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Prediction of carcass composition from measurements of wholesale carcasses

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ABSTRACT

Carcass data from 238 brown bulls were analysed to estimate the possibilities for prediction of carcass composition from measurements of wholesale carcasses. Measurements included carcass weight, carcass length, chest depth, longissimus dorsi muscle area between the 7th and 8th ribs and carcass conformation and fatness notes. Actual tissues weights and proportions were obtained from carcass dissection into lean, fat, tendon and bone. Using carcass weight, carcass length, chest depth, EUROP conformation and fatness notes, it was not possible to accurately predict proportion of carcass tissue of progeny tested Brown bulls (r^2 of 0.142, 0.104, 0.061, 0.230 for lean, fat, tendon and bone). Also inclusion of longissimus muscle area did not significantly improve the coefficient of determination. Accuracy of predicting carcass tissue weight was higher, (r^2 of 0.867, 0.191, 0.076, 0.355 for lean, fat, tendon and bone), but only the prediction of lean weight was sufficiently accurate.
(Keywords: beef, carcass, prediction, tissue weight, tissue proportion)

ZUSAMMENFASSUNG

Schätzung der Schlachtkörperzusammensetzung durch Verwendung meßbare Kriterien beim Rind
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Die Schlachtkörperdaten von 238 Bullen der Rasse Braunvieh wurden analysiert, um die Schätzung der Körperzusammensetzung mit den Schlachtkörpermerkmalen der EUROP-Klassifizierung zu überprüfen. In die Untersuchung wurden folgende Schlachtkörpermerkmale einbezogen: Schlachtkörpergewicht, Schlachtkörperlänge, Brusttiefe, Fläche des Muskels longissimus dorsi zwischen 7 und 8 Rippe, Fleischfülle und Verfettungsgrad. Die Menge der einzelnen Gewebe und deren relative Anteile im Schlachtkörper wurden durch Zerlegen der Schlachthälften ermittelt. Die Gewebeanteile lassen sich bei dem Schlachtkörpergewicht, der Schlachtkörperlänge, der Brusttiefe, der Fleischfülle und dem Verfettungsgrad nur sehr ungenau schätzen (r^2 erreichte 0.142, 0.104, 0.061, 0.230 für Fleisch-, Fett- Sehnen-, und Knochenanteil). Auch das Einbeziehen der Muskelfläche des longissimus dorsi in das Modell trug nicht zur wesentlichen Verbesserung der Schätzgenauigkeit bei. Die Gewebemengen lassen sich mit höherer Genauigkeit schätzen als die Gewebeanteile (R^2 erreichte 0.867, 0.191, 0.076, 0.355 für Fleisch-, Fett-, Sehnen- und Knochenmenge), aber nur die Werte für die Fleischmenge erreichten eine bessere Genauigkeit.
(Schlüsselwörter: Rind, Schlachtkörper, Schätzung, Gewebemenge, Gewebeanteile)

INTRODUCTION

Carcass composition is one of the most important factors that defines their market value. Accurate predictions of carcass composition is required by the breeders and beef industry as well. For the breeders, it is not important only because of payment, but also because of possibilities to use this data for selection purposes. In many countries the data from commercial fatteners and slaughterhouses are used for prediction of sire breeding value. Accuracy of estimated breeding value can be compensated by higher number of progeny tested bulls and by including their relatives. In Slovenia in future all cattle shall be numbered, hence it will be possible to obtain carcass weight, conformation and fatness notes.

The purpose of this work was to estimate the possibilities for prediction of carcass composition from measurements of wholesale carcasses.

MATERIALS AND METHODS

The data for this study were collected from 238 Brown bulls fattened from 1992 to 1996 at progeny testing station in Logatec. Bulls were fed with mixture of maize and grass silage ad libidum and concentrate. They were slaughtered in three different commercial slaughterhouses. After slaughter carcasses were weighted and conformation (EUROP) and fatness (1,2,3,4,5) were noted (*Pravilnik o.., 1994*). Carcass length was measured from cranial part of symphysis pubis to cranial part in middle of the 1st rib and chest depth from ventral part of neural canal of backbone to ventral part of the sternum at 5th rib. Carcass halves were cut into quarters between the 7th and 8th ribs and muscle *longissimus dorsi* area was measured on the cross section. Carcass halves were dissected into lean, fat, tendon and bone and percentage of tissues were calculated. Percentage and quantity of four tissues were first estimated on the basis of carcass weight, carcass length, chest depth, conformation and fatness notes. In the second step longissimus muscle area was added to independent variables. The stepwise regression procedure (SAS, 1989) was used to examine the effectiveness of carcass measurements in prediction of tissue weight and proportion in the carcass, including all independent variables and their quadratic terms.

MODEL:

$$\hat{Y}_{ij} = b_0 + b_1 * X_1 + b_2 * X_2 + \ldots + b_i * X_i + e_{ij}$$

$\hat{Y}_{ij}$ = dependent variable, kg or % of body tissue in the carcass
b_0 = constant
$b_1 \ldots b_i$ = partial regression coefficients
$X_1 \ldots X_i$ = independent variables
e_{ij} = estimation error

RESULTS AND DISCUSION

In *Table 1* the results of carcass grading are represented. Most of the carcasses were graded into R and U conformation classes and only a small part into class O. Carcasses were graded into three fatness classes, but majority of them were graded into fatness class 3.

Table 1

Number of graded carcasses

	E	U	R	O	P	Σ
5	0	0	0	0	0	**0**
4	0	2	4	0	0	**6**
3	0	87	122	11	0	**220**
2	0	0	10	2	0	**12**
1	0	0	0	0	0	**0**
Σ	**0**	**89**	**136**	**13**	**0**	**238**

1. Tabelle: Die Zahl der bewerteten Schlachtkörper

Live weight at slaughter was on average 586 kg with the coefficient of variation of 6.7 % (*Table 2*). The greatest variability was found for quantity and percentage of fat and tendon and for longissimus muscle area.

Table 2

Means and coefficients of variation

	n	$\overline{X}$	MIN	MAX	SD	CV
Live weight at slaughter, kg (1)	238	586	488	705	39	6.7
Carcass weight (kg) (2)	238	322	266	376	24	7.6
Carcass length (cm) (3)	238	136.1	127.0	151.0	4.0	3.0
Chest depth (cm) (4)	238	42.0	36.6	49.5	2.1	5.0
Longissimus muscle area (cm^2) (5)	238	61.1	38.7	85.3	10.0	16.4
Lean (%)(6)	238	68.7	61.1	74.8	2.4	3.5
Fat (%)(7)	238	13.0	5.6	21.4	2.4	19.3
Tendon (%)(8)	238	1.7	0.8	2.7	0.3	17.2
Bone (%)(9)	238	16.6	13.4	19.9	1.2	7.5
Carcass halves: lean (kg) (10)	238	106.8	83.4	132.5	9.7	9.1
fat (kg) (11)	238	20.2	8.3	33.2	4.1	20.9
tendon (kg) (12)	238	2.7	1.5	4.1	0.4	16.4
bone (kg) (13)	238	25.7	20.5	32.1	2.4	9.6

2. Tabelle: Mittelwerte und Variationskoeffizienten

Lebendgewicht(1), Gewicht des Schlachtkörpers(2), Länge des Schlachtkörpers(3), Brusttiefe(4), Fläche des Muskels longissimus dorsi(5), Fleischanteil(6), Fettanteil(7), Sehnenanteil(8), Knochenanteil(9), Fleischmenge in der Schlachthälfte(10), Fettmenge(11), Sehnenmenge(12), Knochenmenge(13)

Prediction of carcass tissue proportion

For predicting tissue proportion we first used carcass weight, carcass length, chest depth and EUROP grades for conformation and fatness. The included independent variables in the model are presented in *Table 3.* It can be seen that included independent variables explained only a small part of tissue variability. Carcass length, as well as chest depth were not included in the model for estimation of lean and fat proportion. The highest r^2 (0.23) was estimated for bone proportion. *Engelhardt* (1991) reported much higher determination coefficient for tissue proportion for Simmental and Black and White bulls, estimated on the basis of carcass weight and conformation and fatness notes (for lean 0.21 and 0.46; for fat 0.39 and 0.45; for bone 0.49 and 0.42). *Engelhardt* noted also higher residual standard deviation for lean and fat, but not for bone. The main reason for small proportion of explained variation in the present investigation is likely in carcass distribution among conformation and fatness classes. Most of the carcasses were graded into conformation classes U and R and fatness class 3.

Table 3

Coefficient of determination (R^2) and residual standard deviations (RSD) for model selected by stepwise procedures for predicting carcass tissue proportion

	Proportion of carcass tissue, % (1)			
	Lean (2)	Fat (3)	Tendon (4)	Bone (5)
Carcass weight (6)	l	-		q
Carcass length (7)	-	q	q	q
Chest depth (8)	-	-	-	q
EUROP conformation (9)	l	q	-	l
EUROP fatness (10)	q	q	-	q
R^2	0.142	0.104	0.061	0.230
RSD	2.271	2.333	0.284	1.096

l, q -Linear term or quadratic term of independent variables included in the model. *(Linearer oder quadratischer Teil der unabhängigen Variablen.)*

3. Tabelle: Determinierung (R^2) und Schätzfehler der Vorhersage (RSD) für das mit der „stepwise“ Prozedur ausgewählte Modell für die geschätzten Gewebeanteile der Schlachthälfte

Gewebeanteil der Schlachthälfte(1), Fleisch(2), Fett(3), Sehnen(4), Knochen(5), Gewicht der Schlachthälfte(6), Länge der Schlachthälfte(7), Brusttiefe(8), EUROP Fleischklasse(9), EUROP Fettklasse(10)

In the second step we included longissimus muscle area in the model. r^2 for lean proportion increased to 0.168, but it was only a low proportion of explained variation. RSDs also decreased, but the decrease was rather negligible. *Johnson et al.* (1992) did not find any significant correlation between longissimus muscle area at 10th rib and lean percentage, but the correlation between longissimus muscle area and lean quantity was as high as 0.68. *Engelhardt* (1991) reported correlation coefficient between longissimus muscle area at 8/9 rib and lean percentage 0.29, fat percentage –0.12 and bone percentage –0.24. Much higher correlation coefficient found *Hartjan* (1993), who reported correlation coefficient between longissimus muscle area in loin region and lean, fat and bone percentage 0.50, –0.16 and –0.52. As can we see in *Table 4* the inclusion of longissimus muscle area did not increase r^2 significantly.

Prediction of carcass tissue weight

Also for predicting tissue weight we first used carcass weight, carcass length, chest depth and EUROP grades for conformation and fatness. r^2 for predicting carcass lean weight, compared with lean percentage increased significantly. The most important predictor was carcass weight. Bulls had to be slaughtered at optimal fatness, so this strait correlation between carcass weight and lean weight is not surprising. Also r^2 for fat weight doubled compared with fat percentage, but was with 0.194 still rather low. For bone weight higher r^2 and lower RSD was estimated than for fat weight.

Table 4

Coefficient of determination (R^2) and residual standard deviations (RSD) for model selected by stepwise procedures for predicting carcass tissue proportion

	Proportion of carcass tissue, % (1)			
	Lean (2)	Fat (3)	Tendon (4)	Bone (5)
Carcass weight (6)	l	l	q	q
Carcass length (7)	-	q	q	q
Chest depth (8)	-	-	-	q
EUROP conformation (9)	l	q	-	l
EUROP fatness (10)	q	q	-	q
Longissimus muscle area (11)	l	l	q	q
R^2	0.168	0.124	0.098	0.240
RSD	2.271	2.316	0.279	1.092

l, q - Linear term or quadratic term of independent variables. (*Linearer oder quadratischer Teil der unabhängigen Variablen.)*

4. Tabelle: Determinierung (R^2) und Schätzfehler der Vorhersage (RSD) für das mit der „stepwise“ Prozedur ausgewählte Modell für die geschätzten Gewebeanteile der Schlachthälfte

Gewebeanteil der Schlachthälfte(1), Fleisch(2), Fett(3), Sehnen(4), Knochen(5), Gewicht der Schlachthälfte(6), Länge der Schlachthälfte(7), Brusttiefe(8), EUROP Fleischklasse(9), EUROP Fettklasse(10), Fläche des Muskels longissimus dorsi(11)

Table 5

Coefficient of determination (r^2) and residual standard deviations (RSD) for model selected by stepwise procedures for predicting carcass tissue weight

	Proportion of carcass tissue, % (1)			
	Lean (2)	Fat (3)	Tendon (4)	Bone (5)
Carcass weight (6)	q	q	l	l,q
Carcass length (7)	-	-	q	q
Chest depth (8)	-	-	-	q
EUROP conformation (9)	q	q	-	-
EUROP fatness (10)	q	q	-	q
R^2	0.867	0.191	0.076	0.355
RSD	3,548	3.701	0.429	1.961

l, q - Linear term or quadratic term of independent variables. *(Linearer oder quadratischer Teil der unabhängigen Variablen.)*

5. Tabelle: Determinierung (R^2) und Schätzfehler der Vorhersage (RSD) für das mit der „stepwise“ Prozedur ausgewählte Modell für die geschätzten Gewebeanteile der Schlachthälfte

Gewebeanteil der Schlachthälfte(1), Fleisch(2), Fett(3), Sehnen(4), Knochen(5), Gewicht der Schlachthälfte(6), Länge der Schlachthälfte(7), Brusttiefe(8), EUROP Fleischklasse(9), EUROP Fettklasse(10)

After addition longissimus muscle area in the model, r^2 for lean, fat and tendon slightly increased and RSD decreased, but the differences were even smaller than those for tissue proportion.

Table 6

Coefficient of determination (R^2) and residual standard deviations (RSD) for model selected by stepwise procedures for predicting carcass tissue weight

	Proportion of carcass tissue, % (1)			
	Lean (2)	Fat (3)	Tendon (4)	Bone (5)
Carcass weight (6)	q	q	l	l,q
Carcass length (7)	l	q	q	q
Chest depth (8)	-	-	-	q
EUROP conformation (9)	q	q	-	-
EUROP fatness (10)	q	q	-	q
Longissimus muscle area (11)	q	l	q	-
R^2	0.875	0.207	0.108	0.355
RSD	3.461	3.673	0.423	1.961

l, q - Linear term or quadratic term of independent variables. (*Linearer oder quadratischer Teil der unabhängigen Variablen.)*

6. Tabelle: Determinierung (R^2) und Schätzfehler der Vorhersage (RSD) für das mit der „stepwise“ Prozedur ausgewählte Modell für die geschätzten Gewebeanteile der Schlachthälfte

Gewebeanteil der Schlachthälfte(1), Fleisch(2), Fett(3), Sehnen(4), Knochen(5), Gewicht der Schlachthälfte(6), Länge der Schlachthälfte(7), Brusttiefe(8), EUROP Fleischklasse(9), EUROP Fettklasse(10), Fläche des Muskels longissimus dorsi(11)

Johson et al. (1992) reported that longissimus muscle area contribution to improvement of r^2 in predicting lean percentage with carcass weight and backfat thickness was higher than in predicting lean weight. This improvement was also more evident in heavier carcasses. Similar findings were reported by *Fan et al.* (1992) as well.

CONCLUSIONS

Using carcass weight, carcass length, chest depth, EUROP conformation and fatness notes, it was not possible to predict accurately proportion of carcass tissue of progeny tested Brown bulls. Also inclusion of longissimus muscle area did not significantly improve the coefficient of determination. Precision of predicting weight of carcass tissue was higher, but only the prediction of lean weight was sufficiently accurate.

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