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A study to estimation of lean meat content in carcasses of cows by half carcass weight, weight of kidney and trimmed fat, and adipocyte diameter

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ABSTRACT

The aim of this study was to establish a prediction equation to estimate the weight of lean meat (WLM) at slaughter from the weight of trimmed fat (WTF), the adipose cell diameter (ADC), the weight of kidney fat (WKF), and the weight of hot carcass halves (WHCH). Holstein-Friesian and Hungarian Fleckvieh cows (n=18) were used in this study. The animals were transported to the slaughterhouse by track and after lairage for overnight were slaughtered. After the slaughter 1 g subcutaneous fat samples were taken from rump and the adipocyte diameter was measured. Means for WLM, WTF, ADC, WKF, WHCH were recorded: 167.5 kg; 35.3 kg; 79.1 μ; 6.6 kg; 261.2 kg, respectively. Moderate positive relationship (r=0.44, P>0.05) was found between ADC and WHCH. This tendency was also observed for weight of lean meat. The correlation was very close (r=0.84, P<0.001) between ADC and WKF. Two factors were determined as follows: carcass and lean meat (I.), fat and adipocyte diameter (II.). Using stepwise multiple regression analysis to estimation of weight of lean meat (y) 98% of total variance is determined (P<0.001) by three independent variables as follows: WTF (x_1), ADC (x_2), WHCH (x_4). Based on the results of this study, we can propose to use the adipocyte tissue diameter to estimate the weight of lean meat within tne context of the other componentparts of the carcass.
(Keywords: carcass composition, prediction of lean meat, adipose cell diameter)

ÖSSZEFOGLALÁS

Tanulmány a tehenek színhúsmennyiségének becslésére a hasított felek súlya, a vese- és kivágott faggyú mennyisége, illetve a zsírsejtátmérő alapján
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A tanulmány célja a színhús mennyiség becslésére való egyenlet vizsgálata a kivágott faggyú mennyiség, a zsírsejtátmérő, a vesefaggyú mennyiség és a meleg hasított felek súlya

alapján. Holstein-fríz és magyar tarka tehenek (n=18) pihentetés után kerültek vágásra. A zsírsejtek méretének megállapítása végett a vágás után a far tájékről 1 g mintát vettünk. A kivágott faggyú mennyiségére, a zsírsejtátmérőre, a vesefaggyú mennyiségére és a meleg hasított felek súlyára vonatkozó átlagértékek a következők voltak: 35,3 kg; 79,1 μ; 6,6 kg; 261,2 kg. A zsírsjetátmérő és a meleg hasított felek súlya között közepes (r=0,44, P>0,05), még a zsírsjetátmérő és kivágott faggyú mennyisége viszonylatában szoros (r=0,84, P<0,001) összefüggéseket számítottunk. Vizsgálatunkban két faktort határoztunk meg: I. faktor: csontoshús-szíhnús, II. faktor: faggyú-zsírsejtátmérő. Stepwise regressziót alkalmazva a színhús mennyiség becslésére (y), a független változókkal (kivágott faggyú mennyisége x_1*, zsírsjetátmérő* x_2*, meleg hasított felek súlya* x_4*) a teljes variancia 98%-át meg tudtuk magyarázni (P<0,001). Eredményeink alapján javasolhatjuk a zsírsjetátmérő más tulajdonsággal együtt történő alkalmazását a színhús mennyiségének becslésére.*
(Kulcsszavak: hasított fél összetétel, színhús becslése, zsírsejtátmérő)

INTRODUCTION

One of the main goals in meat production research is to decrease lipid deposition and to increase protein deposition in carcasses of animals for slaughter. The deposition of fat and adipose tissue cellularity are influenced by a number of factors. Among the quantitative traits the most important ones are the weight of the carcass and the dressing percentage. In fact the carcass quality is mainly influenced by tissue composition, i.e. the ratio of lean, fat and bone. The estimated value out of two slaughter cattle of same live weight and sex is higher in that animal which contains higher amount of lean with lower bone and different ratio of fat according to the consumers' demand (*Bozó et al.,* 1995). A good prediction of body composition of living animal is essential for the determination of fat or energy efficiency.

Several methods of varying cost and accuracy have been investigated with cattle such as body condition scoring (*Agabriel et al.,* 1986), ultrasonic scanning of fat depth (*Miles et al.,* 1983), measuring the speed of ultrasound (*Miles et al.,* 1984), measuring of fat cell sizes (*Robelin et al.,* 1986) and a technique for the dilution injected deuteriated water (*Cowan et al.,* 1979; *Robelin,* 1982). According to *Renand et al.* (1996) the highly positive correlation between adipose cell diameter and fat content (r=0.56) indicates that this characteristic could also be used to further improvement of selection. Several approaches have been studied for the characterisation of meat quality. Non destructive methods of marbling characterization (quantity and distribution of intra-muscular fat) have been investigated for the classification of muscles or parts of muscles using the characteristics of the connective tissue. Among the many methods, ultrasonic techniques (Real-time ultrasound) used on living animals or on muscles, have been extensively explored (*Whittaker et al.,* 1992; *Izquierdo et al.,* 1998).

More recent work that combined image processing parameters (histogram, texture) in multiple regression models showed a good potential for real-time ultrasound technology to predict intramuscular fat *(Wilson et al.,* 1992; *Amin et al.,* 1993; *Brethour et al.,* 1994; *Izquierdo et al.,* 1998).

Cross et al. (1992) used a video image analyzer (VIA) for beef grading. Considering the good results of *Sönnichesn et al.* (1998), VIA seems to be an appropriate instrument for beef classification and prediction of carcass composition.

Thompson (1991) proposed using computer-aided tomography (CT) to quantify intramuscular fat content in beef.

The aim of this study was to establish a prediction equation to estimate the weight of lean meat at slaughter from the weight of trimmed fat, the adipose cell diameter, the weight of kidney fat, and the hot half carcass weight.

MATERIALS AND METHODS

Holstein-Friesian and Hungarian Fleckvieh cows (n=18) were used in this study. The animals were fed corn silage based diets with grass hay and moderate concentrate supplementation free choice. The animals were transported to the slaughterhouse by track and after lairage for overnight were slaughtered. After the slaughter 1 g subcutaneous fat samples were taken from rump and the adipocyte diameter was measured (*Tőzsér et al.,* 1997). The half carcasses are chilled for 24 hrs. Right and left half carcasses are then dissected and the weight of lean, bone and fat are determined by complete tissue separation.

Rotation of factors was done as outlined by the Varimax method (*Sváb,* 1979). The background variables were calculated from the correlation matrix of the parameters. Only components with a eugenic value of over 1.0 were estimated.

Findings recorded were used for estimation of amount of lean in carcasses by means of stepwise multiple regression analysis (backwards). Variables that were included into the model are as listed below: weight of lean meat at slaughter (y), weight of trimmed fat (x_1), adipocyte diameter (x_2), weight of kidney fat (x_3), weight of hot carcass halves (x_4).

RESULTS AND DISCUSSION

The average final weight of cows was 533.61±78.77 kg, respectively. Means and standard deviations for weight of lean meat at slaughter, weight of trimmed fat, adipocyte diameter, weight of kidney fat, weight of hot carcass halves were recorded: 167.5±33.50 kg; 35.3±15.20 kg; 79.1±27.09 μ; 6.6±4.31 kg; 261.2±47.82 kg, respectively. The matrix of correlation is shown in *Table 1*.

Moderate positive relationship (r=0.44, P>0.05) was found between adipocyte diameter and weight of hot half carcass. This tendency was also observed for weight of lean meat. On the contrary, between adipocyte diameter and weight of trimmed fat we observed a close positive correlation (r=0.69, P<0.01). The correlation was very close (r=0.84, P<0.001) between adipocyte diameter and weight of kidney fat. *Lee at al.,* (1983) published the simple correlations between adipose tissue cellularity and some carcass traits in the Hereford and Charolais young bulls. The adipose cell size was positively correlated (Hereford, r=0.70; r=0.62, P<0.01; Charolais, r=0.63; r=0.60, P<0.01) with percentage carcass fat and total carcass fat mass in this study. The medium positive relationships (Hereford, r=0.53; P<0.01; Charolais, r=0.44, P<0.01) were found between adipocyte diameter and yield grade.

The results of means of principal component analysis (PCA) are summarised in *Table 2*.

Table 1

Coefficients of correlation between adipocyte diameter (μ) and further variables analyzed

Variables(1)	Coefficients correlation (r)(2)
Weight of hot half carcass (kg)(3)	0.44
Weight of cold half carcass (kg)(4)	0.44
Weight of lean meat (kg)(5)	0.40
(%)(6)	0.01
Weight of kidney fat (kg)(7)	*0.84****
(%)(8)	*0.80****
Weight of trimmed fat (kg)(9)	*0.69***
(%)(10)	*0.70***

Level of significance *(szignifikancia szint):* *=P<0.05; **=P<0.01; ***P<0.001

1. táblázat: Korrelációs eggyütthatók (r) a zsírsejtátmérő és egyéb vizsgált tulajdonság között

Tulajdonságok(1), Korrelációs eggyüthatók(2), Meleg hasított felek súlya, kg(3), Hideg hasított felek súlya, kg(4), Színhús mennyiség, kg(5), Színhús arány,%(6), Vesefaggyú mennyiség, kg(7), Vesefaggyú arány,%(8), Kivágott faggyú mennyiség, kg(9), Kivágott faggyú arány,%(10)

Table 2

Eigenvalues, share of total variance, factor and factor loading after rotation

Factor loadings for variables (1)	Factor I carcass and lean meat(2)	Factor II fat and adipocyte diameter(3)
Weight of hot half carcass (kg)(4)	*0.9623*	0.2677
Weight of cold half carcass (kg)(5)	*0.9614*	0.2723
Weight of lean meat (kg)(6)	*0.9542*	0.1699
Weight of kidney fat (kg)(7)	0.2303	*0.9266*
Weight of trimmed fat (kg)(8)	0.5897	*0.6947*
Adipocyte diameter (μ),(9)	0.2019	*0.9225*
Eigenvalue(10)	3.2025	2.3669
Variance of eigenvalue,%(11)	*53.4*	*39.4*

Remark: total variance *(megjegyzés: teljes variancia):* 92.8%

2. táblázat: A sajétértékek, a teljes variancia részarányának, a faktorknak és a faktorsúlyoknak az alakulása forgatás után

Faktorsúlyok(1), I. faktor: csontoshús-színús(2), II. faktor: faggyú-zsírsejtátmérő(3), Meleg hasított felek súlya, kg(4), Hideg hasított felek súlya, kg(5), Színhús mennyiség, kg(6), Vesefaggyú mennyiség, kg(7), Kivágott faggyú mennyiség, kg(8), Zsírsejtátmérő, μ(9), Sajátérték(10), Sajátérték-variancia,%(11), Megjegyzés: teljes variancia,%(11)

Two factors were determined as follows: carcass and lean meat (I.), fat and adipocyte diameter (II.). In case of factor I, the individual factor loadings (>0,6) involved in the weight of hot and cold half carcass and the weight of lean meat played predominant roles (variance of eigenvalue:53.4%). Factor II (variance of eigenvalue:39.4%) determined predominantly the weight of kidney fat, the weight of trimmed fat and the adipocyte diameter. In this study, we can account over the 92.8% of the total variance. These results clearly confirmed that the variables for the deposition of fat and adipose tissue cellularity have to be included into the prediction model. The results of multiple regression analysis are presented in *Table 3*.

Table 3

Results of the stepwise multiple regression analysis

Dependent variable (y)(1)	Independent variables (x_1 -x_4)(2)	Partial coefficients of correlation (r)(3)	Partial coefficients of regression (b_1-b_4)(4) step: 0	Partial coefficients of correlation (r)(5)	Partial coefficients of regression (b_1-b_4)(6) step: 1
Weight of lean meat (kg)(7)	Weight of trimmed fat (kg), x_1 (8)	-0.90***	-0.541	-0.89***	-0.511
	Adipocyte diameter (μ), x_2 (9)	0.53*	0.149	0.73**	0.197
	Weight of kidney fat (kg), x_3 (10)	0.29	0.077	-	-
	Weight of hot carcass halves (kg), x_4 (11)	0.99***	1.266	0,99***	1.259
Regression equations (12)	Intercept (13)	-	-40.610	-	-42.325
	Determination coefficients (R^2)(14)	-	*0.98****	-	*0.98****
	Residual standard error (r_{sxy})(15)	-	4.779	-	4.813

Level of significance *(szignifikanci szint):* *=P<0.05; **=P<0.01; ***P<0.001

3. táblázat: A lépésenkénti (stepwise) regresszióanalízis eredményei

Függő változó, y(1), Független változók, x(2), Parciális korrelációs együtthatók, r(3), Parciális regressziós együtthatók, b, lépés: 0(4), Parciális korrelációs együtthatók, r(5), Parciális regressziós együtthatók, b, lépés: 1(6), Színhús mennyiség, kg(7), Kivágott faggyú mennyiség, kg, x_1(8), Zsírsejtátmérő, μ, x_2(9), Vesefaggyú mennyiség, kg, x_3(10), Meleg hasított felek súlya, kg, x_4(11), Regressziós egyenlet komponensei(12), Állandó(13), Determinációs együttható, R^2(14), A becslés hibája, r_{sxy},(15), Szignifikancia szint(16)

The estimation of weight of lean meat (y) from weight of trimmed fat (x_1), adipose cell diameter (x_2), weight of kidney fat (x_3), weight of hot half carcass (x_4) was very close

(R^2=0.98, P<0.001). Using stepwise multiple regression analysis 98% of total variance with 4.81 residual standard deviation is determined by three independent variables as follows: weight of trimmed fat (x_1), adipose cell diameter (x_2), weight of hot half carcass (x_4). Several prediction equations of the body lipids and muscle are proposed by *Robelin et al.*, (1986, 1989) for the use of the animal breeders (e.g: Holstein cow, Lip%=0.144*DIAM+3.88; Mus%= -0.1078*DIAM+71.24, where: lip%= total body fat content as a percentage of empty body weight; Mus%=carcass lean content as a percentage of carcass weight; DIAM=adipose cell diameter, micron). Thirty one fattening young bulls of Holstein were studied at a feed-lot farm in Zirc, Hungary by *Tőzsér et al.,* (1997). The adipose cell diameter joined to live weight gave a reasonably good estimation of total body fat content (R^2%=0.61, P<0.001). The percentage of the determination coefficients (R^2%) by the live weight, empty body weight and adipocyte diameter on the estimation of the lean-to-fat ratio was less than 50%.

From the point of view of practical application, it is very important to the breeders that the heritability of adipocyte diameter be relatively high (h^2=0.50)(*Renand et al.,* 1989).

CONCLUSIONS

The following conclusions can be drawn from this study:

- The close positive correlation between adipocyte diameter and weight of trimmed fat confirm that the adipose cell size can be also used to the improvement of selection for the in vivo total body fat content prediction.
- Respecting of our results by stepwise multiple regression analysis (backwards) and principal component analysis, we can propose to use the adipocyte morphometry to estimation the weight of lean meat with other parameters.
- This first investigation needs to be repeated and confirmed with new samples of cattle from diverse breeds.

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