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RELATIONSHIP BETWEEN BLOOD PHYSIOLOGICAL ATTRIBUTES AND CARCASS CHARACTERISTICS IN IRANIAN FAT-TAILED SHEEP*

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Abstract – The relationship between blood physiological attributes and carcass characteristics was studied in 40 randomly selected 8-month-old ram lambs of Ghezel and Mehraban (20 rams per breed) sheep. One day before slaughter, blood samples were obtained after a 24 hr fast. Serum samples were assayed for glucose, cholesterol, serum urea nitrogen (SUN), total protein, albumin, triglycerides, creatinine, and calcium and magnesium ion concentrations. Dry matter, crude protein, crude fat (ether extract) and ash were determined in carcass soft tissues (carcass without bone and tail fat). Overall, serum cholesterol ($r=-0.70$; $P<0.01$) and creatinine ($r=-0.48$; $P<0.05$) concentrations were negatively correlated with the crude protein percentage of soft tissues dry matter (CPDM) in these sheep. Serum cholesterol concentration was positively correlated with the total dissected fat in both Ghezel ($r=0.83$; $P<0.01$) and Mehraban sheep ($r=0.60$; $P<0.01$). CPDM was negatively ($P<0.01$) correlated with a serum glucose concentration in Ghezel ($r=-0.60$), and with a SUN concentration in Mehraban ($r=-0.60$). A positive correlation was also found between the serum cholesterol concentration and crude fat (ether extract) as a percentage of the soft tissues dry matter in Ghezel ($r=0.66$; $P<0.01$). In general, fewer carcass traits in Mehraban were significantly correlated with cholesterol, and the coefficients were generally smaller than those for the Ghezel breed. The regression equations showed that blood cholesterol, glucose, triglyceride and SUN could be regarded as good predictors of carcass characteristics in Ghezel sheep. Serum cholesterol concentration was the only blood attribute that was retained in equations for Mehraban sheep. The coefficients of determination for Mehraban sheep were much smaller than those for Ghezel. More research with a larger number of animals is needed before they find application in carcass evaluation.

Keywords – Blood attributes, sheep, carcass characteristics, Mehraban, Ghezel

1. INTRODUCTION

There is a need to reduce the average fat content of carcasses of meat producing animal species. Consumers in many countries are demanding less fat in meat, mainly for reasons of the perceived benefits to health [1, 2]. Production of excess fat in the carcass is inefficient in terms of the energy resources required [3]. This has motivated animal scientists to search for ways of producing carcasses with lower levels of fat. These extend from simple changes in production factors such as breed, sex, and feeding systems to more sophisticated techniques of metabolic control. In sheep, an effective method for lean meat production and carcass fat reduction is the selection in terminal sire breeds [4, 5], as selection can be concentrated on a numerically small group of animals which have a large contribution to meat production. Secondly, in this program, selection can be concentrated on growth

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and carcass traits rather than a combination of production and reproduction traits, therefore animals can be selected which are superior in carcass or body composition. Carcass composition can be predicted after slaughter and dissection of the relatives, or the individual itself after collecting an adequate supply of semen or eggs. However, both approaches are rather costly, and the former lacks precision unless a large number of close relatives are used [1].

An accurate *in vivo* method allowing repeated measurement of composition in the same animal would reduce the number of animals required and the dissection costs. Ultrasonic pulse-echo techniques, X-ray computed tomography, nuclear magnetic resonance, neutron activation analysis, photon activation analysis, positron-emission tomography, electrical conductivity, tracer dilution technique, and infrared interactance have been used to evaluate body composition in live farm animals. Most of these modern techniques have been used in developed countries and their application in those countries may be limited because of expense. Almost all of these instruments are in medical diagnostic use and their precision and accuracy depend highly on the procedure of operation. On the other hand, if available and in use, all of these techniques are not applicable to some species, and size limitations are observed in some cases. Although it is said that these techniques are harmless, the risk of exposing animals and staff to irradiation and mutagenic waves must be considered [1, 2].

Considering these limitations, physiological predictors may be a better choice [1]. A limited amount of data has been published about the variation of blood attributes in lines of sheep selected for high and low back fat depth [6-8] and there is no information on the relationship between blood attributes and carcass composition in random-bred sheep. Cameron [6] studied the correlated responses in blood physiologic traits in two Texel-Oxford selected lines and concluded that blood urea may be a useful predictor of genetic merit for lean meat production; it was correlated with estimated carcass lean content and substantial differences between lines were found. Wylie et al. [9] reported that serum IGF-1 concentration was correlated to the eye-muscle area, and was higher in naturally leaner rams and wethers than in ewes. They found no useful correlations of any metabolite or mineral to any production measure. Van Maanen et al. [8] found a lower concentration of creatinine in the lean line sheep during normal feeding, fasting and re-feeding. Carter *et al.* [7], studying the high and low back fat Southdown selected line, concluded that baseline plasma urea concentration and the responsiveness of plasma non-esterified fatty acids and glucose to glucagon and glucose challenges, respectively, might provide useful predictors of genetic merit for lean meat production; however, they stated that it is not known whether these differences would be exhibited under less standardized conditions, and hence have application to the large scale screening of rams in the field.

The aim of this study was to investigate the relationship of physiological blood attributes and carcass composition in two random-bred populations of Iranian fat-tailed sheep (Ghezel and Mehraban). Such information would be valuable in genetically improving these sheep for meat production. Although electronic techniques can give reliable information, the limitations mentioned earlier preclude their application under Iranian conditions.

2. MATERIALS AND METHODS

This experiment was carried out in the Farm Animal Experimental Station of the College of Agriculture, Shiraz University. Forty 8-month-old ram lambs of Ghezel and Mehraban fat-tailed sheep (20 rams per breed), which were under a feedlot performance trial, were used in this

experiment. The sheep were fed *ad libitum* with a ration, supplying 2.5 Mcal metabolizable energy and 13% crude protein per kg dry matter, and consisting (dry matter basis) of 50% alfalfa hay and 50% barley grains. The ration was formulated to support an average daily gain of 200 g per sheep. Clean water and salt lick were available at all times. On days 50 and 100, 10 animals from each breed were randomly selected and slaughtered. The day before slaughter, blood samples were obtained after a 24 hr fast, centrifuged and the serum stored at -20° C until analysis.

Body weight and hot carcass weight were determined on the day of slaughter. Renal, cardiac and gastrointestinal fats were removed and weighed separately. Cold carcass weight was determined 24 hrs after slaughter. Fat depth over carcass was measured at the cross section of the 12th and 13th thoracic ribs at 4 points, and the values were averaged as a measure of subcutaneous fat depth (SCFD).

A cross sectional area of the eye muscle (*longissimus dorsi* muscle) was measured on both sides of the carcass between the 12th and 13th ribs. This cross section was traced on a nylon sheath and the area was then measured by using a planimeter (Tamaya Digitising Area-Meter, Tamaya Technics, Japan). The right side of the carcass was cut into the leg, shoulder, back, neck and flaps. The cuts were dissected into bone, trimmed meat and fat. Soft tissues (trimmed meat and trimmed fat from the right side of the carcass, excluding the tail fat) were minced and mixed thoroughly, and samples were kept at -20° C until analyzed for dry matter, ether extract (crude fat), nitrogen contents (expressed as crude protein) and ash contents [10].

Serum samples were assayed in duplicate for glucose (11), cholesterol [12], serum urea nitrogen (SUN) [13], total protein [14], albumin [15], triglycerides [12], creatinine [13], and calcium and magnesium ions [16].

The data were analyzed by using the SAS for windows program on a personal computer [17]. The effects of breed (Ghezel and Mehraban), fattening duration (day 50 and day 100; corresponding to approximately 300 and 350 days of age, respectively), and their interactions were included in the model. Live weight at slaughtering time was used as the covariate for the analysis of organ weights, fat associated with organs, carcass weight, daily weight gain and blood attributes. Cold carcass weight was used as the covariate for the analysis of carcass characteristics because less error is associated with its measurement as compared with live weight measurement. Repeated measures ANOVA were utilized to assess the differences between the concentrations of blood attributes determined on days 50 and 100 for the animals, which were slaughtered on day 100. Pearson's correlation coefficients between carcass characteristics and blood attributes were calculated. The regression analysis of various carcass characteristics on blood attributes was performed by using the stepwise procedure ($P=0.05$).

3. RESULTS AND DISCUSSION

For both breeds, concentrations of serum cholesterol, glucose, and creatinine were greater ($P<0.001$), but those of triglycerides were lower ($P<0.02$) on day 100 as compared with day 50 of the fattening period (Table 1). Concentrations of serum attributes were not significantly different between Ghezel and Mehraban sheep, and no significant interactions were found ($P>0.05$) between breeds and the duration of fattening.

As expected, the crude fat (ether extract) percentage in soft tissues increased, but crude protein (nitrogen content x 6.25) percentage decreased as the fattening period advanced; however, dry matter and ash percentages did not change significantly (data not shown).

Table 1. Concentrations of blood serum attributes on days 50 and 100 of the fattening period in Ghezel and Mehraban rams (n=10 for each period)

	Day	Ghezel		Mehraban		P[$]
		Mean	SEM	Mean	SEM	
Albumin (g dL^{-1})	50	14.65	1.28	14.5	0.83	NS
	100	15.33	0.49	17.48	0.57	
Urea N (SUN: mg dL^{-1})	50	14.65	1.28	14.50	0.83	NS
	100	15.33	0.49	17.48	0.57	
Cholesterol (mg dL^{-1})	50	40.63	6.23	33.10	4.25	0.001
	100	78.97	2.67	75.17	4.07	
Creatinine (mg dL^{-1})	50	0.76	0.09	0.79	0.07	0.001
	100	1.02	0.09	1.13	0.09	
Calcium (mg dL^{-1})	50	10.11	1.25	10.65	1.42	NS
	100	11.28	0.98	9.60	0.66	
Glucose (mg dL^{-1})	50	63.51	4.53	65.14	5.44	0.001
	100	79.73	2.91	77.02	3.52	
Magnesium (mg dL^{-1})	50	2.57	0.09	2.29	0.05	NS
	100	2.41	0.08	2.38	0.10	
Total proteins (g dL^{-1})	50	19.19	1.84	14.09	1.95	NS
	100	14.02	1.70	15.02	0.87	
Triglycerides (mg dL^{-1})	50	44.62	4.34	43.82	4.45	0.02
	100	34.51	2.97	32.31	12.10	

[$] Probability of significance of difference between fattening periods for each attribute
NS: P>0.05

The correlation between blood cholesterol and carcass characteristics in the ovine species has not been reported previously, and the current study is the first report of the correlation of serum cholesterol concentration with carcass characteristics in two non-selected fat-tailed sheep breeds. Significant correlation coefficients were found between serum cholesterol concentration and most carcass measurements (Table 2). In Ghezel, correlation coefficients of serum cholesterol concentration with many carcass characteristics, except with the neck bone, back joint bone, renal fat and *longissimus dorsi* area were significant (P<0.05), and varied between 0.52 to 0.89. The largest correlation coefficient of serum cholesterol concentration was that with SCFD (r=0.89, P<0.01). Correlation coefficients of serum cholesterol concentration with crude protein and ash percentages in soft tissues of Ghezel rams were negative and significant, but other correlation coefficients were positive. Similarly, in Mehraban sheep, the correlation coefficient of serum cholesterol concentration with a crude protein percentage of carcass soft tissues was negative and significant, and in the same order of magnitude, but the correlation between serum cholesterol concentration and ether extract percentage of carcass soft tissues was low and non-significant. In general, fewer carcass traits in Mehraban were significantly correlated with cholesterol and the coefficients were generally smaller than those for the Ghezel.

Table 2. Pearson's correlation coefficients of serum cholesterol concentration with some carcass traits in Ghezel and Mehraban sheep (n=20 for each breed)

Carcass Trait	Ghezel	Mehraban
Soft tissue weight (dry matter)	0.51*	0.46*
Crude protein % in soft tissues	-0.69**	-0.61**
Crude protein % in soft tissues DM	-0.71**	-0.66**
Total crude protein in soft tissues	0.49*	0.30
Ether extract % in soft tissues	0.69**	0.30
Ether extract % in soft tissues DM	0.66**	0.14
Total ether extract in soft tissues	0.78**	0.48*
Total soft tissues	0.70**	0.51*
Ash % in soft tissues	-0.78**	-0.30
Ash % in soft tissues DM	-0.78**	-0.47*
Heart (pericardial) fat	0.59**	0.63**
Renal (perinephric) fat	0.39	0.14
Pelvic fat	0.61**	0.31
Mesenteric and omental fat	0.69**	0.42
Subcutaneous fat depth	0.89**	0.61**
Tail weight	0.81**	0.59**
Total dissected fat $	0.83**	0.60**
Total lean from major cuts (leg, shoulder, back)	0.63**	0.48*

* $P<0.05$

** $P<0.01$

$ Physically separated fat from carcass and internal organs including the tail

The serum triglyceride concentration was not significantly correlated with any of the carcass traits in both breeds (see results of regression analysis later in this section); but decreased significantly from day 50 to day 100 of the fattening period (Table 1). Leaner pigs [18] and sheep [6] had lower concentrations of triglycerides as compared with their corresponding fat lines. Several studies reported a high correlation between blood triglyceride concentration and body fat in poultry. Griffin *et al.* [19] found correlation coefficients ranging from 0.33 in females, to 0.50 in males between the blood triglyceride level and fat content in the carcass of 8-week-old broiler chicks. Also, significant correlation coefficients were found between blood triglyceride concentrations and abdominal fat in male (r=0.39) and female (r=0.36) 7-week-old chicks [20].

A serum glucose concentration was correlated with some carcass traits in both breeds. In Ghezel, the largest correlation coefficient was r=-0.75 ($P<0.01$) with a crude protein percentage of carcass soft tissues, and in Mehraban r=0.47 ($P<0.05$) with the heart fat. A significant correlation of serum glucose concentration with total dissected fat (fat removed from carcass and internal organs) (r=0.57, $P<0.01$), SCFD (r=0.61, $P<0.01$), tail weight (r=0.62, $P<0.05$), crude protein percentage in soft tissues dry matter (r=-0.57, $P<0.05$), total ether extract in soft tissues dry matter, and the weight of soft tissues (r=0.46, $P<0.05$) was observed for Ghezel, but not for Mehraban. In Mehraban sheep, the serum glucose concentration had small and negative correlation coefficients with a crude protein percentage in soft tissues (r=-0.44, $P<0.05$). Studies in cattle showed no differences in plasma glucose concentrations between beef breeds [21, 22]. Glucose concentrations of the lean and fat lines were not different for sheep [6-8] and pigs [14]. Cameron [6] suggested that glucose may be maintained at a constant level by homeostatic control, while concentrations of other metabolites fluctuate in response to physiological changes; however, in the present study, the serum glucose concentration on day 100

of the fattening period was significantly greater than the concentration on day 50 (Table 1). With increasing body weight daily feed consumption increases, but protein requirement decreases. Since the same diet containing 13% crude protein was fed *ad lib.* throughout the experiment, the protein consumption on day 100 might have been in excess of the requirements. This surplus protein will be used as an energy source that could spare blood glucose, and thus increase blood glucose concentration.

Total serum protein concentration was not significantly correlated with any of the carcass traits in these breeds. Heart fat in Mehraban was the only trait significantly correlated with the serum albumin concentration ($r=0.50$, $P<0.05$). Matsuzaki *et al.* [22], comparing two Japanese breeds with Holstein steers, observed no differences in plasma albumin, and Wylie *et al.* [9] found no correlation between serum albumin and carcass characteristics in sheep.

Serum creatinine concentration was negatively correlated with the crude protein percentage of soft tissues in Ghezel ($r=-0.49$, $P<0.05$); in Mehraban sheep, it was negatively correlated with the percentage of crude protein in soft tissues dry matter ($r=-0.48$, $P<0.05$), but positively correlated with the percentage of crude protein in soft tissues dry matter ($r=0.57$, $P<0.01$) and heart fat ($r=0.51$, $P<0.05$). Serum creatinine concentration was significantly greater in fatter sheep (Table 1). Lower creatinine concentration in a lean line sheep was reported by Van Maanen *et al.* [8] during normal feeding, fasting and refeeding. Clark *et al.* [23] reported lower creatinine concentration in the line selected for increased fleeceweight than in the control line. Istasse *et al.* [21] found very high correlation coefficients between the plasma creatinine concentrations and carcass weight (0.98), dressing percentage (0.97), bone (-0.96), lean meat (0.92) and adipose tissue (-0.87) in cattle.

Plasma urea concentrations differed between sheep lines selected for increased or reduced back fat [7, 8], dairy cows selected for high or low milk yield [24, 25], and between genetically obese and lean pigs [18]. The selection lines for the increased level of production had lower concentrations of plasma urea. In Ghezel sheep, SUN showed positive correlation coefficients with ether extract percentage in soft tissues dry matter ($r=0.39$, $P<0.10$), total ether extract in soft tissues dry matter ($r=0.46$, $P<0.05$), total crude protein in soft tissues dry matter ($r=0.54$, $P<0.05$), total weight of soft tissues ($r=0.49$, $P<0.05$), renal fat ($r=0.51$, $P<0.05$), heart fat ($r=0.47$, $P<0.05$), gastrointestinal (omental and mesenteric) fat and cavity fat ($r=0.48$, $P<0.05$), and total lean from major cuts ($r=0.47$; $P<0.05$). In Mehraban sheep, SUN had significant correlation coefficients with crude protein percentage in soft tissues ($r=-0.52$, $P<0.05$), percent crude protein in soft tissues dry matter ($r=-0.63$, $P<0.01$), heart fat ($r=0.48$, $P<0.05$) and SCFD ($r=0.44$, $P<0.05$). In both breeds, positive correlation coefficients were observed between SUN and the *longissimus dorsi* width ($r=0.43$, $P<0.10$ in Ghezel, and $r=0.63$, $P<0.01$ in Mehraban).

The principal source of urea is from the liver conversion of ammonia produced by the deamination of surplus amino acids and rumen degradation of dietary protein. It is suggested [17] that differences in plasma urea concentrations observed between lean and fat lines of pigs occurred as a result of more efficient use of amino acids for protein synthesis, and consequently reduced the requirement to deaminate amino acids in the lean line. Alternative explanations for differences in plasma urea concentrations were that urea excretion rate and/or the urea distribution space differed between the lines. Kidney excretion of urea is principally by passive diffusion, and is, therefore, a function of glomerular filtration rate. Experiments carried out by McCutcheon *et al.* [26] and

Bremmers *et al.* [27] with high and low back fat Southdown rams, and fleeceweight-selected and control Romney rams, respectively, failed to show between-line differences in the urea excretion rate or creatinine clearance rate (indicative of glomerular filtration rate).

Matsuzaki *et al.* [22] suggested that the gradual increase of SUN with increasing body weight seems to reflect the surplus of substrates for protein metabolism. In the present study, there was a tendency ($P<0.07$) for SUN concentrations to increase as the fattening period increased (Table 1). As body weight increases, the daily feed consumption also increases, but protein requirement decreases. Therefore, the excess protein is catabolized into urea, and urea concentration in the blood increases.

The correlation coefficients of magnesium and calcium concentrations with carcass traits were small and non-significant ($P<0.05$), confirming the results of Wylie *et al.* [9], who found no significant correlation of minerals with carcass characteristics in sheep.

Regression equations derived for some carcass traits of Ghezel and Mehraban sheep are shown in Table 3. More regression equations were obtained for Ghezel sheep. In Ghezel sheep, the coefficients of determination for seven of the nine equations ranged from 0.62 to 0.85. All but one of the equations contained cholesterol and/or SUN. Serum cholesterol concentration accounted for a major proportion of the total variation in the crude protein percentage of fresh soft tissues (51%), ether extract percentage in soft tissues dry matter (52%), total ether extract in soft tissues (55%), cavity fat (46%), and SCFD (76%). Serum glucose and creatinine concentrations accounted for 64% and 9% of the total variation in the crude protein percentage of fresh soft tissues, respectively. In equations that contained SUN, it contributed between 20-30% to the total variation in the respective carcass trait. The proportion of total variance that was assigned to the serum triglyceride concentration was 14% for percentages of crude protein and ether extract in soft tissues dry matter.

The serum cholesterol concentration was the only blood attribute that was retained in equations for Mehraban sheep. The coefficients of determination for Mehraban sheep were small and ranged from 0.272 to 0.387.

The results of this study showed that blood cholesterol, glucose, triglyceride and SUN could be regarded as good predictors of carcass characteristics in Iranian fat-tailed Ghezel sheep. Considerable breed differences were noted in this study. More research with a larger number of animals with the inclusion of other physiological attributes is needed before these findings can be recommended for a large-scale application of carcass evaluation in less standardized conditions. The inclusion of a physiological trait in a selection index of genetic improvement requires knowledge of the heritability of the physiologic trait, together with the phenotypic and genotypic correlations between the physiologic trait and the traits in the breeding objective [6].

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