distance between floor and top of trochanter, (3) chest circumference, cm : in vertical level, behind scapula, and (4) diagonal body length, cm :distance between top of shoulders and isocheims. Two measurements of ultrasound are taken (1) *Longissimus muscle area:* between ribs 12 and 13 (*Falco 100,* Pie Medical equipment, linear head: 18 cm, wave length: 3.5 MHz, depth: 23 cm), and (2) *P8, rump fat thickness*, cm: at 3rd lumbar vertebra, and the break-even point of normal drawn to the vertebral column and the line parallel with vertebral column from ischium; which means about one palm distance from vertebral column (*Falco 100,* Pie Medical equipment, linear head: 18 cm, wave length: 3.5 MHz, depth: 5 cm).

Experimental animals were slaughtered and boned at the same age in OSSARI slaughterhouse, Italy in the autumn of 2007. Live weight was measured at the fattening farm and at arrival at slaughterhouse as well. Slaughtering and boning was carried out according to the method proposed by ATK (Research Institute for Animal breeding and Nutrition at Herceghalom in Hungary). Carcasses were categorised by an official judge, according to EUROP-system (System of carcass qualification for musculaints and fatness in point). Both right and left carcasses were boned. Some characteristics of slaughtering and boning: warm carcass weight (383.3 kg), EUROP muscularity score (E: n=2, U: n=24), EUROP fattiness score (2.38), lean meat (305.6 kg), bone (47.2 kg), fat (21.1kg).

Statistical analyses:

Live weight of Charolais and Aubrac bulls fattened to the same age in the same environment did not differ statistically (38.278 kg, t: 1.914, df: 23.088, P= 0.068, α= 0.05), so data of the two breeds were evaluated together. Means, standard deviations, coefficient of variability, sipmple correlation and stepwise regressions were evaluated using program SPSS 14.: basic statistics, correlation analysis. Stepwise regression analysis (backward method, entering condition $P<0,05$, exiting condition P<0,10) was used to estimate effect of *age* (x_1), *height at withers* (x_2), *hip height* (x_3), *chest circumference* (x_4), *diagonal body length* (x_5), *m. longissimus dorsi area* (x_6), and *rump fat thickness* (x_7) on *round weight* (y). On other words, seven models of multiple regression to predict round weigh (Y) was constructed, the first model includes all independent variables (x1, x2,........and x7), while one independent variable was omitted in each model .

RESULTS AND DISCUSSION

Means, standard deviations and coefficient of variability (CV%) values for the measured traits of experimental animals are presented in Table 1. As in present experiment, Polgár *et al*. (2005) also fattened bulls to heavy weight, 550-600 kg. Red Angus F1 and R1 bulls were fattened to 615-kg average weight, which is similar to results of present study. This weight was reached by an average age of 568 days, which is also just the same. However, results show a difference from the data published by Holló and Holló (2008) for Hungarian Simmental fattening bulls (age: 540 days, live weight: 580 kg), and Herring *et al*. (1994) for Hereford fattening bulls (age: 500 days, live weight 534 kg). In the two experiments mentioned before, carcass weights were 42-43 kg less than in present study. These examples show that it is very hard to find a publication that can be used for comparison, since circumstances are always different (breed, age, live weight, nutrition, etc.). Török *et al*. (2007) measured lower values for Rib eye area and P8 (Charolais and its crosses, REA: 82.3 cm^2, P8: 0.46 cm), than present data. The CV % values for different traits studied are ranged from 1.12 % to 32. 86 %. The present CV% are lower than those reported by May *et al*. (2000) and ranged from 14.90 to 50.40. The large CV % value for rump fat thickness (P8, Table 1), reflect a great variation between fattening bulls in important beef trait. The different between the present means and those reported in other studies for fattening bulls raised in Hungarian bulls could due to one or more of the following (1) the herds were raised under different climatic and managerial conditions, (2) different herds could possibly be genetic and phenotypic different from other and (3) different methods and models of analysis were used.

Most publications reveal positive correlations between age and body measurements. As a practical use of this fact, Simmental breeders used chest circumference and body condition (low, average, high) to estimate live weight of animals (e.g. 200 cm chest circumference means 649 kg for an average-, 604 kg for a low, and 694 kg for a high-condition animal (Horn, 1976).

In the present experiment, correlations for live weight and body measurements r= 0.57 (P<0.001) for height at withers, r= 0.55 (P<0.01) for hip height, r= 0.60 (P<0.001) for chest circumference, and r= 0.18 for diagonal body length. In a Hungarian Aubrac herd, Szentléleki *et al*. (2005) calculated closer correlation values for n=54 heifers (live weight – height at withers: r= 0.64, live weight – hip height: r= 0.58, live weight – chest circumference: r= 0.85, live weight – diagonal body length: r= 0.74, P<0.05). Earlier results on weaned Charolais bull calves are also supporting the importance of taking body measurements (Tőzsér *et al*. 2000). Using stepwise regression analysis, a common significant effect (R= 0.94, P<0.001) of diagonal body weight (x_1) and chest circumference (x_2) on live weight was revealed. In this respect, Tozser *et al*. (1995) reported significant growth (P < 0.001) in height at withers (10 %), chest girth (34 %0< chest width (15 %) and scrotum circumference (38 %) of Charolais bulls (n=40) during the 133 day long period of farm self performance test.

Correlations between body measurements and ultrasound measurements are presented in Table 2. Weak correlations were observed between age and body measurements (age – height at withers: r= 0.05, age – hip height: r= -0.25, age – chest circumference: r= 0.20, age – diagonal body length: r= -0.31), which results are similar to those of Bene (2007), and Nagy *et al*. (2007). This can be explained by the fact that real age and the so-called biological age of animals were not the same. In this respect, Tozser *et al*. (2004) found no difference in estimated rib eye area of Charolais bulls (age 545 days) and heifers (age 540 days) reared under the same conditions (bull: 84.6 cm2; heifers: 80.2 cm2).

Body measurements showed weak or medium positive correlations to each other (r= 0.38-0.65, Table 2). Chest circumference showed the closest (r= 0.62, P<0.001), while diagonal body length the loosest correlation (r=0.10) to round weight. Rib eye area correlated positively both to round weight (r= 0.35; P<0.05), and chest circumference (r= 0.49; P<0.01). These are no surprising results, considering the positive correlation between rib eye area and live weight (at least r=0.30; Silva *et al.*, 2003, Wolcott, 2003, Tőzsér *et al.*, 2005 b, Török *et al*, 2008). The present results indicated that body measurements and Rib eye area, are indicator to round weight and selection fattening bulls according to body measurements, round weight will increase. In this respect, Tozser *et al*. (2004) calculated medium and close correlations between estimated rib eye area and slaughtering parameters of Hungarian Grey fattening bulls (meat, kg: experiment I, r= 0.88, P < 0.05; experiment II, r = 0.66).

Negative correlation coefficients were found between rump fat thickness (P8) and each of weight of round, age at slaughters, high height, chest circumference and rib eye area and being - 0.08, - 0.30, - 0.11, - 0.16 and – 0.22, respectively (Table 2). The present results indicated that selection fattening bulls against lower rump fat thickness (P8) will increase weight of round and other body measurements. On the other hand, Torok *et al*. (2007) were the first in Hungary to calculate correlation between different subcutal fat thicknesses (P 8, rump fat, back fat) of n = 51 fattening bulls of different genotypes (Angus, Limousin, Hungarian Simmental, Charolais and Charolais x Hungarian Simmental), found correlation P8 and rump fat thickness was r = 0.93, P < 0.01.

Characteristics of the different regression models are detailed in Tables 3 & 4. In Table 4, correlation coefficients (R) achieved at different steps and errors of estimation (r_{sxy}) are introduced. In Model I, common effect of the 7 independent variables (x_1-x_7) on round weight (y) was described by an R-value of 0.70 (P<0.10), with a standard error of 11.65 kg and R^2 = 0.48. In Model III, age, height at withers, chest circumference, diagonal body length and longissimus muscle area were present as independent variables: R= 0.69, (P<0.05), r_{sxy}= 11.08 kg and R^2= 0.48. Model IV contained age, height at withers, chest circumference and longissimus muscle area as independent variables, R-value (0.69; P<0.01) was the same, standard error (r_{sxy}= 10.88 kg) and R^2= 0.48 was similar to those calculated in case of Model III. The present results indicated the important of Rib eye area in the model and omitted these trait from the model reduced R^2 from 0.49 to 0.38. The last model was based only on chest circumference: R= 0.62 (P<0.001), r_{sxy}= 11.11 kg and R^2= 0.38. This result implies that chest circumference alone determined round weight by 38.

Data in Table 4 give information on changes of components in regression equations. It is interesting to pay attention to the growth of correlation coefficients with the different steps: e.g. chest circumference, Model I: r= 0.41, Model VI: r= 0.51. When choosing the optimal solution – in accordance with professional consideration – mainly two things must be evaluated in the same time: 1. In which case is R the highest? 2. In which case is standard error of estimation the lowest? Considering these, among Models III and IV, Model IV seems to be the best to be applied, since determination coefficient is the same high as in Model III, while number of independent variables is less, and standard error of estimation is lower.

Change of multiple correlation coefficients was also examined when live weight was involved into the regression model as independent variable. Estimating round weight, R value varied between 0.93-0.95 in the different models. These results can be explained partly with the close correlations with body measurements already reported before, and partly with the strong relation between live weight and round weight (r= 0.93, P<0.001). Theoretically, if aim was to work out regression equations for in vivo estimation of round weight, putting live weight into the models would increase determination coefficient (R^2). However the fact that animals of similar age are fattened to a given weight (e.g. 600 kg in case of great framed types) does not support the involvement of live weight into the model.

CONCLUSION

- It was proven by a multiple regression analysis that in beef bulls fattened to heavy weight, round weight was determined in 38% only by chest circumference.
- In vivo estimation of round weight is possible using data on age, height at withers, chest circumference and ultrasound measurement of longissimus muscle area: R= 0.69, P<0.01, standard error of estimation r_{sxy}= 10.88 kg. Inserting live weight into the model can theoretically increase reliability.

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Table 1. Means, Standard deviations (SD) and coefficient of variability (CV %) of age, body weight, body measurements and results of ultrasound measurements of the fattening bulls (n=26)

Traits	Mean	SD	CV %
Age at slaughter, day	570	6.41	1.12
Live weight at slaughter, kg	621	60.76	9.78
Height at withers, cm	122.9	4.83	3.93
Hip height, cm	130.5	3.61	2.77
Chest circumference, cm	201.9	7.64	3.78
Diagonal body length, cm	149.1	8.77	5.88
Rib eye area, REA, cm^2	96.2	8.85	9.20
Rump fat thickness (P8), cm	0.70	0.23	32.86
Weight of round, kg	133.5	13.84	0.37

Table 2. Correlation coefficients and significance levels between the examined traits

Traits		Weight of round, kg	Age at slaughter, day	Height at withers, cm	Hip height, cm	Chest circum-ference, cm	Diagonal body length, cm	Rib eye area, REA, cm^2
Correlation coefficients (r)	Age at slaughter, day	-0.06						
	Height at withers, cm	0.49	0.05					
	Hip height, cm	0.46	-0.25	0.65				
	Chest circumference, cm	0.62	0.20	0.44	0.43			
	Diagonal body length, cm	0.10	-0.31	0.43	0.38	0.01		
	Rib eye area, REA, cm^2	0.35	-0.03	0.04	0.17	0.49	-0.11	
	Rump fat thickness (P8), cm	-0.08	-0.30	0.07	-0.11	-0.16	0.30	-0.22
Significance level (one tailed)	Age at slaughter, day	0.381						
	Height at withers, cm	0.006	0.398					
	Hip height, cm	0.009	0.107	0.000				
	Chest circumference, cm	0.000	0.169	0.013	0.013			
	Diagonal body length, cm	0.307	0.061	0.014	0.028	0.487		
	Rib eye area, REA, cm^2	0.038	0.448	0.425	0.202	0.005	0.292	.
	Rump fat thickness (P8), cm	0.341	0.066	0.361	0.286	0.219	0.069	0.144

Table 3 Multiple correlation coefficients, determination coefficients and estimated standard error by models (backward stepwise)

Models	Multiple correlation coefficient, R	Determination coefficient, (R^2)	Estimated standard error, (r_{sxy})
1	0.70*	0.49	11.65
2	0.70**	0.49	11.34
3	0.69**	0.48	11.08
4	0.69***	0.48	10.88
5	0.68***	0.47	10.71
6	0.66****	0.44	10.78
7$^{\times}$	0.62****	0.38	11.11

*= P<0.10, **= P<0.05, ***= P<0.01, ****= P<0.001

$^{\times}$ = simple correlation coefficient (r)

التنبأ بوزن موخرة الفخذ بواسطة بعض مقاييس الجسم - العمر والاشعة فوق الصوتية لطلائق اوبراك والشارولية المسمنة

تورستين[١] ، سزينتلك[١] ، دوماكس[٢] ، فرتين [١]، بوتارة[٣] ، البرت[٣] و عادل صلاح خطاب[٤]

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أستخدم فى هذه الدراسة عدد ١٨ ذكرا من كل من طلائق اوبراك والشارولية المسمنة بغرض دراسة بعض العوامل المحددة لصفة وزن مؤخرة الفخذ . أجريت هذة الدراسة عام ٢٠٠٧ فى مزرعة التسمين الايطالية بالمجر والمشتملة على عدد ٢٦ حيوان و متوسط العمر ٥٧٠ + ٦,١٤ يوم ومتوسط الوزن ٦٢١ +٦٠,٦٧ كجم . درست أربعة مقاييس للجسم وهى (ارتفاع الكتف- ارتفاع الكفل – محيط الصدر و طول الجسم) بينما درس مقياسان باستخدام الاشعة فوق الصوتية (حجم العضلة العينية و سمك طبقة دهن منطقة الكفل).

قدر متوسط مفاييس الجسم ١٢٢,٩ سم و ١٣٠,٥ سم و ٢٠١,٩ سم و ٩٤١,١ سم لكل من ارتفاع الكتف ، ارتفاع الكفل ، محيط الصدر و طول الجسم على التوالى. بينما كان متوسط حجم العضلة العينية و سمك طبقة دهن الكفل ٩٦,٢ سم٢ و ٠,٧٠ سم على التوالى..

كانت قيم معامل الارتباط البسيط بين صفة وزن الجسم و مقاييس الجسم (ارتفاع الكتف– ارتفاع الكفل– محيط الصدر – طول الجسم كانت ٠,٧٥، ٠,٥٥ ، ٠,٦٠، ٠,١٨ على التوالى) . بينما كان معامل الارتباط بين وزن الجسم ووزن مؤخرة الفخذ (٠,٩٣).

أستخدم معامل الانحدار المتعدد باستخدام سبع نماذج للتحليل لمعرفة أهم العوامل المؤثرة على صفة وزن مؤخرة الفخذ . اشتمل النموذج الاول على سبعة متغيرات ثابتة وهى العمر عند الذبح - ارتفاع الكتف - ارتفاع الكفل- محيط الصدر- طول الجسم – حجم العضلة العينية – سمك طبقة دهن الكفل). بينما أستبعد متغير واحد فى باقى معاملات الانحدار المتعدد.

كانت قيمة معامل الارتباط المتعدد باستخدام النموذج الاول ٠,٧٠ والخطأ القياسى ٦٥و١١ كجم . كذلك كانت قيمة معامل الارتباط المتعدد باستخدام النموذج الرابع والمشتمل على (العمر- ارتفاع الكتف- محيط الصدر وحجم العضلى العينية (٠,٦٩ والخطا القياسى ١٠,٨٨ كجم) . بينما كان معامل الارتباط المتعدد باستخدام النموذج الاخير والمشتمل على محيط الصدر (٠,٦٢ والخطأ القياسى ١١,١١ كجم.

أوضخت تلك الراسة أن محيط الصدر يؤثر بنسبة ٣٨% ، وبذلك يجب الاهتمام ببعض النتغيرات مثل العمر وحجم العضلة العينية للتنبأ بوزن مؤخرة الفخذ فى عجول التسمين.