Using Linear Body Measurements of Live Sheep to Predict Carcass Characteristics for Two Iranian Fat-tailed Sheep Breeds

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ABSTRACT : Live animal selection programs that favor animals with a minimum amount of carcass fat are used for improving breeding flocks of sheep. To predict carcass characteristics of live sheep using body measurements in breeding flocks, 200 male and female lambs of two fat-tailed Iranian sheep breeds (Moghani and Makui) were used. Depth of soft tissue over the 12th rib of the live animals was measured with ultrasound (ULGR) and with hypodermic needle (NGR). The height at withers (HW), body length (BL), circumference of heart girth (CH) and width of hooks (WH), were measured. All animals were slaughtered; carcasses were cut into joints and dissected. Breed had a significant effect on all of the live measurements. The Moghani breed showed a higher value for HW, CH, ULGR and NGR, compared to that of Makui. Except for soft tissue depths; ULGR, NGR and GR, the male lambs showed higher values in live and carcass measurements than females. Percentages of carcass, total fat and intermuscular fat in females were higher than that of male lambs. In spite of the higher amount of subcutaneous and intermuscular fat in female (which is usually used for their physiological need, such as pregnancy and lactation), the male lambs had a heavier fat-tail than females. There was a wide range of variation of percentage of total carcass fat and total chemical fat content of carcass in the two breeds. Eventually this wide variation could be use by animal breeders for selection of animals with a lesser amount of carcass fat. Live weight of lambs showed a relatively low correlation with percentage of carcass lean, total fat and subcutaneous and intermuscular fat. Total lean meat was predicted with relatively high coefficients of determination in the two breeds (R^2=0.61 and 0.89, respectively). Live weight and carcass traits were predicted using simple measurements, but with R^2 ranging from 0.53 to 0.93. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 5 : 693-699)***

Key Words : Iranian Sheep, Fat-tailed, Body Measurements, Ultrasound, Needle, Carcass Characteristics

INTRODUCTION

Programming for reducing fat content in herbivore animals is a long-term animal production objective in most developing countries. So live animal selection programs including the animals with a minimum amount of carcass fat is to be used for improving achieving that objective (Osfoori and Fesus, 1996; Bourden, 2000).

Reduction of sheep carcass fat content to an optimum level causes a reduction of cost of production and increasing the output due to the fact that a 40% of less energy is used to produce an extra unit of meat than fat (Dehghanian, 1987; Emamjomeh et al., 1997; Abouheif et al., 1999).

Different techniques are now available to measure the fat content of live animals in which criteria such as efficiency, rapidness, cost, transferability and precision in action are considerable. The ultrasonic technique is one of the methods used now to estimate the carcass fat percentage of live animals. Researchers (Fortin and Shrestha 1986; Edwards et al., 1989; Leymaster et al., 1989) concluded that for sheep, ultrasound lacked the required precision to be a useful predictor of carcass composition. Body composition improved in sheep after 3-4 years of selection on indexes based on ultrasonically measured back fat, muscle depths and live weight (Simm et al., 1990; Cameron and Bracken, 1992). Some equations have been presented by using this technique can be used for evaluation of fat content of lambs of New Zealand mixed sheep breeds (Ramsey et al., 1991). Stanford et al. 1995 used 1,162 lambs at live weights ranging from 32.5 to 70.5 kg and age ranging 3 to 15 months. They predicted lean-meat yield percent (R^2=0.48) using ultrasound longissimuss dept and width, ultrasound subcutaneous fat, age and live weight measurements.

Moghani and Makui are two fat-tailed sheep of East Azarbaijan and Ardabil provinces, both located in North West of Iran. The flocks are mostly managed by the nomadic tribes under the transhumance system. Moghani sheep flocks move from the Ardabil summer ranges down to the winter ranges of the Moghan plane year around, but the group of Makui moving from the Turkish border heights down to the Arasbaran area in West Azarbayjan province. The purpose of the present study was to evaluate several methods of predicting carcass characteristics of live sheep using body measurements in breeding flocks.

MATERIALS AND METHODS

Measurements on live animals

One hundred male and one hundred female lambs of the Moghani and Makui sheep breeds (50 male and 50 female of each breed) were selected and purchased at three months of age. The lambs were born at the end of summer to the

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Table 1. Description of live and carcass traits measured on live animal and carcass

	Traits under the measurement	Description
1	Live weight (LW)	Live weight after an overnight fast before slaughter.
2	Empty body weight (EBW)	Live weight without digestive tube contents.
3	Body length (BL)	The distance along the media line from the anterior edge of the spinous process on the first thoracic vertebra to the posterior edge of the pin bon (tuber ischii).
4	Height at withers (HW)	The height from the button (of the ground) of the front foot to the highest point of the withers between the shoulders.
5	Circumference of heart girth (CH)	The circumference of the body immediately behind the shoulder blades in a vertical plane, perpendicular to the long axis of the body. Measurements were made using a cloth measuring tape.
6	Width of hooks (WH)	The horizontal distance between the extreme lateral points of the Hook bones (tuber coax) of the pelvis.
7	Needle measurement of GR (NGR)	Measurements of GR with a 22 gauge hypodermic needle over the 12th rib 12 cm from the dorsal midline.
8	Ultrasonic measurement of GR (ULGR)	Ultrasonic Measurements of GR with a 22 gauge hypodermic needle over the 12th rib 12 cm from the dorsal midline.
9	Hot carcass weight (HCW)	Hot carcass weight after removal of head, skin, viscera, kidneys, kidney and pelvic fat, and shanks (including metacarpals and metatarsals).
10	Carcass length (CL)	The distance along the anterior edge of the spinous process on the first thoracic vertebra to the posterior edge of the pin bon (tuber ischii).
11	Longissimus dorsi size (A)	Maximum width of the longissimus muscle cross-section posterior to the last rib.
12	Longissimus dorsi size (B)	Maximum depth of the longissimus muscle cross-section posterior to the last rib.
13	Fat depth (C)	Subcutaneous fat thickness over the point of greatest depth of the longissimus muscle posterior to the last rib.
14	True depth of soft tissue (GR)	True depths of soft tissue over 12th rib 11 cm from the dorsal midline on the intact cold carcass.

beginning of spring. They were selected randomly from 10 flocks of sheep belonging to the RPP (Ram Pivot Project), of East Azarbaijan and Ardabil provinces Livestock Affairs Department of Jehad-e-Keshavarzy. After conducting the initial preventive measures (i.e. vaccination, anti parasite administration, etc) animals were weighed and managed in the same type of summer and winter range management system until 12±2 months of age. The animals were transferred to the Animal Science Research Institute in Karaj and weighed after a period of 14-18 h of fasting. Body length (BL) circumference of heart girth (CH) and width of hook (WH) were measured by a cloth tape. Height of withers (HW) measured using a big caliper (Table 1).

Each lamb was restricted in a crate, and the wool was closely clipped over the GR measured site. Depth of soft tissue over the 12th rib 12 cm from the dorsal midline in the live lambs was measured with an ultrasonic instrument (Pi-Medical 480 equipped with 5 MHz transducer, freeze-frame device, and internal measuring scale). Mineral oil was used as the couplant between the transducer and skin. To prevent distortion of the tissues underlying the transducer, minimal pressure was applied on the transducer as the image was frozen on the oscilloscope (Ramsey et al., 1991). Soft tissue depth was measured to the nearest millimeter on the oscilloscope with internal measuring device. At the same anatomical site, a 22 gauge hypodermic needle, attached to small syringe, was inserted until the lateral surface of the 12th rib was connected. Small amount of edible dye was injected to mark the measurement site to measuring the true soft tissue depth. The depth of skin plus soft tissue was measured on the needle with a ruler. The needle was immersed in Methanol alcohol between measurements (Ramsey et al., 1991; Kiyanzad, 1999).

Measurements on carcass

Animals of each breed were weighed, measured and slaughtered. Head, feet (including metacarpals and metatarsals), skin, digestive tract; empty and full, liver, lungs, heart, kidneys, pelvic fat, spleen, diaphragm and genital organs, were removed and weighed during dressing. The remainder was weighed as hot carcass weight (HCW) and stored in a cool room at a 4°C for 24 h. Skin depth was measured in the marked point. The carcasses were taken out of the cold room and the depth of soft tissue was measured with sharpened metal rule. Then carcasses were split longitudinally in two sides and the right side was used for carcass measurements. Carcass length (CL) was measured by using a measuring band. Longissimus dorsi sizes (A, B) and fat depth (C) were measured by metal caliper (Ramsey et al., 1991) (Table 1). Loin eye area was figured by applying acetate paper and then traced area measured by digital planimeter. Then the left side of carcass was cut according to the traditional method comprising of cutting in six different joints of neck, shoulder, brisket and flank, loin, legs and fat-tail weighed each joint separately. Each joint was dissected and the lean meat, intermuscular and

Table 2. Means and standard deviations of live and carcass measurements

Traits	Breed				
	Moghani (n=100)		Makui (n=100)		
	Mean	SD	Mean	SD	Sig.
LW (kg)	38.64	4.48	36.30	6.01	0.02
EBW (kg)	31.35	3.49	29.45	4.90	0.00
HW (cm)	67.65	2.72	64.24	3.67	0.08
CH (cm)	85.71	3.40	84.13	4.78	0.00
BL (cm)	41.77	1.86	42.95	2.47	0.00
WH (cm)	18.31	1.08	19.08	1.06	0.00
ULGR (mm)	5.10	1.28	4.18	1.33	0.00
NGR (mm)	5.40	1.50	4.14	1.26	0.00
CL (cm)	65.68	2.36	65.37	3.02	0.42
GR (mm)	3.50	1.58	2.66	1.45	0.00
A (mm)	55.5	4.90	58.07	5.32	0.01
B (mm)	31.05	4.27	27.70	3.42	0.01
C (mm)	2.69	1.09	2.15	0.88	0.01
Loin eye area (cm^2)	11.39	1.78	10.90	2.02	0.04
Skin depth (mm)	2.20	0.53	1.66	0.34	0.09

subcutaneous fat were separated from the bones accurately. After separating all carcass tissues, total soft tissues were ground two times through plates with 4 mm orifices. A grab samples (nearly 150 g.) were taken for determining moisture, protein, ash and chemical fat according to AOAC, 1995.

Data analysis

The effect of breed and sex on the traits under study was determined by using F ratio test. Means, variances and standard deviations of each trait were calculated as well as linear correlation coefficients between measurements on live animals and carcasses with physical and chemical composition characteristics. Multiple linear regression equations were also calculated in order to estimate the physical and chemical components on live animals and carcasses by the stepwise method (Steel and Torrie, 1980; SPSS, 1999).

Table 3. Means and standard deviation for carcass measurements

Traits	Breed				
	Moghani (n=100)		Makui (n=100)		
	Mean	SD	Mean	SD	Sig.
Cold carcass weight (kg)	17.78	2.28	15.75	2.96	0.00
Lean meat (kg)	8.91	1.29	8.66	1.49	0.21
Total fat (kg)	4.36	0.98.	3.23	1.12	0.00
Subcutaneous fat (kg)	1.56	0.46	1.08	0.37	0.00
Intermuscular fat (kg)	0.87	0.31	0.73	0.38	0.00
Fat-tail (kg)	0.96	0.34	0.71	0.37	0.00
Bone (kg)	3.27	0.50	2.87	0.46	0.00
Dressing out % [1]	46.04	2.56	43.32	3.03	0.00
Lean meat % [2]	53.01	4.79	57.60	2.88	0.00
Total fat % [2]	25.73	3.83	21.01	4.83	0.00
Subcutaneous fat % [2]	9.21	2.35	7.09	1.96	0.00
Intermuscular fat % [2]	5.22	1.91	4.89	2.34	0.28
Fat-tail % [2]	11.3	3.36	9.03	3.46	0.00
Bone % [2]	19.56	3.08	19.22	2.16	0.38
Moisture % [3]	54.53	4.00	61.98	4.65	0.00
Protein % [3]	17.55	2.51	15.93	1.53	0.00
Chemical fat % [3]	26.70	4.21	20.12	4.86	0.00
Ash % [3]	0.70	0.18	0.88	0.18	0.00

[1] Based on live weight. [2] Based on cold carcass weight.
[3] As a percent of soft tissue.

RESULTS

Except for HW, CL and skin depth, breed had a significant effect ($p<0.05$) on all the other live measurements (Table 2). The Moghani breed shows higher values for CH, ULGR, NGR, GR, C and loin eye area

Table 4. Means of sexes in n measured traits on live animals and carcass

Traits	Breed							
	Moghani				Makui			
	Male n=50		Female n=50		Male n=50		Female n=50	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
LW (kg)	41.64*	3.72	35.93*	3.22	40.17^+	5.48	32.58^+	3.72
EBW (kg)	33.33*	3.19	29.55*	2.70	32.44^+	4.45	26.58^+	3.37
HW (cm)	69.01*	2.25	66.41*	2.53	65.78^+	3.92	62.76^+	2.73
CH (cm)	87.16*	3.23	84.40*	3.03	85.95^+	4.84	82.38^+	4.05
BL (cm)	42.43*	1.98	41.17*	1.53	43.85^+	2.61	42.09^+	1.99
WH (cm)	18.05	1.01	18.20	1.14	19.22^+	1.20	18.95^+	0.90
ULGR (mm)	4.43*	1.03	5.70*	1.19	3.87^+	1.03	4.49^+	1.52
NGR (mm)	4.44*	1.08	6.27*	1.29	3.79^+	0.95	4.48^+	1.42
GR (mm)	2.44*	1.06	4.48*	1.33	2.18^+	0.98	3.13^+	1.67
CL (cm)	66.76*	2.08	64.72*	2.21	33.88^+	2.89	63.92^+	2.37
A (mm)	57.55*	4.30	53.65*	4.69	59.59^+	5.22	56.27^+	4.81
B (mm)	32.33*	4.76	29.89*	3.42	27.10	3.26	28.28	3.50
C (mm)	2.19*	0.91.	3.13*	1.05	2.25	0.90	2.05	0.87
Loin eye area (cm^2)	12.06	1.89	10.81	1.46	11.19^+	2.03	10.09^+	1.88
Skin depth (mm)	2.15	0.49	2.24	0.57	1.69	0.36	1.64	0.34

*, + $p<0.05$ (between sexes within breeds).

compared to those of Makui. Because of higher ($p<0.05$) lean meat and lower total fat, subcutaneous and intermuscular fat and fat-tail percentages The Makui breed showed a better carcass quality compared to that of Moghani (Table 3).

Except soft tissue depths; ULGR, NGR and GR, the male lambs showed higher values in live and carcass measurements than females (Table 4). Percentages of carcass, total fat and intermuscular fat in female were higher than that of male lambs (Table 5). In spite of the higher amount of subcutaneous and intermuscular fat in female (which is usually used for their physiological need, such as pregnancy and lactation), the male lambs had a heavier fat-tail than females.

Correlation coefficients

Because of the significant effect of breed on the most traits, the coefficients of correlation and regression equations were established separately in each breed.

Correlation coefficients in Moghani sheep : EBW, LW, CH and HW had the highest relationships with carcass lean meat. HCW and A showed a relatively high correlation with lean meat weight of carcass. Total fat content of carcass had a high relation with HCW and LW (Table 6). Carcass weight had a relatively high correlation with carcass bone. Loin eye area was not closely associated with physical and chemical components of carcass. Among the measurements on carcass, A showed an intermediate relationship with carcass lean meat weight and carcass bone. B had a relative intermediate associate with carcass lean meat weight and fat-tail weight. C had a significant ($p<0.01$) relationship with bone and subcutaneous fat percentages. Percentage of

Table 5. Effect of sex on carcass compositions

Traits	Breed							
	Moghani				Makui			
	Male n=50		Female n=50		Male n=50		Female n=50	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Lean meat (kg)	9.56*	1.38	8.31*	0.86	9.46^{+}	1.42	7.89^{+}	1.11
Total fat (kg)	4.45	1.11	4.27	0.84	3.64^{+}	1.19	2.84^{+}	0.90
Subcutaneous fat (kg)	1.40*	0.48	1.70*	0.39	1.09	0.35	1.07^{+}	0.40
Intermuscular fat (kg)	0.69*	0.28	1.03*	0.25	0.69	0.40	0.77	0.37
Fat-tail (kg)	1.18*	0.32	0.77*	0.21	0.93^{+}	0.38	0.50^{+}	0.17
Bone (kg)	3.64*	0.38	2.94*	0.34	3.18^{+}	0.42	2.57^{+}	0.26
Dressing out % [1]	45.74	3.090	46.30	1.96	42.6^{+}	2.59	44.01^{+}	3.28
Lean Meat % [2]	53.42	5.76	52.65	3.69	56.96^{+}	3.06	58.28^{+}	2.55
Total Fat % [2]	24.56*	4.14	26.79*	3.22	21.39	4.95	20.64	4.73
Subcutaneous fat % [2]	7.62*	1.94	10.66*	1.65	6.39^{+}	1.47	7.76^{+}	2.15
Intermuscular fat % [2]	3.81*	1.35	6.50*	1.35	4.08^{+}	1.99	5.66^{+}	2.41
Fat-tail % [2]	13.3*	3.45	9.64*	2.25	10.92^{+}	3.70	7.22^{+}	1.93
Bone % [2]	20.58*	3.73	18.63*	1.96	19.30	2.45	19.14	1.85
Moisture % [3]	58.88*	3.41	53.3*	4.13	61.73	5.26	62.22	4.02
Protein % [3]	17.29	1.69	17.79	3.07	15.94	1.80	15.92	1.24
Ash % [3]	0.73	0.16	0.67	0.20	0.82^{+}	0.16	0.93^{+}	0.19
Chemical fat % [3]	25.85	3.84	27.48	4.41	20.12	5.31	20.11	4.30

*, $^{+}$ $p<0.05$ (between sexes within breeds). [1] Based on live weight. [2] Based on cold carcass weight. [3] As a percent of soft tissue.

Table 6. Live and carcass measurements correlation with carcass components in Moghani breed

Traits	LW	Lean meat	Total fat	Bone	Su. Fat[1]	In. Fat[2]	Fat-tail	Protein	Chemical fat
LW	1.00	0.77**	0.60**	0.28*	0.25*	0.02	0.69**	0.07	0.07
EBW	0.95**	0.88**	0.69**	0.63**	0.40**	0.09	0.67**	0.09	0.12
HW	0.48**	0.49**	0.16	0.61**	-0.08	-0.13	0.34*	0.05	-0.08
CH	0.62**	0.57**	0.39**	0.51**	0.18	0.21	0.34*	0.02	0.00
BL	0.46**	0.30*	0.19	0.29*	0.01	-0.09	0.33*	0.04	0.00
HW	0.15	0.08	0.05	0.45**	0.12	0.18	-0.09	0.22	0.00
ULGR	-0.06	-0.05	0.25*	0.15	0.52**	0.43**	-0.19	0.09	0.15
NGR	-0.14	-0.08	0.29*	0.26*	0.57**	0.50**	0.20	0.10	0.21
HCW	0.90**	0.79**	0.75**	0.37*	0.44**	0.07	0.75**	0.07	0.22
Loin eye area	0.26*	0.31*	0.15	0.56**	0.07	0.03	0.16	0.09	-0.02
A	0.51**	0.47**	0.18	0.67**	0.02	-0.09	0.28*	0.11	-0.11
B	0.37*	0.39**	0.22	0.15	0.04	-0.03	0.30*	0.03	-0.03
C	0.09	0.03	0.21	0.39**	0.43**	0.33*	-0.13	-0.09	0.16
GR	0.17	-0.1	0.38*	0.09	0.59**	0.59**	0.12	-0.01	0.34*

* $p<0.01$. ** $p<0.01$. [1] Subcutaneous fat, [2] Intermuscular fat.

Table 7. Live and carcass measurement correlation coefficients with carcass components in Makui breed

Traits	LW	Lean meat	Total fat	Bone	Su. fat	In. fat	Fat-tail	Protein	Chemical fat
LW	1.00	0.95**	0.71**	0.85**	0.54	0.14	0.75**	-0.13	0.35*
EBW	0.98**	0.96**	0.76**	0.84**	0.58	0.19	0.76**	0.15	0.42**
HW	0.60**	0.61**	0.43**	0.65**	0.30	0.10	0.45**	-0.05	0.11
CH	0.77**	0.74**	0.53**	0.63**	0.45	0.08	0.53**	-0.06	0.30*
BL	0.60**	0.58**	0.40**	0.63**	0.36	0.15	0.35*	-0.09	0.06
HW	0.53**	0.52**	0.37**	0.45**	0.38	0.09	0.33*	-0.06	0.27*
ULGR	0.23*	0.27*	0.44**	-0.01	0.66	0.34*	0.16	-0.08	0.59**
NGR	0.24*	0.29*	0.43**	-0.01	0.68	0.36**	0.12	-0.14	0.56
HCW	0.93**	0.95**	0.77**	0.78**	0.68	0.27*	0.68**	-0.16	0.49**
Loin eye area	0.49**	0.54**	0.43**	0.33*	0.39	0.25*	0.32*	0.00	0.16
A	0.60**	0.60**	0.40**	0.51**	0.27	0.15	0.38**	-0.19	0.08
B	0.09	0.22	0.02	-0.02	0.03	0.14	-0.11	0.16	0.07
C	0.33*	0.34**	0.30*	0.28*	0.52	0.06	0.16	0.27*	0.37**
GR	0.15	0.23	0.41**	-0.09	0.68	0.42**	0.06	-0.13	0.54**

* p<0.01. ** p<0.001.

Table 8. Regression analysis for predicting empty body weight, lean meat, fat, bone and fat-tail

		Equation	Dependent variable	Independent variable	a	b	R^2	P
		Measurements on live animals						
Breed	Moghani	1	EBW (kg)	LW[1]	-7.9325	0.7107	0.86	0.00
				NGR		0.3831		
				HW		0.1441		
		2	Total lean meat (kg)	EBW	-0.4784	0.2994	0.61	0.00
		3	Total fat (kg)	EBW	-2.822	0.2674	0.58	0.00
				Sex[2]		0.8518		
				WH		-0.1379		
		4	Total bone (kg)	Sex	2.814	0.5133	0.58	0.00
				EBW		0.0544		
				BL		0.0439		
		5	Fat-tail (kg)	Sex	-1.4045	-0.2269	0.53	0.00
				EBW		0.0609		
				WH		-0.0463		
	Makui	6	EBW (kg)	LW	0.01777	0.7895	0.93	0.00
				NGR		0.1859		
		7	Total lean meat (kg)	EBW	-0.9951	0.2068	0.89	0.00
				Sex		0.2967		
				LW		0.0858		
		8	Total fat (kg)	EBW	-2.293	0.1574	0.59	0.00
				NGR		0.2129		
		9	Total bone (kg)	LW	-3.968	0.0617	0.74	0.00
				NGR		0.0709		
				HW		0.0205		
		10	Fat-tail (kg)	EBW	-0.4313	0.047	0.58	0.00
				Sex		-0.1603		

[1] Live weight after an overnight fast before slaughter. [2] Male=1 and female=2.

protein had a low and non-significant (p>0.05) correlation with most of the live animal and carcass measurements. Chemical fat percentage was affected by total, subcutaneous and intermuscular fat and fat-tail of carcass (p<0.01). oefficients of correlation between ULGR, and NGR with percentage of protein and fat content showed lower values compared to the values reported by Ramsey (1991). Consequently, considering the data presented herein the most appropriate measurements for the estimation of carcass lean meat weight in Moghani sheep are EBW, LW, HW and BL respectively.

Correlation coefficients in Makui sheep : EBW, LW, CH, HW, and BL had a high correlation with carcass lean meat relating to the live animal measurements, respectively (Table 7). Total carcass fat content was associated with EBW, LW, CH, BL, ULGR NGR and HW, respectively. ULGR and NGR showed the highest correlation with subcutaneous and intermuscular fat. Among measurements on carcass, total carcass fat had a relatively high relationship with HCW, loin eye area and GR, respectively.

Except C all of the live animals and carcass, measurements had a low and non-significant ($p<0.05$) correlation with protein percentage. Chemical fat was significantly ($p<0.01$) associated with ULGR, NGR, GR, HCW, EBW and C.

Regression equation

All variables passed with tolerance criterion to be entered in the equation, regardless of the entry method specified. The various simple and multiple linear regressions analysed for growth and carcass traits are given in Table 8. The association between the traits identified was found to be significant with R^2 ranging from 0.53 to 0.93.

DISCUSSION

Soft tissue depth measured by ultrasound at 12th rib in New Zealand mixed breed was 7.3 mm (Ramsey, 1991). In the present study, this parameter averaged 5.1 in Moghani and 4.8 mm in Makui. Besides differences related to the models of scanners and probable effects of various operators, however, it might have two other main sources of variation as follows.

Firstly, Iranian sheep accumulate fat inside the cells, between the muscles, under the skin, inside the viscera and in the fat-tail. However, exogenous sheep are not fat-tailed so the depth of soft tissue measured could be attributed to subcutaneous fat that is more abundant in exogenous sheep. Therefore, the difference could be caused by the subcutaneous fat depth or depth of muscle (*serratus muscle)* variations in GR site. Average dorsal fat depth (C) was 2.69 (range 1-5.3) mm in Moghani and 2.13 (range 0.7-5.4) mm in Makui. This parameter was reported to be 2 mm (range 1-8) in New Zealand mixed breed lambs, which is not very different from the Iranian sheep. Consequently, it is concluded that the differences in GR could be more attributed to the *serratus muscle* depth than dorsal fat depth. Secondly, in present study, the animals are in the same age group, but the sheep studied by Ramsey (1991), Simm (1992) and Miles (1991) were in different age (lamb and ewe). So different between age classifications could also be the origin of part of the range of variation.

CONCLUSION

EBW and total lean meat were predicted with relatively high coefficients of determination in the two breeds. Breed differences could be a good basis for animal breeders to select animals with a less amount of carcass fat. Attention should be paid to comparison between breeds. Percentage of total fat content considerably affected by breed, age, sex and nutrition (Baily et al., 1986; Dehghanian, 1987; Ramsey et al., 1991). These effects should be considered in using regression equations to predict the carcass components.

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