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Image Process Tool an Alternative Method for Quantitative Assessment of Mammary Gland Structure in Mohabadi Goat

Research Article

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ABSTRACT

Milking ability in goat farming is not particularly new, however, it has frameworks for receiving economic benefits from marketing of milk. For this reason, investigation of varied methods plays an important role to evaluate mammary gland structure in dairy animal. Hence, the overall objective of current work was to test the image processing tools as an alternative method for quantitative assessment of mammary gland structure in Mohabadi goat. Under this circumstance, survey data was collected from 72 Mohabadi does from research station of Department of Animal Science, University of Tehran. The fixed effects for each candidate animal consists of pedigree, birth date, milk characteristics as well as monitoring the history of record during assessment was monitored. Image process tools was based on two stages: First, three different camera photos were taken from different angels of mammary gland structure from both sides of each animal and next step, Digimizzer image processing software was employed for further analysis and estimation of seven morphological dimensions (udder length, teat length and teat angle at both sides and as well as udder height). To investigate this statistically, the descriptive statistics, correlation, different regression analysis, principal component analysis and as well as association study between linear mammary gland traits and milk were analyzed using SAS 9.3 software. The highest correlation was observed in the length of right and left udder (r=0.67 P<0.05). The results revealed that the milk yield was significantly influenced by the length of the right teat (P<0.05). In conclusion, digital image processing may be considered as alternative tools for linear morphological characterization that would provide more accurate observation and measurements on the indigenous goat population.

KEY WORDS dairy goats, milk characteristics, udder morphology.

INTRODUCTION

In dairy goat farming, milk production is an increasingly marked area due to a wide range of advantages and wealth of human health (Abd-Allah *et al.* 2011). Milking ability in goat farming is not particularly new, however, it has frameworks to receive economic benefits of milk marketing (El-Awady and Oudah, 2011). For this reason, the investigation of varied methods plays an important role to evaluate mammary gland structure in dairy animals (Capote *et al.* 2006). Traditionally, to recognize high potential milk producer animals, farmers generally focus on visible morphological appearance of mammary gland structure as the main organ of milk secretion using visual assessments. This kind of measurement is complex problem and to simplify it is required to understand key factors affecting the parameters which in summary included nutrition and feed formulation, lactation stage (Knight and Wild, 1993), breed (Kominakis *et al.* 2009), age of does (Kor *et al.* 2005), kidding type (Ketto *et al.* 2014), parity (Adegoke *et al.* 2016), offspring sex (Carnicella *et al.* 2008), year and season of kidding (Hilali and Jesry, 2009), milking frequency (Ishag *et al.* 2012) and type of milking system (Fatima *et al.* 2019), lactation rate (James and Osinowo, 2004) and milking time (Katanos *et al.* 2005), udder size are important (Berry *et al.* 2004).

The strong association between the anatomy of mammary gland structure, udder attachments, and milk production of dairy livestock have been found in several recent studies (Altincekis and Koyucu, 2011; Sadeghi *et al.* 2013).

For this reason, understanding the key factors influencing mammary gland structure is the appropriate scenario for research and several previous researches focused on the estimation of genetic parameters and the heritability coefficient for linear mammary gland structure in different farm animals (Amao *et al.* 2003).

It is critical to have initial phenotypic records in the breeding of any candidate traits during the production stage (Carta *et al.* 2009). Traditionally, the most of traits have been performed using conventional tools such as scales, meters, laboratory measurements or precision volumetric tools (Fernandez *et al.* 1995). The summary of previous reports of heritability coefficient for udder characteristics showed the low to medium level as including: udder depth (0.16), udder attachment (0.17), teat placement (0.24), teat size (0.18) and udder shape (0.24) were similar to those for dairy cattle which reflect a positive genetic response to direct selection (Fernandez *et al.* 1997; McLaren *et al.* 2016). Genetic correlations among udder traits were generally favorable, implying that selection for improvement of one trait would result in improvement of others (Martinez *et al.* 2011). However, the process of recording is not accurate, time-consuming, laborious, and costly. One of the major drawbacks of biometric measurements in animal farming is that the unstable nature of the animal and its aggressive behavior as well as unwanted mobility which often make measurements wrong and not trustable; therefore, alternative methods are required to minimize contract and touch of animal (Torres *et al.* 2012). Image processing is an alternative technology inside machine vision science used to extract information from a simple image and to create accurate inputs for further interpretation (Sadeghi *et al.* 2016). Image processing is also one of the dependent tools of artificial intelligence and it is defined as the science for using the properties of constant or moving objective to identify and make decisions about different people or subjects (Sadeghi *et al.* 2014).

As detail, in the present technology, instead of being directly measured by humans, the image is first taken from the subject or object, and then it is analyzed using various computer and software features and finally by appropriate algorithm design.

In recent decades, the use of image processing has been developed in many disciplines. Main application is namely, agriculture-related industries and nowadays researchers have investigated the various methods to use image processing techniques to facilitate and enhance the accuracy of assessment and decision-making systems in various agricultural sciences.

Animal processing technology today has many applications such as carcass quality, body and breast biometrics studies, skin quality determination, egg quality determination, live animal weight estimation, sperm motility and viability studies in reproductive physiology and animal behavioral issues (Khojastekey and Dianat, 2016).

Mahabadi goat is one of the indigenous goats of Iran and is considered for its meat, milk, and fiber production. Geographically, this goat was distributed in the south of west Azerbaijan province and in Mahabad, Piranshahr and Sardasht cities. Marketing live body dependence of the sex of animal is between 50 above 80 kg. Twining percentage is estimated at 70-80% and 216- liter milk during 120 day of the lactation period. The overall goal of this work was to test the image process tool an alternative method for quantitative assessment of mammary gland structure in Mohabadi goats.

MATERIALS AND METHODS

Animal and geographical location

The present study started in the first middle of July- the end of November 2019. Under this circumstance, survey data was collected from 72 Mohabadi does from research station of Department of Animal Science, University of Tehran. Fixed effects for each candidate animal in this work consisted of pedigree, birth date, milk characteristics as well as monitoring the history of record during assessment. Image process tools were based on two stages:

First, three different camera photos were taken from different angels of mammary gland structure of each animal which in turn, seven morphologic measurements including udder length, teat length and teat angle from both side and also udder height were measured. These parameters were measured by the protocol as described by Labussière *et al.* (1981). Figure 1 illustrated the detail of taking photo and position of each candidate animal for investigation.

Next step, Digimizzer image processing software was used for further analysis and estimation of morphological dimensions. The Descriptive statistics for Digimizzer image processing in this study are shown in Figure 2.

Figure 1 Phenotype of Mohabadi does and identification of investigated animal

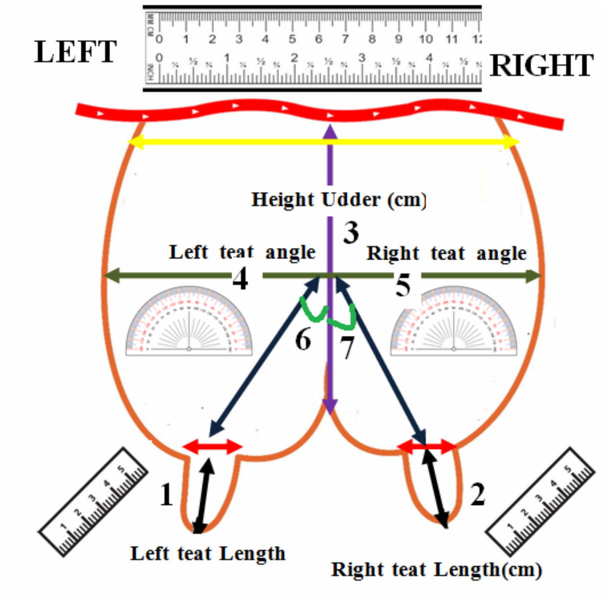

Figure 2 Measurements and understanding of udder morphological characteristic
1: left teat length (cm); 2: right teat length (cm); 3: height udder (cm); 4: right udder length (cm); 5: left udder length (cm); 6: left teat angle (degree) and 7: right teat angle (degree)

Statistical analysis

To investigate this statistically, the descriptive statistics, correlation, regression, principal component analysis and association study between linear mammary gland trait and milk were calculated using SAS 9.4 software (SAS, 2004). Before enter to Generalized Linear model (GLM) analysis, Shapiro-wilk test was used for residual values of each certain measurement. Table 1 shows the condition for classification of investigated traits based on outputs of descriptive statistics.

Principal component analysis (PCA) according to correlation outputs was done and Kaiser-Meyer-Olkin Measure (KMO) and Bartlett's Test were employed for the power of sample size and suitability from raw data volume.

Table 1 Condition for classification of investigated traits based on outputs of descriptive statistics

Variable	Class 1	Class 2	Class 3	Class 4	Class 5
R teat length (cm)	X1<2.35	2.35=<X1<3.73	3.73=X1<5.11	5.11=<X1<6.49	X1>=6.49
L teat length (cm)	X2<2.11	2.11=<X2<3.29	3.29=<X2<4.47	4.47=<X2<5.65	X2>=5.65
Height udder (cm)	X3<13.25	13.25=<X3<16.14	16.14=<X3<19.03	19.03=<X3<21.92	X3>=21.92
R udder length (cm)	X4<5.26	5.26=<X4<6.75	6.75=<X4<8.24	8.24=<X4<9.73	X4>=9.73
L udder length (cm)	X5<5.83	5.83=<X5<7.66	7.6=<X5<9.49	9.49=< X5<11.32	X5>=11.32
R angle (degree)	X6<26.73	26.73=<X6<34.87	34.87=<X6<43.01	43.01=<X6<51.15	X6>=51.15
L angle (degree)	X7<22.04	22.04=<X7<31.59	31.59=<X7<41.14	41.14=<X7<5 0.69	X7>=5 0.69

R: right and L: left.

Value above 70 for KMO may demonstrate input file has to permit for further interpretations (Keskin *et al.* 2005; Keskin *et al.* 2007). Eventually, the regression equation of daily milk yield on udder morphological characteristic was determined using the stepwise selection.

RESULTS AND DISCUSSION

From the above-mentioned short review, key findings emerge that the descriptive statistics for Digimizzer image processing in this study are shown in Table 2. As can be seen, results show a reasonable variation for measured parameters within the investigated population. Notably, teat angels and teat length showed the highest and lowest variation among parameters.

Linear regression equation of effective morphological factors and as well as lactation period on milk production was done and stepwise regression linear equation for estimation of daily milk production for Mahabadi breed was as follows:

$$Y= 799.07 + 58 X_1 - 2.35 X_2$$

Where:
Y: variable (daily milk yield).
X_1: right udder length.
X_2: lactation day.

To justify this equation, it can be stated that since the animals in this study have passed the lactation peak (4-6 weeks), the amount of milk production and lactation day will be negatively correlated. As correlation analysis of udder characteristics provided a low to a medium correlation between studied parameters overall (Figure 3). The present findings confirmed that the length of the right teat was showed the significant factor affecting milk yield during lactation. Regression outputs also revealed the mean milk yield decreased as a result of increased right teat length. Other measured parameters showed no significant response during statistical interpretation.

Figure 3 clearly indicated Rteat has negative significant correlation with most measured parameters and also Rhight and Lhight has positively correlated in the analysis. Furthermore, the results of PCA to condense the information for udder morphological characteristics with minimal loss of information were reported in Table 3. The first 5 components (left teat length; right teat length; height udder; right udder length; left udder length) and the second 2 components (left and right teat angles) consisting of positive coefficients explained 37.46% and 21.84% of the total variance respectively, which is considered sufficient to capture most of the variation for udder morphological traits.

Figure 4 illustrated the significance statue between milk and udder morphological structure. When lactation period increased the dimension of mammary gland and teat have tendency to change.

Udder characteristics in dairy animals are directly involved in economic production (Emediato *et al.* 2008). Udder shape and its related traits are effective on milk production and easy milking (Perez-Cabal *et al.* 2013; Sadeghi *et al.* 2014), and high correlation of mammalian traits with quantitative and qualitative traits of milk is an appropriate factor and an accessible way to select dairy cattle by breeders (Eyduran *et al.* 2013). It has been reported that nutritional status (Morand-Fehr *et al.* 2007), animal genotyping (Sezenler *et al.* 2016), pregnancy (Rogers and Spencer, 1999), lactation, lactation stage (Skapetas *et al.* 2005), weight, physical condition (Merkhan, 2014), animal health status (Milerski *et al.* 2006) and breeding systems (Mckusick *et al.* 1999) are the most prominent factors affecting udder morphology.

We hypothesized that the pattern and variability of udder morphology in Mohabadi goat could influence milk yield and can to play as criteria for identification does with high potential for milk production. The study results provided some interesting findings regarding the correlations between udder and milk.

The key outputs of our study demonstrated that the right udder length is a significantly associated with higher milk production.

Table 2 Descriptive statistics for Digimizzer image processing in current study

Variable	n	Mean	Std Dev	Minimum	Maximum
Lactation period (day)	72.00	115.24	25.64	87.00	159.00
Milk (L)	72.00	984.04	269.03	400.00	1647.00
Right (R) teat length (cm)	71.00	3.14	1.33	0.97	7.88
left (L) teat length (cm)	72.00	3.38	1.50	0.93	6.85
Height udder (cm)	70.00	17.19	3.26	10.36	24.84
R udder length (cm)	71.00	7.80	1.93	3.77	11.23
L udder length (cm)	72.00	7.88	1.77	4.00	13.17
R angle (degree)	50.00	36.81	10.01	18.59	59.33
L angle (degree)	66.00	39.87	8.75	12.49	60.28

R: right and L: left.

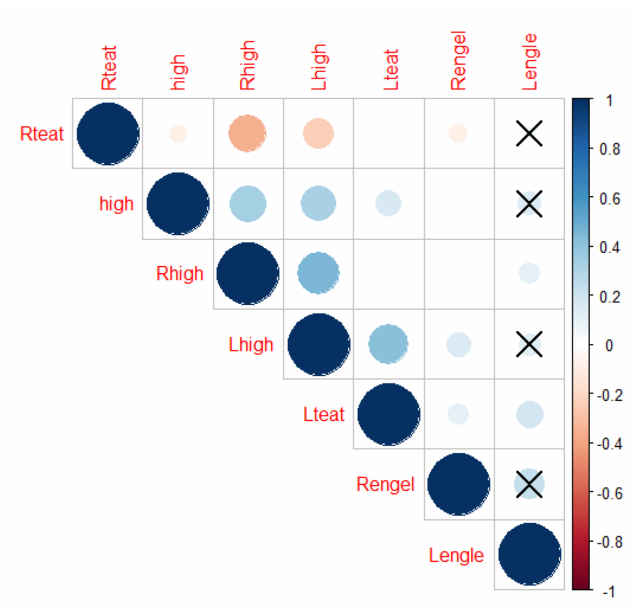

Figure 3 Correlation outputs and significant statue of seven investigated udder characteristics
Left teat length (Lengle); Right teat length (Rengle); Height udder (high); Right udder length (Rhight); Left udder length (Lhight); Left teat angle (Lteat): Right teat angle (Rteat)
Dark blue color is the highest positive correlation and dark red color also representative of the highest negative correlation pattern

To understand this finding, due to the existence of milk in the right side of the dairy animal, or by the development of more alveoli and blood vessels in the right side of the udder, or by greater sucking of the right teat in the animals studied by the offspring. Those that release more oxytocin and thus facilitate milk excretion from the right udder.

Here, we compared the finding of the proposed image processing method with those of the traditional methods. In line with our highlights, Sadeghi *et al.* (2013) emphasized a significant an association between right teat length and milk yield during lactation period. Contrary to our findings, some similar reports highlighted the association between other udder morphology on milk and in addition to, authors pointed different pattern of correlation in their goat population. Table 4 showed a wide board of similar literatures on morphological characteristics of goat and sheep with traditional method of measurement.

As reasonable justification, this inconsistency may be due to the multiple possibilities and invisible different between the condition of study designs, including nutrition and feed formulation, lactation stage, breed, age of does, kidding type parity, offspring sex, year and season of kidding, milking frequency and type of milking system lactation rate and milking time, udder size.

Table 3 Principal component (PC) analysis (Rteat, Lhigh, Rhigh, Lteat, high, Lengle, Rengel) outputs and extracted component and related variance values in this study

Item	Component[1]	
	PC 1	PC 2
Rteat	0.80	
Lhigh	0.76	
Rhigh	0.69	
Lteat	0.68	
high	0.66	
Lengle		0.76
Rengel		0.74
	Total variance explained	
Total	2.62	1.52
% of variance	37.46	21.84
Cumulative %	37.46	59.30

[1] Extraction Method: Principal component analysis.

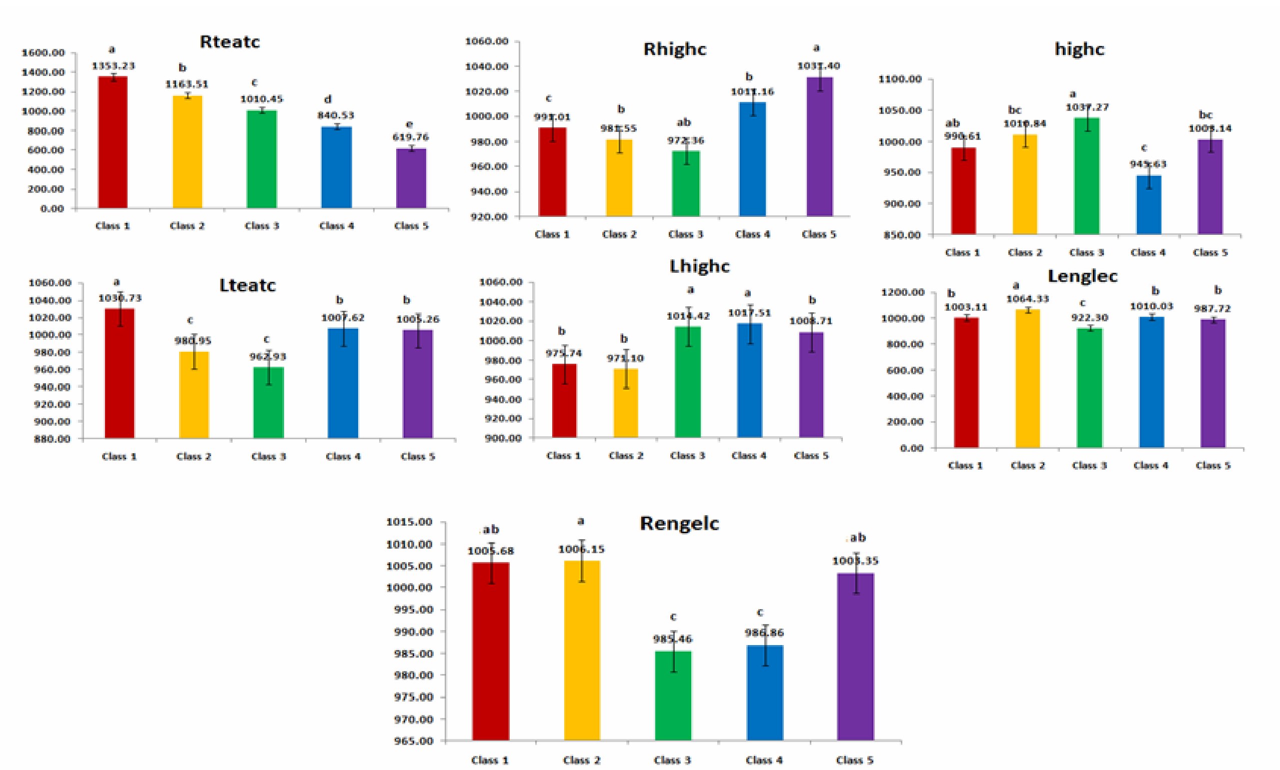

Figure 4 Results of significance statue between milk and udder morphological structure class; Rteat length (cm), Lteat length (cm), Height udder (cm), R udder length (cm), L udder length (cm), Rangle (degree) and Langle (degree)

However, this study is restricted with several limitations, such as sample size and history of milking, availability of fixed effects are not sufficient and therefore, it is not surprising to see that low significance during the interpretation of data. Therefore, further validation will be required using high inputs and goat breeds.

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Table 4 Summary for similar pieces of literature on morphological characteristics

Author	Country	Breed	Species	n	Investigated trait	Sig corr
Akbaş *et al.* (2019)	Turkey	Honamh	Goats	40	Udder depth, udder circumference udder width, teat length, teat diameter, distance between teats, distance to floor from the teat	Yes
Milerski *et al.* (2006)	Czech	Tsigai Walachi Lacaune	Sheep	266	Udder length, udder width, rear udder depth, cistern depth, teat length, teat angle, sum of cistern cross-section areas	Yes
Iñiguez and Hilali (2009)	Syria	Awassi	Sheep	273	Udder (circumference, width, height, and length), udder cistern (height), and teats (length, width, and position score)	Yes
Torres *et al.* (2012)	Spain	Majorer Tinerfeñ Palmera goat	Goat	12	Udder measurements	Yes
Suárez-Trujillo *et al.* (2013)	Spain	Majorera Tinerfeña Palmera	Sheep	1	Udder histological structures	Yes
Adegoke *et al.* (2016)	Nigeria	West African dwarf	Sheep	12	Udder length, udder width, udder, circumference, udder volume, teat length, teat width, teat circumference, distance between the teats and teat height	Yes
Türkyılmaz *et al.* (2017)	Turkey	Morkaraman, Tuj Awassi	Sheep	68 64 26	Udder width, udder depth and distance udder teats places were measured by measuring cane. Udder circumference, udder teats, udder teats diameter	Yes
Fatima *et al.* (2019)	Algeria	Bedouin	Goat	40	Udder morphology	Yes

CONCLUSION

Udder morphological traits are important parameters traditionally used in dairy goat production. They are essential for accurately monitoring milk ability of herds. On this basis, we conclude that the length of right and left udder showed the highest correlation. The results demonstrated that the length of the right teat significantly influenced milk yield. As a final message, digital image processing may be considered as alternative tool for linear morphological characterization that would provide more accurate observation and measurements on indigenous goat population.

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