

## Cross breeding of Saudi Aradi with Damascus goats breeds for genetic improvement in the milk yield and composition

Kamal El-den M. A.<sup>a\*</sup>, Mohammed K. M.<sup>b</sup>, Dahmouh A. Y.<sup>c</sup>

<sup>a</sup>Animal Production Department, Faculty of Agriculture, Al-Azhar University, Assiut, Egypt

<sup>b</sup>Animal Reproduction Research Institute, Agriculture Research Center, Giza, Egypt

<sup>c</sup>Camel and Range Research Center, Al Jouf, Saudi Arabia

### Abstract

The aim of the present study was to evaluate the effects of crossing Saudi Aradi with Damascus goat breeds in improvement milk yield and composition. A total number of 366 healthy goats (150 Aradi goats, 157 Damascus goats and 59 their cross) was included in the study. Does were randomly divided into two groups and each group, Aradi does were subdivided into two subgroups; the first one was inseminated artificially from semen of bucks of the same breed and the second group was inseminated artificially from semen of Damascus breed bucks. Data were recorded for all animals during two seasons (S<sub>1</sub>, winter/Autumn, S<sub>2</sub>, spring/summer). Effects of the type of birth, breed, season, year and number of kids on milk yield (MY), fat% (F%) and protein% (P%) were statistically analyzed. The percentages of variation for milk yield and fat were moderate (38.93 % and 39.36%, respectively) but the differences between minimum and maximum were high ranged from 90.54 to 514.9 kg for milk yield and from 0.580 to 8.259% for fat%, while these variations for protein% were low (12.43%) but the difference between minimum and maximum were high ranged from 2.133 to 5.280%. The breed had a higher significant effect on milk yield and fat% ( $P \leq 0.01$ ) and significant effect on protein% ( $P \leq 0.05$ ). Crosses had higher protein% than Damascus and Aradi goats breeds. There was significant effect of the year on milk yield, fat% and protein% (highest level of milk yield,  $P \leq 0.05$  and protein%,  $P \leq 0.01$  recorded during 2006). Number of kids had highly significant effect ( $P \leq 0.01$ ) on milk yield, protein and fat%. There were significant correlations among total milk yield, protein and fat% ( $P \leq 0.01$ ). In conclusions, milk yield traits in Aradi goats were the lowest, so crossing with Damascus goats is the best program for upgrading and genetic improvement of milk yield in that breed.

**Keywords:** genotype, milk composition, milk yield, Aradi goats, Damascus goats.

\*Corresponding author: Kamal El-den M. A.,  
E-mail address: [mohammedkamal.4419@azhar.edu.eg](mailto:mohammedkamal.4419@azhar.edu.eg)

## 1. Introduction

Goat farming is of primary importance to the national agricultural economy considering inputs needed for sheep or cattle farming. Most goat breeds in the kingdom of Saudi Arabia (KSA) are reared in the desert. The one of the main breeds of goats in Saudi Arabia are Aradi goats (Aljumaah *et al.*, 2012; Al-Atiyat *et al.*, 2015). Aradi is the largest breed and reared under harsh desert conditions. Their superior tolerance to the harsh environment, less demanding status of nutritional requirements and reasonable profit return from milk production and they concluded that these goats can produce milk steadily even during periods of drought KSA. Sawaya *et al.* (1984) in Saudi Arabia reported that milk production of Aradi goats was relatively low (60–150 kg/year) and they concluded that these goats can produce milk steadily even during periods of drought and, therefore, they are greatly appreciated by desert dwellers. Aradi goats could record higher production than the other local breeds under the same conditions and therefore more attention should be paid to this breed. In order to improve productivity of goats in Saudi Arabia, there is a great deal of interest to increase productivity of native goat breeds through crossbreeding and upgrading programs. These programs together with selection are required to characterize genetically these local goat breeds as well as of the so-called exotic breeds that could be used for genetic improvement (Barillet, 2007; Fahmy and Shrestha, 2000; Shrestha and Fahmy, 2007a,b). Furthermore, Guney *et al.* (1990a,b) indicated that some attempts

have been made to improve the production of goats milk by crossing the indigenous breed with exotic breeds, promising results were reported on German Fawn x Hair goat crossbreeds in terms of milk yield, but the gross composition of the goats milk during the lactation was not given. The introduction of Damascus (Shami) goats have a high milk yield, these goats are an indigenous breed in Syria and have been imported into other Middle East countries, Cyprus and North Africa (Constantinou, 1981; Shetaewi *et al.*, 2001). Studies carried out with Damascus goats have focused on the increase in milk yield and on improving the gross composition of the milk (Louca *et al.*, 1975; Constantinou, 1981; Hadjipanyiotou and Koumas, 1991). These improvements are essential to meet the increasing nutritional demands of the growing human population. Crossbreeding project is currently to improve milk production and milk composition in the local Aradi breed via the mating of Aradi goats with Damascus goats. The long-term objective of this project is to improve milk production and milk composition by increasing total milk yield and important traits in milk composition. Evaluating the performance, particularly aspects relating to milk production and milk composition, of crossbred animals at each stage of the project is essential as both factors affect kg milk yield and percentage of traits in milk composition. Thus, the objective of the current study was to improve the milk yield and composition, as well as upgrading of genetic merits of Saudi Aradi breed by crossing with Damascus goats.

## 2. Materials and methods

### 2.1 Location of study and animal management

All Institutional and National Guidelines for Ethical Conduct for Use and Care of animals were followed according to the guidelines in Animal Production Research Station of Al-Qassim, Saudi Arabia and approved by the Al-Qassim University ethics care committee. A total number of 366 clinically healthy goats were included in this study (Aradi goats, AA, n=150; Damascus goats, DD, n=157 and their crosses, n=59) during the time period from 2006 to 2010. The animals were kept at Camel and Range Research Center (Al-Jouf province, Northern region of Saudi Arabia located at latitude of 29.97 °N and longitude of 40.21 °W and at 684 meters above sea level) and at Animal Production Research Station in Al-Qassim University. All animals were raised under similar environmental, nutritional, and management conditions. The animals were housed in semi-shaded/open front barn and fed on a commercial concentrate and alfalfa hay. The amount of concentrate and hay were calculated according to the nutritional requirements for goats (NRC, 1981) which were dependent on animal ages and production status. Water, straw, salt and minerals supplemented in blocks were freely available to all animals.

### 2.2 Breeding plan of the genetic groups

A crossbreeding program between Saudi

Aradi goats (A) and Syrian Damascus goats (D) was started since 2006 in two locations, the first in Camel Research Centre in Jouf and the second in Animal Production Research Station in Al-Qassim University, Saudi Arabia. Does were locally born in both farms and they were in the first kidding. In each location, Aradi does were subdivided into two subgroups; one division was inseminated artificially from semen of bucks of the same breed and the second division was inseminated artificially from semen of bucks of Damascus breed, producing a genetic group of ( $\frac{1}{2}D\frac{1}{2}A$ ). In both experiments, does of Damascus breed were inseminated from bucks of the same breed to produce purebred litters and kids. In such crossbreeding program, three genetic groups of AA, DD and ( $\frac{1}{2}D\frac{1}{2}A$ ) were produced in each location. The measurement of milk production began after the 3<sup>rd</sup> day post-partum to allow kids consuming colostrum. Milk yield was recorded by the ICAR (International Committee for Animal Recording) A4 method at 28-day intervals during the 240 days of lactation (ICRPMA, 1990). All goats were milked after weaning by an automatic milking system that can measure the milk yield automatically. Milk yields of the dams were measured using the alternate day system until weaning. In this system, goats were milked at 6 AM on the recording day. Then, kids were fed with dams' milk with the assistance of the stock person and suckled their dams until 6 AM the following day. Kids were

isolated from their dams until the 6 PM milk recording. Sampling was started after weaning. Every 28 days, 200 ml milk samples were collected from the morning milk and immediately taken to the laboratory in an icebox. The samples were analysed for total solids by the gravimetric method, for fat by the Gerber method, for ash by the gravimetric method, and for treatable acidity as lactic acid using N/10 NaOH as described in Turkish Standard and for No TS1018 (The Institute of Turkish Standards, 1981). Total protein was determined by the phenol titration method as described by James (1998). By subtracting the sum of protein, fat and ash from the total solids content, the lactose content was calculated.

### 2.3 Data collection for statistical analysis

Data recorded for all animals during two seasons (first, winter/Autumn) and second spring/summer), and during years from 2006 to 2010. All data regarding to breed, season, year, and type of birth were collected and recorded. The collected data were analysed using PROC GLM procedure (SAS, 2008) for the least-square means and standard errors of the fixed factors. Data were expressed in mean  $\pm$  S.E.M. and the level of significance was set at  $P \leq 0.05$  and  $P \leq 0.01$ . The following statistical model was used for data analysis:

$$Y_{ijklm} = \mu + B_i + S_j + Y_k + T_l + e_{ijklm}$$

Where;  $Y_{ijklm}$ : The record of MY, F % or P % measured on does had milked at  $k^{\text{th}}$  year,  $i^{\text{th}}$  breed,  $j^{\text{th}}$  season and  $l^{\text{th}}$  type of birth;  $\mu$ : Overall mean when equal subclass numbers exists;  $B_i$ : effect of  $i^{\text{th}}$  breed ( $i = 1, 2$  and  $3$ );  $S_j$ : Fixed effect of  $j^{\text{th}}$  season ( $j = 1$  and  $2$ );  $Y_k$ : Fixed effect of  $k^{\text{th}}$  year ( $1, 2, 3, 4$  and  $5$ );  $T_l$ : Fixed effect of  $l^{\text{th}}$  type of birth ( $l = 1, 2,$  and  $3$ );  $e_{ijklm}$ : Random error particular to the  $ijklm^{\text{th}}$  observation assumed to be independently and normally distributed with mean zero and variance of  $\delta^2 e$ . The assumed model for heritability, genetic correlations and breeding values was:

$$y = Xb + Zu + e$$

Where;  $y$ : a vector of observations,  $b$ : a vector of fixed effects with an incidence matrix  $X$ ;  $u$ : a vector of random animal effects with incidence matrix  $Z$ ;  $e$ : a vector of random residual effects with mean equals zero.

### 3. Results and Discussion

The obtained results articulated wide phenotypic variations in all traits of the milk yield, fat and protein%. The percentages of variation for milk yield and fat were moderate (38.93 % and 39.36 %, respectively), but the differences between minimum and maximum were high ranged from 90.54 to 514.90 kg/season for milk yield and it ranged from 0.58 to 8.26 for fat%, while these variations for protein were low

(12.43%), but the difference between minimum and maximum were high it ranged from 2.13 to 5.28% (Table, 1). Data of milk yields and milk compositions for Aradi goats (AA), Damascus goats (DD) and their crosses

(½A½D) are shown in Table (2). In purebreds, the Damascus goats had higher MY (260.41 kg) than Aradi goats (225.16 kg). Also, the resulted crossbred does (½D½A) had higher MY (253.51 kg) than Aradi goats.

Table (1): Actual means, standard error (SE), coefficient of variation (CV%), standard deviations (SD) and ranges for milk studied traits.

Traits	Mean	S. E	CV%	S. D	Minimum	Maximum
MY,(kg)	244.851	4.982	38.926	95.311	90.535	514.900
F %	3.714	0.076	39.362	1.461	0.580	8.259
P %	3.297	0.021	12.432	0.410	2.113	5.280

Table (2): The studied milk traits from Aradi goats (AA), Damascus goats (DD) and their crossbreds (½A½D) (Actual means, standard error (SE), coefficient of variation (CV%), standard deviations (SD) and ranges).

Traits	N	B	Sig	Mean	SE	CV%	SD	Min	Maxi
MY	150	AA	**	225.159	7.276	39.580	89.119	90.535	429.840
	157	DD		260.409	6.921	33.305	86.730	124.20	514.90
	59	½A½D		253.513	15.837	47.985	121.647	102.00	502.580
F	150	AA	**	3.915	0.131	41.175	1.612	0.580	8.250
	157	DD		3.626	0.114	39.548	1.434	1.120	8.259
	59	½A½D		3.434	0.132	29.616	1.017	1.400	5.582
P	150	AA	*	3.187	0.029	11.233	0.358	2.149	5.280
	157	DD		3.316	0.026	9.922	0.329	2.822	4.432
	59	½A½D		3.529	0.0769	16.719	0.590	2.113	5.035

Sig-significant; \*\*= highly significant (P≤ 0.01); \* = significant (P≤ 0.05).

Serradilla (2001) reported that exotic high yielding breeds have always better milk yields than local breeds, but lower, in general, than their yields in their countries of origin. These performances are very variable, depending on the production systems and environmental conditions. The more intensive and similar to those of the regions of origin are these conditions, milk yield of first generation (F<sub>1</sub>) does are intermediate between the exotic and local breed or, in some cases, and they are closer to the exotic breed. Heterosis for milk yield has seldom been reported, in general, with the F<sub>1</sub>, either for milk yield or for milk

composition. However, does with a higher proportion of exotic genes (15/16) had better milk yields than those with a lower proportion (7/8). The recorded result is coincide with those reported by Montaldo *et al.* (1995), where they found that the differences between goats' breeds were highly significant (P ≤ 0.01) on total milk. The total milk yield ranged from (339 kg) in Nubian goats to (513 kg) in Saanen goats. In a Mexican study, a genetic groups consisting of 1/2 to 15/16 crosses of Alpine, Saanen, and Toggenburg × local Mexican goats had greater total milk production than a genetic groups consisting of 1/2 to

15/16 crosses of Granadina and Nubian × local Mexican goats (Montaldo *et al.*, 1997). In New Zealand farms, it was found that pure breed Saanen does had higher milk yield than other breeds (Singireddy *et al.*, 1997). Furthermore, Güler *et al.* (2007) found that the differences in mean values of milk yield were significant ( $P \leq 0.05$ ) between the genotype groups. Environmental variance, which by definition embraces all variation of non-genetic origin, can have a great variety of causes and its nature depends very much on the character and the organism studied. Generally, among different non-genetic effects on quantitative traits are season, year and type of birth. However, Kala and Prakash (1990) found that year and season of lambing accounted for variation of milk yield in two Indian goat breeds while it was reported that production year and birth type were significant effects for milk yield in the Spanish Verata goats (Rabasco *et al.*, 1993). Moreover Kominakis *et al.* (2000) indicated that production year, lambing month and birth type were found to be statistically significant for MY. Season of kidding, litter size and year significantly affected the milk yield in

goats (Valencia *et al.*, 2002; 2007). Many workers reported that all fixed effects were significant ( $P \leq 0.01$ ) for milk yield, fat% and protein% (Torres-Vázquez *et al.*, 2009; Pesce Delfino *et al.*, 2011). Our results indicated that for fat %, and protein % year effects were significant ( $P \leq 0.01$ ). Similarly, it was found that found that milk yield was affected by year of lactation ( $P \leq 0.001$ ) and type of birth ( $P \leq 0.05$ ) (Pesce Delfino *et al.*, 2011). Generally, increasing the percentage of environmental variance component indicates that the trait is highly affected by environmental conditions such as climatic conditions, management system, feeding regime and ruse stability to diseases. Throughout lactation, considerable changes occurred both in milk yields and in the main components of the milk samples (Figures 1 and 2). Breed had a highly significant ( $P \leq 0.01$ ) effect on milk yield and fat% and significant ( $P \leq 0.05$ ) effect on protein%. Damascus goats and their crosses had higher than Aradi in milk yield, but Aradi goats had higher than Damascus goats and their crosses in fat. Also, the crossbred had higher than Damascus and Aradi goats in protein (Table 2).

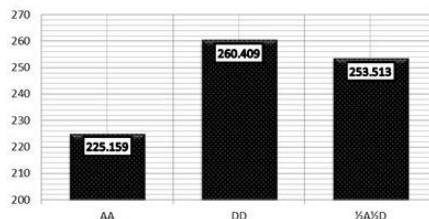


Figure (1): The milk yield from Aradi goats (AA), Damascus goats (DD) and their crossbreds (1/2A1/2D).

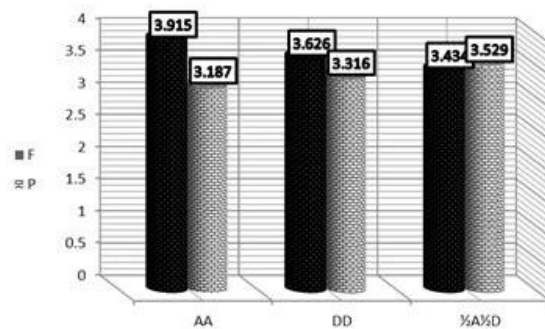


Figure (2): The milk traits (Fat% and protein%) from Aradi goats (AA), Damascus goats (DD) and their crossbreds (1/2A1/2D).

Analyses of variance showed that the fixed effects of year and type of birth were significantly ( $P \leq 0.01$  or  $P \leq 0.05$ ) different for all milk traits studied, while season of birth had no significant effect on milk traits (Tables 3). Milk yield during Summer/Spring season (S2) had a lower level than at Winter/Autumn (S1) of season but it was not significant, as well as not significant differences between seasons for fat% and protein%. The studying period (years) had significant ( $P \leq 0.05$ ) effect on milk yield

and highly significant ( $P \leq 0.01$ ) effect on fat and milk protein% (Table 3). The highest milk yield ( $P \leq 0.05$ ) was recorded during the year 2006. Conversely, the lowest milk yield was recorded during the year 2010. The highest fat % was registered during the year 2010, but the lowest fat % was recorded during the year 2006. The highest protein % recorded during the year 2006 as well as 2010. Conversely, the lowest milk protein was recorded at the year 2009.

Table (3): Least-square means  $\pm$  SE of non-genetic factors affecting milk yield, Fat % and protein % in goats.

Season \ Items	N	Milk yield	Fat (%)	Protein (%)
		NS	NS	NS
Winter and Autumn	321	281.827 $\pm$ 7.410	3.313 $\pm$ 0.118	3.455 $\pm$ 0.030
Summer and Spring	45	276.855 $\pm$ 15.56	3.169 $\pm$ 0.249	3.480 $\pm$ 0.064
Year		*	**	**
2006	21	316.425 $\pm$ 20.579	2.552 $\pm$ 0.329	3.596 $\pm$ 0.085
2007	191	276.928 $\pm$ 11.317	3.310 $\pm$ 0.181	3.330 $\pm$ 0.046
2008	76	297.591 $\pm$ 12.039	2.858 $\pm$ 0.193	3.332 $\pm$ 0.049
2009	45	259.506 $\pm$ 15.365	3.303 $\pm$ 0.246	3.234 $\pm$ 0.063
2010	33	246.256 $\pm$ 17.593	4.183 $\pm$ 0.282	3.845 $\pm$ 0.072
Type of birth		**	**	**
Single	161	220.567 $\pm$ 9.139	3.777 $\pm$ 0.146	3.439 $\pm$ 0.037
Twins	178	263.002 $\pm$ 10.526	3.412 $\pm$ 0.168	3.368 $\pm$ 0.043
Triplets	27	354.455 $\pm$ 18.552	2.533 $\pm$ 0.297	3.594 $\pm$ 0.076

\* =  $P \leq 0.05$ ; \*\* =  $P \leq 0.01$ ; NS= non-significant.

Table (4): Correlation coefficients between the studied milk traits in goats.

Traits	F	P
MY	-0.66870 **	0.17564 **
F	-0.08313	NS

Dams giving triplets kids had high significant ( $P \leq 0.01$ ) milk yield than that giving twins or single kid. The type of birth had highly significant ( $P \leq 0.01$ ) effects on protein% and fat% (Table 3). Data in table 4 indicated significant correlation ( $P \leq 0.01$ ) among total milk yield, fat% and protein%. Other correlations were close to zero or not Significant. From the obtained results it can be concluded that the improvement of genetic traits for milk yield and its' composition in Aradi goats obtained from crossing with Damascus breeds. It has marked and plausible genetic upgrading in Aradi goats taking in consideration that the non-genetics factors such as climatic conditions, management system and feeding regime play crucial role also and should be optimal.

### Acknowledgements

Authors thank and gratitude King Abdulaziz City for Science and Technology, Saudi Arabia, for providing the financial support to this project (No. ARP: 24-22).

### References

Al-Atiyat, R. M., Alobre, M., Aljumaah, R. S. and Alshaikh, M. A. (2015), "Microsatellite based genetic diversity and population structure of

three Saudi goat breeds", *Small Ruminant Research*, Vol. 130, pp. 90–94.

Aljumaah, R. S., Musthafa, M., Al-Shaikh, M., Badri, O. and Hussein, M. (2012), "Genetic diversity of Ardi goat based on microsatellite analysis", *African Journal of Biotechnology*, Vol. 11 No.100, pp. 16539–16545.

Al-Saef, A. M. (2013), "Genetic parameters for milk yield and components traits of Saudi Arabian Aradi, Damascus goats and their crosses", *Asia life sciences*, Vol. 22 No. 2, pp. 479–488.

Barillet, F. (2007), "Genetic improvement for dairy production in sheep and goats", *Small Ruminant Research*, Vol. 70, pp. 60–75.

Constantinou, A. (1981), "Damascus Goats in Cyprus", *World Animal Review*, Vol. 40, pp. 17–22.

Fahmy, M. H. and Shrestha, J. N. B. (2000), *Genetics for the improvement of goat meat production*, Proceedings of the Seventh International Conference on Goats, France, pp. 187–190.

Güler, Z., Kesklın, M., Masatçıglu, T., Gül, S. and Blçer, O. (2007),



- "Effects of breed and lactation period on some characteristics and free fatty acid composition of raw milk from Damascus goats and German fawn ×hair goat b1crossbreds", *Turkish Journal of Veterinary and Animal Sciences*, Vol. 31 No. 5, pp. 347–354.
- Güney, O., Özcan, L., Pekel, E., BiÇer, O., Torun, O., Gall, C. and Ninten, G. (1990b), "Improvement of milk yield and reproductive performance of native Awassi sheep and hair goat by crossbreeding with German milk sheep and German fawn goat", III. Colloquium of Çukurova-Hohenheim Universities Scientific Cooperation, Adana, Turkey, pp. 36.
- Güney, O., Torun, O. and BiÇer, O. (1990a), *Milk Production and reproductive efficiency characteristics of two new dairy goat types in the East Mediterranean part of Turkey*, Proceedings of Int. Symposium on "Livestock in the Mediterranean Cereal Production, Rabat, Morocco, European Association for Animal Production Publication No. 49, pp. 174–176.
- Hadjipanyiotou, M. and Koumas, A. (1991), "Effect of protein source on performance of lactating Damascus goats", *Small Ruminant Research*, Vol. 5, pp. 319–326.
- ICRPMA (1990), *International regulation for milk recording in goats*. International committee for recording the productivity of milk animals, Italy.
- James, C. S. (1988), *Analytical Chemistry of Foods*, Aspen Publishing, New York, USA.
- Kala, S. N. and Prakash, B. (1990), "Genetic and phenotypic parameters of milk yield and milk composition in two Indian goat breeds", *Small Ruminant Research*, Vol. 3, pp. 475–484.
- Kominakis, A., Rogdakis, E., Vasiloudis, C. and Liaskos, O. (2000), "Genetic and environmental sources of variation of milk yield of Skopelos dairy goats", *Small Ruminant Research*, Vol. 36 No. 1, pp. 1–5.
- Louca, A., Mavrogenis, A. and Lawlor, M. J. (1975), "The effect of early weaning on the lactation performance of Damascus goats and the growth rate of the kids", *Animal Production*, Vol. 20, pp. 213–218.
- Montaldo, A., Jutiez, J., Berruecos, M. and Sinchez, F. (1995), "Performance of local goats and their backcrosses with several breeds in Mexico", *Small Ruminant Research*, Vol. 16, pp. 97–105.
- Montaldo, H., Almanza, A. and Juárez, A. (1997), "Genetic group, age and season effects on lactation curve shape in goats", *Small Ruminant Research*, Vol. 24, pp. 195–202.
- N.R.C., (1981), *Nutrient requirements of*

- goats, National Academy Press, Washington DC, USA.
- Pesce Delfino, R., Selvaggi, M., Celano, G. V. and Dario, C. (2011), "Heritability estimates of lactation traits in maltese goat", *World Academy of Science, Engineering and Technology*, Vol. 78, pp. 666–668.
- Rabasco, A., Serradilla, J. M., Padilla, J. A. and Serrano, A. (1993), "Genetic and non-genetic sources of variation in yield and composition of milk in Verata goats", *Small Ruminant Research*, Vol. 11, pp. 151–161.
- S.A.S., (2008), *Statistical analysis system*, User's Guide (Release 9.2), SAS Institute, Cary, North Carolina, USA.
- Sawaya, W. N., Safi, W. J., Al-Shalhat, A. F. and Al-Mohammad, M. M. (1984), "Chemical composition and nutritive value of goat milk", *Journal of Dairy Science*, Vol. 67, pp.1655–1659.
- Serradilla, J. M. (2001), "Use of high yielding goat breeds for milk production", *Livestock Production Science*, Vol. 71, pp. 59–73.
- Shetaewi, M. M., Abdel-Samee, A. M. and Bakir, E. A. M. (2001), "Reproductive performance and milk production of Damascus goats fed Acacia shrubs and Berseem clover hay in North Sinai, Egypt", *Tropical Animal Health and Production*, Vol. 33, pp. 67–79.
- Shrestha, J. N. B. and Fahmy, M. H. (2007a), "Breeding goats for meat production: a review (2). Crossbreeding and formation of composite population", *Small Ruminant Research*, Vol. 67, pp. 93–112.
- Shrestha, J. N. B. and Fahmy, M. H. (2007b), "Breeding goats for meat production: a review (3). Selection and breeding strategies", *Small Ruminant Research*, Vol. 67, pp. 113–125.
- Singireddy, S. R., Lopez-Villalobos, N., Garrick, D. J. and Villalobos, N. L. (1997), "Across breed genetic evaluation of New Zealand dairy goats", *Proceedings of the New Zealand Society of Animal Production*, Vol. 57, pp. 43–45.
- The Institute of Turkish Standards (1981), *Turkish standards: raw milk standards* (no. 1018), The Institute of Turkish Standards, Ankara, Turkey.
- Torres-Vázquez, M., Valencia-Posadas, H., Castillo-Juárez, H. and Montaldo, H. (2009), "Genetic and phenotypic parameters of milk yield, milk composition and age at first kidding in Saanen goats from Mexico", *Livestock Science*, Vol. 126, pp. 147–153.
- Valencia, M., Dobler, J. and Montaldo, H. H. (2007), "Genetic and phenotypic parameters for lactation

traits in a flock of Saanen goats in Mexico", *Small Ruminant Research*, Vol. 68, pp. 318–322.

Valencia, P. M., Dobler, L. J. and Arbiza, S. I. (2002), "Sources of environmental variation affecting lactation and pre-weaning growth characteristics in Saanen goats", *Cuban Journal of Agricultural Science*, Vol. 36, pp. 117–122.