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PREDICTION OF BODY FATNESS FROM BODY MEASUREMENTS IN NEW ZEALAND WHITE RABBITS

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SUMMARY

Possibilities of predicting body fatness from body measurements were examined using 121 New Zealand White rabbits aged 90 days. Body measurements included body weight at marketing age (FBW), heart girth (HG), abdomen circumference (AC) and chest width (CW). The fatness indicating traits (FIT) were weights of total body fat (TBFW), non-carcass fat (NCFW), subcutaneous fat (SCFW) and inter muscular fat (IMFW) and TBFW as percentage of marketing body weight (TBFP). Each of FIT was highly significantly correlated with FBW (0.79 to 0.91), HG (0.76 to 0.86), AC (0.70 to 0.85) and CW (0.73 to 0.81). Several prediction equations based on final body weight and linear body measurements alone (simple regression) and on final body weight and linear measurements simultaneously (stepwise regression) were developed. Prediction of FIT based on final body weight alone was more accurate (R^2 = 0.62 to 0.82) than that based on individual linear body measurements with the HG being the most accurate predictor within this group. The inclusion of final body weight and linear body measurements into one equation did not increase the accuracy of prediction (+ 2% to +9%). The results further indicate that final body weight alone is a reasonably accurate predictor for body fatness expressed in gram using the equation: TBFW= -120.39 + 0.102 FBW (R^2 = 0.82) or as percentage of final body weight using the equation: TBFP= -2.96 + 0.004 FBW (R^2 = 0.67) or expressed in grams of non-carcass fat: NCFW= -63.89 + 0.053 FBW (R^2 = 0.82) or subcutaneous fat: SCFW= -22.73 + 0.019 FBW (R^2 = 0.62) or inter muscular fat: IMFW= -33.66 + 0.029 FBW (R^2 = 0.76).

Keywords: body fatness, body measurements, prediction equations, New Zealand White rabbits

INTRODUCTION

Over the last three decades, rabbit meat has gained wide popularity among consumers mainly for their health benefits. Compared with red meats, rabbit meat is usually considered as low fat meat (Dalle Zotte, 2002). This is due to the low conversion rate of grams of usable protein into K calorie in meat, which is 105 for rabbit meat, 427 for sheep meat and 442 for beef (Lebas *et al*., 1986). The chemical composition of lipid component in rabbit is extremely variable, ranging from 3.6% (Ouhayoun *et al*., 1981) to 7.1% (Pla *et al*., 2004). This range of variation may impact the consumer desire for rabbit meat. Moreover, the poor partition of fat component between depots is a problem for rabbit breeders and processors for waste dietary energy, management and product yield. Prediction of body fatness using correlated indicators will enable the rabbit breeder select against body fatness thereby enhancing the quality of its meat. Previous studies on rabbits showed relationships between linear body measurements and carcass attributes (Lukefahr and Ozimba, 1991; Shemeis and Abdallah, 2000; Pinna *et al*., 2004 and Ogah , 2012). However, there is lack of information on the relationship between body fatness and body measurements. This information gap necessitated the interest shown in the current study.

The aim of the present study was to develop simple and multiple regression equations to predict body fatness in New Zealand White rabbits using body measurements.

MATERIAL AND METHODS

Source of data:

A total of 121 New Zealand White rabbits were chosen randomly at marketing age (90 days) to be slaughtered. The rabbits were born (march- April, 1996) in private rabbit farm and slaughtered, dressed out and dissected in the Meat Laboratory of Animal Production Department, Faculty of Agriculture, Ain Shams University.

Management of Animals:

At 28 days of age, weaning age, rabbits were separated from their dams into fattening batteries. They were fed *ad libitum* a commercial pelleted diets providing 2800 K. Cal. digestible energy/kg diet until marketing age (90 days).

Traits Measured:

At marketing, rabbits were weighed (FBW) and transferred to the Meat Laboratory of Animal Production Department, Faculty of Agriculture, Ain Shams University. They were measured for body dimensions according to the procedures described by Blasco *et al.* (1992). They were then slaughtered and dressed within one hour of their arrival with the heart, mesenteric, caul and kidney knob and channel fats removed and weighed (NCFW). Carcasses were held at 2 °C for 24 hours before subcutaneous fat (SCFW) and intermuscular fat (IMFW) of the right side were dissected and weighed. Weights of SCFW and IMFW were multiplied by two and added to weights of the non-carcass fat (NCFW) depots to give total body fat (TBFW) according to the method described by Shemeis *et al*., 1994). Total body fat weight as % of body weight (TBFP) was calculated.

Statistical Analyses:

Each dependent variable (TBFW, TBFP,SCFW, IMFW and NCFW) was predicted from the body measurements using the following regression models:

Single variable model $\mathbf{Y_i = a + bx_i + e_i}$

Multiple variables model: $\mathbf{Y_i = a + b_1X_{1i} + b_2X_{2i} + ... + b_pX_{pi} + e_i}$

Where :

Y_i = the dependent variable (fatness indicating traits) of the i^{th} rabbit;

x_i = the i^{th} independent variables

a = intercept;

X_{pi} = the p^{th} independent variable (linear body measurements) of the i^{th} rabbit;

b_1 , b_2, ..., b_P =partial regression coefficients of Y on X's; and

e_i = error assumed to be NID (0, σ^2_e).

The regression analysis was performed using the REG procedure of SAS (2001)

Detecting Multicollinearity:

To indicate Multicollinearity, a high degree of correlation among the independent variables, as among the considered predictors in the present study, tolerance value and variance inflation factor value (VIF) were calculated according to Montgomery (2001).

RESULTS AND DISCUSSION

Means and coefficients of variation for body measurements and body fatness indicating traits are given in Table (1).

It appeared that the coefficients of variability for the traits describing body weight (16.9%), heart girth (7.6%), abdomen circumference (7.0%) and chest width (12.3%) were obviously lower than those for body fatness indicating traits (37.2 to 56.2%). The variability in total body fat in absolute value was lowered by 11% when expressed as percentage of final body weight (48.6 *vs*. 37.2%).

Correlations:

Correlation coefficients between body FIT and body measurements are given in Table (2).

Linear body measurements showed highly significant and comparable positive correlations with total body fat weight (0.81 to 0.91), total body fat weight expressed as a percentage of final body weight (0.77 to 0.82), non-carcass fat weight (0.81 to 0.91), subcutaneous fat weight (0.70 to 0.79) and intermuscular fat weight (0.76 to 0.87). These correlations indicate that the body weight and linear body measurements could be used to predict body fatness indicating traits with reasonable accuracy.

The high positive correlation obtained in the present study between final body weight and heart girth (0.87, Table 2; 0.86, Akinsola *et al*., 2014; 0.84, Udeh, 2013; 0.92, Afolabi *et al*., 2012; 0.76, Hassan *et al*., 2012; 0.62, Okoro *et al*., 2010; 0.91, Yakubu and Ayoade, 2009), final body weight and chest width (0.85, Table 2; 0.75 – 0.87, Shahin and Hassan, 2000), final body weight and abdominal circumference (0.87, Table 2; 0.67, Hassan *et al*., 2012) indicated the necessity of testing these predictors for multicollinearity.

Table 1. Means ($\bar{X}$), standard errors (SE) and coefficient of variations (CV %) of body measurements and body fatness

Trait	$\bar{X}$ ±SE	CV (%)
Body measurements :		
- Final weight (g)	1919±29.5	16.9
- Heart girth (cm)	23.4±0.2	7.6
- Abdomen circumference (cm)	26.0±0.2	7.0
- Chest width (cm)	5.5±0.1	12.3
Body Fatness :		
- Total body fat weight (gm)	75.0±3.3	48.6
- Total body fat percentage *	3.4±0.1	37.2
- Non-carcass fat weight (g)	38.6±1.7	49.6
- Total subcutaneous fat weight (g)	14.2±0.7	56.2
- Total intermuscular fat weight (g)	22.2± 1.0	49.0

* : calculated relative to body weight at marketing

Table 2. Simple correlation coefficients* between body measurements and body fatness indicating traits and between them

Trait	Body measurements				Body Fatness				
	FBW	HG	AC	CW	TBFW	TBFP	NCFW	SCFW	IMFW
Body measurements									
Final weight (FBW)	-	0.87	0.87	0.85	0.91	0.82	0.91	0.79	0.87
Heart girth (HG)		-	0.80	0.83	0.86	0.82	0.85	0.76	0.84
Abdomen circumference (AC)			-	0.75	0.84	0.79	0.85	0.70	0.82
Chest width (CW)				-	0.81	0.77	0.81	0.73	0.76
Body Fatness									
Total body fat weight (TBFW)					-	0.98	0.98	0.90	0.97
Total body fat percentage (TBFP)						-	0.95	0.89	0.95
Non-carcass fat weight (NCFW)							-	0.82	0.92
Total subcutaneous fat weight (SCFW)								-	0.84
Total intermuscular fat weight (IMFW)									-

*: All coefficients are highly significant at P<0.001.

Table 3. Diagnoses of multicollinearity among the predictors

Predictor	Tolerance value[a]	Variance inflation value[b]
Final body weight	0.14	7.38
Heart girth	0.20	5.10
Abdominal circumference	0.24	4.18
Chest width	0.24	4.25

a: Tolerance value less than 0.10 indicates collinearity,
b: VIF value greater than 10 indicates collinearity.

Multicolinearity:

Values of tolerance and variance inflation factor of the predictors are given in Table (3). Tolerance value represents the amount of variability in independent variable that is not explained by other independent variables. The tolerance values indicated that 14% of the variability in final body weight is not explained by linear body measurements. The corresponding figures were 20% for heart girth and 24% for each of abdominal circumference and chest width. The values of VIF illustrated that 92.62% of the variance in final body weight could be explained by linear body measurements. The corresponding figures were 94.90% for heart girth, 95.82% for abdominal circumference and 95.75% for chest width. These results indicate that the degree of multicollinearity among the four predictors could be negligible. So, these findings can be trusted and applied to other samples.

Prediction Equations:

The regression equations for predicting body fatness from final body weight, heart girth, abdominal circumference and chest width with their accuracy of prediction (R^2) values are given in Table (4).

Prediction of total body fat weight from final body weight alone (E_1) was more accurate (R^2 = 0.82) than that based on heart girth alone (R^2= 0.75), abdomen circumference alone (R^2 = 0.71) and chest width alone (R^2= 0.66). Adding linear body measurements to final body weight (the best single predictor) to formulate E_5 didn't increase accuracy of prediction drastically (R^2 =0.85, E_5 *vs* 0.82, E_1). This is due to the strong correlation among the predictors (r = 0.75 to 0.87).

Expressing total body fat weight as percentage of marketing body weight was associated with higher reduction in prediction accuracy using final body weight alone (R^2 = 0.67 *vs* 0.82), heart girth alone (R^2= 0.67 *vs* 0.75), abdominal circumference alone (R^2 = 0.62 *vs* 0.71) and chest width alone (R^2= 0.59 vs 0.66). Prediction accuracy was decreased by 12% unit with the four traits as predictors (E_{10} *vs* E_5).

Accuracy of predictions of total non-carcass fat weight was similar to those obtained for total body fat weight. This similarity was found using either single variable models (R^2= 0.66 to 0.82 for each of E_1 to E_4 and E_{11} to E_{14}) or multiple variables model (R^2= 0.85 for E_5 *vs* 0.84 for E_{15}).

Prediction of subcutaneous fat weight from final body weight alone (E_{16}) was more accurate than that based on heart girth alone (E_{17}) by 4%, abdomen circumference alone (E_{18}) by 12% and chest width alone (E_{19}) by 9%. As compared with prediction based on final body weight alone (R^2 = 0.62, E_{16}), adding heart girth, abdominal circumference and chest width to formulate E_{20} was not useful in increasing accuracy of prediction (R^2 = 0.64).

Prediction of intermuscular fat using the same predictors appears that the four predictors were more accurate in predicting the weight of intermuscular fat (R^2 = 0.58 to 0.76 for single trait model and 0.80 for the multiple trait model) than that of subcutaneous fat (R^2 = 0.50 to 0.62 for the single trait model and 0.64 for the multiple trait model).

CONCLUSION

The results obtained in the present study permit to use the final body weight (FBW) alone as a reasonably accurate predictor for body fatness

Table 4. Prediction equations for body fatness indicating traits from live performance traits one decimal only

Dependent trait	Model type[Ɩ]	Equation No. (E)	Intercept	b-Values [a] FW	HG	AC	CW	R^2	R.E (%)[b]
Total Body fat weight (gm)	SVM	1	-120.39	0.102	-	-	-	0.82	100.00
		2	-336.44	-	17.59	-	-	0.75	91.46
		3	-361.468	-	-	16.79	-	0.71	86.59
		4	-164.828	-	-	-	43.46	0.66	80.49
	MVM	5	-254.701	0.059	5.45	3.43	-	0.85	103.66
Total body fat as percentage of final body weight	SVM	6	-2.96	0.004	-	-	-	0.67	100.00
		7	-11.08	-	0.633	-	-	0.67	100.00
		8	-11.759	-	-	0.595	-	0.62	92.54
		9	-4.884	-	-	-	1.56	0.59	88.06
	MVM	10	-10.384	0.001	0.306	0.185	-	0.73	108.96
Total Non-carcass fat weight (gm)	SVM	11	-63.89	0.053	-	-	-	0.82	100.00
		12	-173.867	-	9.085	-	-	0.72	87.81
		13	-191.688	-	-	8.857	-	0.71	86.59
		14	-87.328	-	-	-	22.83	0.66	80.49
	MVM	15	-130.130	0.033	2.196	2.113	-	0.84	102.44
Total Subcutaneous fat weight (gm)	SVM	16	-22.73	0.019	-	-	-	0.62	100.00
		17	-65.06	-	3.387	-	-	0.58	93.55
		18	-65.467	-	-	3.063	-	0.50	80.65
		19	-32.755	-	-	-	8.50	0.53	85.48
	MVM	20	-42.784	0.012	1.416	-	-	0.64	103.23
Total intermuscular fat weight (gm)	SVM	21	-33.66	0.029	-	-	-	0.76	100.00
		22	-97.52	-	5.118	-	-	0.71	93.42
		23	-104.313	-	-	4.865	-	0.67	88.16
		24	-44.745	-	-	-	12.13	0.58	76.32
	MVM	28	-79.593	0.015	1.864	1.167	-	0.80	105.26

Ɩ: SVM= single variable model; MVM= Multiple variables model;
a: FW : final weight; CC: chest circumference ; AC: abdomen circumference; CW: chest width;
b: calculated relative to final weight accuracy

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التنبؤ بتدهن الجسم اعتماداً على مقاييس الجسم فى أرانب النيوزيلندى الابيض

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قسم الانتاج الحيوانى، كلية الزراعة ، جامعة عين شمس ، شبرا الخيمة ،١١٢٤١ القاهرة، مصر

تم اختبار امكانيات التنبؤ بتدهن الجسم من مقاييس الجسم على عدد ١٢١ أرنب نيوزيلندى ابيض. شملت مقاييس الجسم وزن الجسم عند عمر التسويق، محيط الصدر، محيط البطن، عرض الصدر. وكانت الصفات الدالة على تدهن الجسم هى إجمالي وزن دهن الجسم، دهن الاحشاء، دهن تحت الغطاء، دهن بين العضلات إضافة الى إجمالي وزن دهن الجسم كنسبة مئوية من وزن الجسم. أظهرت الدراسة وجود ارتباط معنوي عالي بين كل الصفات الدالة على تدهن الجسم وكل من وزن الجسم عند التسويق (من ٠.٧٩ إلى ٠.٩١) ومحيط الصدر (من ٠.٧٦ إلى ٠.٨٦) ومحيط البطن (من ٠.٧٠ إلى ٠.٨٥) وعرض الصدر (من ٠.٧٣ إلى ٠.٨١). تم عمل العديد من معادلات التنبؤ على كل من وزن الجسم عند التسويق والمقاييس الخطية كل بصورة منفردة (simple regression) أو على وزن الجسم عند التسويق والمقاييس الخطية بصورة مجتمعة (stepwise regression). وقد بينت النتائج ان دقة التنبؤ للصفات الدالة على تدهن الجسم اعتماداً على وزن الجسم عند التسويق منفرداً (R^2 = 0.62 to 0.82) كانت أكبر من تلك المعتمدة على مقاييس الجسم الخطية منفردة وان مقياس محيط الصدر كان أكثر المقاييس الخطية دقة في التنبؤ بتدهن الجسم من بين كل المقاييس الخطية. كذلك فإن إضافة المقاييس الخطية إلى وزن الجسم عند التسويق في معادلة واحدة لم يضف كثيراً في دقة التنبؤ بتدهن الجسم (+٢% إلى + ٩%). وخلصت نتائج الدراسة إلى أفضلية وزن الجسم عند التسويق مقارنة ببقية المقاييس الخطية فى التنبؤ بتدهن الجسم سواء فى صورة جرامات: إجمالي وزن دهن الجسم = -١٢٠.٣٩ + ٠.١٠٢ وزن الجسم (R^2=0.82) أو في صورة نسبة مئوية من إجمالي وزن الجسم: %وزن دهن الجسم = -٢.٩٦ + ٠.٠٠٤ وزن الجسم (R^2=0.67) أو في صورة جرامات لوزن دهن الأحشاء: وزن دهن الأحشاء = -٦٣.٨٩ + ٠.٠٥٣ وزن الجسم (R^2=0.82) أو وزن دهن الغطاء: وزن دهن الغطاء = -٢٢.٧٣ + ٠.٠١٩ وزن الجسم أو وزن دهن بين العضلات : وزن دهن بين العضلات = -٣٣.٦٦ + ٠.٠٢٩ وزن الجسم (R^2= 0.76).