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Abstract

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To predict body weight of beef cattle using traditional methods and digital image analysis system, 140 animals were used and prediction models were developed. The R^2 values of prediction equations were 52.1, 63.6, 53.2, 47.1, 43.1 and 49.8% for body area, body length, wither height, hip height, hip width and chest depth, respectively. The regression equations which included only body area, body length or wither height showed that the prediction ability of digital image analysis system was better than the equations including other body traits. The results showed that the prediction ability of digital image analysis system was very promising to predict body weight.

Keywords: Prediction, body weight, body measurements, digital image analysis, beef production.

Introduction

An evaluation procedure for predicting weights and yields of carcasses and beef retail cuts becomes of great importance for the beef industry (Cross and Belk, 1994). Several technologies have been evaluated to determine the accuracy and precision for predicting body weight and carcass meat weights, but more recently, video image analysis have drawn attention to be used as a tool in the development of cattle marketing systems (McClure *et al.*, 2003). No information on the use of such systems for the determination of preslaughter body weight of live animal is available. Therefore, in this study it was aimed to predict body weight of slaughtering beef cattle by using both traditional methods and digital image analysis system.

Materials and Methods

One hundred and forty animals were selected from commercial slaughterhouses in Isparta and Burdur provinces in the Mediterranean part of Turkey. All animals were weighed by a digital weighing scale prior to slaughter (Marmara 0580 MEB). Body measurements of animals were obtained from both digital images using a video camera (Canon MV850i) and metric measurements using measuring stick and tape (Hauptner, Germany) respectively. Body weight, wither height, body length, chest depth, hip width and hip height were taken while animals were standing in a crush. All body traits were

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measured by measuring stick and tape; except body area which was determined from the digital images only.

The camera was set on a standard quality (640x512 pixel resolution). Location of camera and camera settings were tried to be constant while taking images. Whole body images were taken by placing the reference card over each live animal (Fig. 1) and obtaining two sequential but separate images without moving the camera head unit in a fixed position. Digital images were downloaded from the camera to a computer file and processed using Image Pro Plus.5 software to obtain the above-mentioned body measurements including body area from the images.

The differences between actual and predicted body measurements were examined by paired t-test using statistical program (Minitab v.13). The actual and predicted body measurements were also compared using MSPE (Mean Square Prediction Error).

$$\text{MSPE} = \frac{1}{n}\sum_{i=1}^{n} (Oi-Pi)^2$$

Where n is the number of pairs of actual and predicted values being compared i = (1, 2, 3,......, n), Oi is the observed (or actual) measurements with ith variable and Pi is the predicted measurements with ith variable.

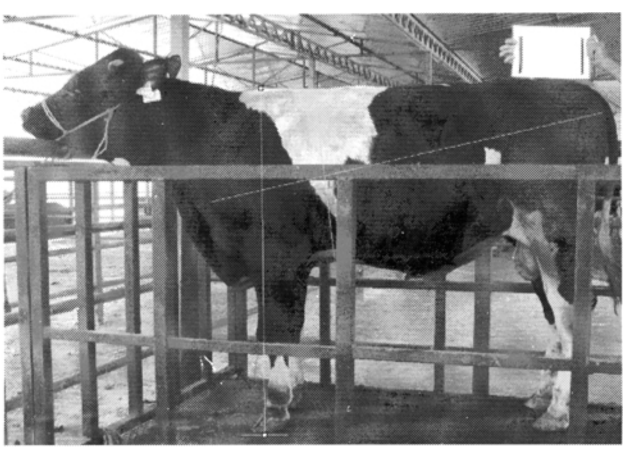

Fig. 1. Typical digital body measurements in Image Pro plus software

The MSPE can be considered as the sum of three components described by Rook *et al.* (1990).

$$\text{MSPE} = (O\text{-}P)^2 + S_p^2(1\text{-}b)^2 + (1\text{-}r^2)\, S_o^2$$

Where, S_O^2 and S_P^2 are the variances of the actual and predicted measurements respectively. O and P are the means of the observed (actual) and predicted measurements, b is the slope of the regression of actual values on predicted and r is the correlation coefficient between O and P.

Regression of body weight on body area (BA), wither height (WH), body length (BL), chest depth (CD), hip width (HW) and hip height (HH) utilizing individual observations were performed. The body measurements obtained by image analysis system included body area (BA) as a different parameter for prediction of body weight. Pearson's correlation coefficients were calculated between actual and predicted values obtained by image analysis. Linear effects of the independent variables were also considered and included in the following model:

$$Y_i = b_0 + b_1 x_i + e_i$$

Where Y_i= BW observation of an i th animal, b_0= intercept, b_1 = corresponding linear regression coefficient i x_i = body measurements (BA, WH, BL, CD, HW and HH) and e_i = residual error term.

Results and Discussion

Body measurements were overpredicted for all traits and in terms of contribution of components to MSPE; the values of bias, line and random error were 24.3%, 11.6%, 16.9%, 15.6% and 20.7% for BL, WH, HH, HW and CD, respectively (Table 1). The model had a greater proportion of error derived from both bias and random than line component. A small proportion of line as a component of MSPE showed that the error derived from line was substantially low and there was a statistically significant (P<0.05) variation between predicted and actual measurements. Overpredictions were 2.46, 1.63, 1.54, 3.9 and 4.6% more than the actual values for BL, WH,

Table 1
Mean square prediction error and proportions of MSPE (%) between actual and predicted body measurements

N=140		Mean	SE	Mean bias*	Proportion of MSPE (%)			
					MSPE	Bias	Line	Random
BL	Actual	141.9	0.80					
	Predicted	145.4	0.87	3.5±0.575	24.3	0.50	0.063	0.44
WH	Actual	128.8	0.66					
	Predicted	130.9	0.67	2.14±0.422	11.6	0.37	0.019	0.61
HH	Actual	133.5	0.66					
	Predicted	135.6	0.68	2.1±0.581	16.9	0.26	0.065	0.677
HW	Actual	44.4	0.39					
	Predicted	46.2	0.38	1.8±0.594	15.6	0.21	0.110	0.682
CD	Actual	66.4	0.48					
	Predicted	69.6	0.53	3.2±0.530	20.7	0.51	0.082	0.412

*Statistically significant (P<0.05).

HH, HW and CD, respectively. However, these overpredictions were ignorable in practical terms.

The highest R^2 values were obtained from BL (63.6%) followed by WH (53.2%) and BA (52.1%) (Table 2). These results indicated that the regression equations which included only BL, BA or WH showed that the prediction ability of digital image analysis system was better than the rest of the equations including other body traits (Table 2). Results also showed that a 1 cm^2 change in BA resulted in approximately 0.033 kg change in weight. Similarly, a 1 cm change in BL, WH, HH, HW and CD resulted in 8.46, 10.07, 9.25, 15.8 and 12.3 kg change in weight, respectively (Table 2). It was evident that a 1 cm^2 change in BA resulted in lesser weight change compared to the rest of body traits. When considering multiple regressions of bodyweight on digital image body measurements, the highest R^2 value was obtained from the equation including all body traits (R^2=66.7%). It was observed that inclusion of BL in the multiple regression equations increased R^2 greatly (Table 3). All linear terms of all body traits were significant (P <0.05). The R^2 values from the regressions indicate that BL, BA and WH to be the most highly related variables to body weight considering all linear coefficient terms.

All correlation values obtained for all body traits were statistically significant (P<0.05) and highest correlation was found between BL and BW (r=0.80). The second highest correlation was between WH and BW (r=0.73).

Thus body area (BA) and body length (BL) obtained by digital image analysis can provide a considerably reliable prediction of body weight. It is unavoidable that some images may not be clear enough for processing or improper position of live animal and of reference cards placed on live

Table 2
Linear effects of the independent variables

Measurements*	Constant	Linear	R^2,%
BA	-32.5	0.033	52.1
BL	-752.6	8.459	63.6
WH	-841.9	10.07	53.2
HH	-776.7	9.253	47.1
HW	-252.2	15.79	43.1
CD	-376.1	12.26	49.8

*Statistically significant (P<0.05).

Table 3
Multiple linear regression equations with the highest R^2 values to predict bodyweight using digital body measurements

Prediction Equations	Constant	BA(cm^2)	BL	WH	HH	HW	CD	$R,^2$%
$Y=a+b_1x_1+b_2x_2+b_3x_3+b_4x_4+b_5x_5+b_6x_6$	–778	0.00194^{ns}	5.94	2.67^{ns}	-1.63^{ns}	4.98	0.04^{ns}	66.7
$Y=a+b_1x_1+b_2x_2+b_3x_3+b_4x_4+b_5x_5$	–779	0.00194^{ns}	5.96	2.67^{ns}	-1.63^{ns}	4.98	-	66.7
$Y=a+ b_2x_2+b_3x_3+b_4x_4+b_5x_5+b_6x_6$	–805	-	6.09	2.68^{ns}	-1.38^{ns}	5.01	0.04^{ns}	66.7
$Y=a+b_1x_1+b_2x_2+b_3x_3+b_5x_5$	–826	0.00035^{ns}	5.76	1.83^{ns}	-	4.77	-	66.5
$Y=a+b_1x_1+b_2x_2+b_4x_4 +b_5x_5$	–739	0.00198^{ns}	6.78	-	-0.25^{ns}	5.07	-	66.1
$Y=a+b_1x_1+b_2x_2+b_5x_5+b_6x_6$	–749	0.00166^{ns}	6.55	-	-	5.01	0.26^{ns}	66.0
$Y=a+b_2x_2+b_3x_3+b_4x_4+b_5x_5$	–805	-	6.11	2.68^{ns}	-1.38^{ns}	5.01	-	66.7
$Y=a+b_2x_2+b_3x_3+b_5x_5+b_6x_6$	–829	-	5.73	1.86^{ns}	-	4.78	0.14^{ns}	66.5
$Y=a+b_2x_2+b_4x_4+b_5x_5+b_6x_6$	–764	-	6.79	-	0.01^{ns}	5.08	0.25^{ns}	66.0
$Y=a+b_1x_1+b_2x_{2+}b_5x_5$	–752	0.00165^{ns}	6.68	-	-	5.02	-	66.0
$Y=a+b_2x_2+b_4x_4+b_5x_5$	–766	-	6.93	-	0.01^{ns}	5.09	-	66.0
$Y=a+b_1x_1+b_2x_2$	–727	0.00310^{ns}	7.95	-	-	-	-	63.7
$Y=a+b_1x_1+b_3x_3$	–709	0.0118	-	7.66	-	-	-	55.6
$Y=a+b_1x_1+b_6x_6$	–363	0.0158	-	-	-	-	8.55	55.0
$Y=a+b_2x_2+b_5x_5$	–766	-	6.93	-	-	5.10	-	66.0

ns: Statistically non-significant (P>0.05).

animal can make it difficult to measure correctly on digital images. Prediction ability of the equations may also be affected by the variation of the animal's breed and size.

It is concluded that the prediction ability of digital image analysis system was very promising to predict BW. However, there is still a need for further investigations for different breeds of cattle, taking into account their size as well under better controlled experimental conditions.

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वाई.बोज्कुर्ट, एस.अक्तान, एस.ओज्काया। अंकीय छाया विश्लेषण के द्वारा वधित मांसद गौ के शरीर भार की प्रागुक्ति।

पारंपरिक विधि और अंकीय छाया विश्लेषण विधि से मांसद गौ के शरीर भार के प्रागुक्ति हेतु 140 पशुओं का उपयोग किया गया और प्रागुक्ति माडलों को विकसित किया गया। प्रागुक्ति समीकरणों के आर^2 मान शारीरिक क्षेत्रफल, शारीरिक लंबाई, स्कंध पर ऊंचाई, चुत्तड़ तक ऊंचाई, चुत्तड़ की चौड़ाई और छाती की गहराई का क्रमश: 52.1, 63.6, 53.2, 47.1, 43.1 और 49.8% था। केवल शारीरिक क्षेत्रफल, शारीरिक लंबाई या स्कंध तक ऊंचाई से विकसित समाश्रयण समीकरणों तथा अन्य शारीरिक मापों से निर्मित समीकरणों की तुलना में अंकीय छाया विश्लेषण अच्छा है। परिणामों से पता चला कि शरीर भार प्रागुक्ति हेतु अंकीय छाया विश्लेषण विधि की प्रागुक्ति दक्षता बहुत ही आशाजनक है।