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A Study on Some Physical Attributes of Naeini Sheep Wool for Textile Industry

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Abstract: In order to evaluate some physical and qualitative characteristics of Naeini sheep wool for using in textile industry, herds from 6 different regions of Isfahan province were chosen. Staple length from 3 different body parts (shoulder, side and britch) was measured prior to shearing. Wool samples were taken from a 100 cm^2 surface on the mid-side of the Animals. Then the samples were transferred to the Laboratory of Animal Sciences for evaluations of some quality characteristics and to the Fiber Physics Laboratory for measuring tenacity, breaking strength and elongation at break of fibers. The means and standard deviations of staple length were estimated (10.8±2.36), (9.71±3.14) and (10.99±2.49) cm for shoulder, side and britch parts, respectively. The total average staple length of Naeini sheep (10.5 cm) is suitable for using in textile industry. Wool fibers of Naeini sheep have desirable tenacity and breaking strength (1.22 cN/dtex and 13.76 centi-Newton) to resist against mechanical tensions of the spinning step. However, Naeini sheep wool fibers have an adequate, but not a desirable %elongation at break (28.6%). Based on the fiber diameter mean of Naeini sheep and its variation (28.51±4.33 μm) the fleece grade of Naeini sheep was predicted 54's, which is an intermediate grade. However, by conducting breeding programs toward enhancing fleece grade, Naeini sheep wool will be simply applicable in textile industry.

Key words: Naeini sheep, fiber, length, strength, diameter, textile

INTRODUCTION

Fibers that have proper flexibility, delicacy, enough length and a high ratio of length to diameter are useful for producing textile materials. In addition, sufficient strength against mechanical operations is required for using in textile industry. In order to optimum use of Iranian sheep wool; first, all wool characteristics including quantitative and qualitative, mechanical and physical characteristics should be recognized, in which quantitative and qualitative traits are of the most important due to their importance in value-determining systems and incomes.

Iran is one of the most important greasy wool producer countries of the world (Table 1). Also, Fig. 1, shows Iran's wool production trend in the recent few decades. Although, Iran has a high annual wool production, due to high fiber diameter mean and variability in fleeces, most of the produced wool is applicable in carpet industry rather than textile industry and Iran has to import most of the wool needed for textile industry (fine wool) from other countries (e.g., Australia, New Zealand, South Africa and etc). Allocation a part the large outlays related to wool importation to Iran in order to improve wool quality through genetics and breeding, nutrition and improving life conditions may help to optimal use of internal recourses.

Naeini sheep consists of about 30% of the total Iranian sheep population. In addition, this breed has a good wool quality among the other Iranian breeds (Taherpoor, 1988). The kind of wool usage is greatly depends on fiber length, fiber diameter and uniformity. Usually, there is a high variability in fiber length and diameter for carpet wool (Dashab *et al.*, 2006; Coop, 1986). The appearance of Naeini sheep and its wool quality characteristics has been reported by Dashab *et al.* (2006).

All breeding plans for increasing wool production should include staple length. Staple length is an important

Table 1: FAO estimates of wool production for 15 highest producing countries in 2004 (FAO, 2006)

Rank	Country	Production^{MT}
1	Australia	520,000
2	China	325,000
3	New Zealand	229,600
4	Iran	75,000
5	United Kingdom	60,000
6	Argentina	60,000
7	India	51,400
8	Turkey	46,500
9	Sudan	46,000
10	South Africa	44,156
11	Uruguay	43,000
12	Russian Federation	42,000
13	Morocco	40,000
14	Pakistan	39,700
15	Syrian Arab Rep.	29,800

MT: Million Ton

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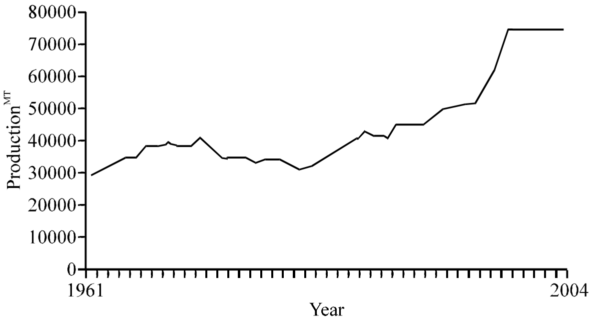

Fig. 1: Greasy wool production trend in Iran from 1961 to 2004. This figure is drawn based on FAO estimates (FAO, 2006). MT: Million Ton

value determining characteristic of wool. The wool manufacturing industry consists of two apparel and carpet divisions. Based on fiber length and diameter, the apparel division is categorized to worsted and woolen systems. Woolen system can make use of wool with more variability in length and diameter (Botkin *et al*., 1988). Staple length in Iranian native breeds is ranged from 7 to 19 cm; the lowest refers to Mehraban and Sangsari breeds and the highest staple length is related to Lori-Bakhtiari and Kalkoohi breeds (Taherpoor, 1988; Taherpoor and Salehi, 1987). Staple length is affecting by the length of fibers and their crimp. Fiber length depends on fiber growth rate and the length of growth period. Growth rate and crimp themselves are under the control of genotype and environmental effects, especially nutrition (Coop, 1986; Botkin *et al*., 1988). Generally, Iranian sheep has a high variation in staple length that causes the staple to have a shape like cone.

Fiber strength is very important in the spinning step, because in this procedure wool fibers should be combed and spun to produce yarn. Thus, fibers should have enough strength to withstand against various mechanical and physical tensions. The term sound wool is used by the trade to describe wool that is considered strong enough to withstand versus stresses of combing operations (Botkin *et al*., 1988). Various factors have been proposed for tenderness of wool fibers, which one or a combination of them could lead to fiber thickness and loss of strength (e.g., Genetic and environmental influences, such as a temporary reduction in nutrients, energy, limitation of specific dietary amino acids or minerals and finally microbial degradation of fibers during storage (Botkin *et al*., 1988)). Generally, Iranian sheep wool is categorized as a medium to coarse wool type having coarse fibers which is usually applicable to carpet industries (Taherpoor, 1988).

The objective of this study was to experiment and evaluate the length and some physical characteristics of Naeini sheep wool for using in textile industry.

MATERIALS AND METHODS

The experiment of this study was conducted in 1999 on Naeini sheep herds which were under the supervision of nucleus ram scheme of Animal Husbandry center of Agriculture organization in Isfahan province. Herds were chosen randomly from 6 different regions of Isfahan province; including Isfahan city, Naein, Ardestan, Najaf-Abad, Moorchekhort and Varzaneh. Wool samples were taken from a 10×10 cm^2 surface on the mid-side of each animal. However, staple length of different body parts (side, britch (lower thigh of rear legs) and shoulder) was obtained prior to shearing by measuring an unstretched lock of wool, with a stiff ruler. Wool samples were collected in specific envelopes marked by a label of the animal registration ID, including 36 rams and 191 ewes in 7 age classes (year). Then, samples were transferred to the Animal Science Laboratory of the Isfahan University of Technology for measuring some wool quality traits such as fiber diameter and its variability, the percentage of different kinds of fibers (true, heterotype and modulated) and scales accumulation (the number of scales in 100 μm length of fiber). Afterwards, 5 samples were chosen randomly from each herd and consequently at least 30 fibers were taken incidentally from each randomly selected sample which then transferred to the Fiber Physics Laboratory of the Isfahan University of Technology, in order to measure some physical characteristics on wool fibers of Naeini sheep. After fixation of individual fibers on special frames, breaking strength and fibers elongation at break were measured on the basis of centi-Newton and millimeter, respectively, by the Zwick instrument. In order to provide similar conditions for samples, the movement speed of jaws were set on 25 mm min^{-1} and the distance between jaws were set on 20 mm (ASTM., 1997). Then, elongation at break was rescaled on the percentage of the initial length (20 mm). Overall, breaking strength, elongation at break and tenacity were measured for about 1,000 fibers. Breaking strength is the force (Newton) that leads to the rapture of yarn. Elongation at break is the increase in length produced by stretching a sample to the breaking point expressed as a percentage of the initial length. Tenacity of fibers was estimated as follows (Thornton and Pearson, 1973):

$$\text{Tenacity} = \text{cN/dtex}, (\text{dtex} = 0.007854\,(d^2 + s^2)\,\rho)$$

where cN, d and s were breaking strength (centi-Newton), fiber diameter (μm) and its standard deviation, respectively. ρ was the prolonging index for sheep wool fibers, equals to1. 3 (Thornton and Pearson, 1973). Statistical analyses were performed applying SAS/STAT software (SAS Inst., 1997) and the mean comparisons were done using Duncan test by the following models:

$$Y_{ijkl} = \mu + Herd_{I} + Age_{j} + Sex_{k} + \varepsilon_{ijkl} \quad \text{(for fiber length)}$$

$$Y_{ijkl} = \mu + Herd_{I} + Age_{j} + e_{ijk} + \varepsilon_{ijkl} \quad \text{(for fiber strength)}$$

where; Y is the record of observation, μ is the overall population mean, Herd, Age and Sex are the related fixed effects; e and ε are within sample and random residual errors, respectively.

RESULTS AND DISCUSSION

Mean±standard deviation for staple length of shoulder, side and britch parts were estimated 10.8±2.36, 9.71±3.14 and 10.99±2.49 cm, respectively (Table 2). Staple length of the britch part was estimated higher relative to the two other parts, which was in consistent with the other reports (Taherpoor and Salehi, 1992; Botkin *et al*., 1988; Coop, 1986). Side samples had the lowest mean and the highest variation in staple length. Staple length of Naeini sheep is shorter than reports on staple length for some other Iranian sheep such as Lori-Bakhtiari (14-16.94 cm), Sanjabi (12.6-14 cm), Afshari (12.8 cm) and Baloochi (12-15.56 cm) breeds and longer than Mehraban (8.8-9.3 cm), Ghezel (7.73 cm) and Marivan (7.9 cm) breeds (Taherpoor, 1988). However those breeds have coarser fibers of lower quality.

Fleece weight is directly related to staple length and fiber diameter (Botkin *et al*., 1988). So, according to the relatively high Coefficients of Variation (CV) for the staple length of Naeini sheep (21.85, 32.34 and 22.66 for shoulder, side and britch parts, respectively), fleece weight can be improved by selecting individuals with longer staple length and lower fiber diameter mean to maintain its quality as well. In the present study, high correlations were found between staple lengths of different body parts (0.71 and 0.76 between side with shoulder and britch, respectively and 0.77 between shoulder and britch). Therefore, a staple length measurement from one of these parts could be a good representative for the staple length of other parts; it reduces the need for having several measurements of staple length per animal and animals can be compared for staple length based on one measurement (side measures which are more common in use). Staple length had low correlations with fiber diameter (0.05, 0.08 and -0.04 for shoulder, side and britch, respectively) which indicates that breeding for increasing staple length does not make important problems through increasing fiber diameter; however, these correlations were moderate with uniformity in fiber diameter (0.21, 0.24 and 0.18, respectively) which confirms that in breeding programs staple length and variability in fiber diameter should be considered simultaneously.

Among the studied effects (sex, age and herd) only herd shown a significant effect on fiber length ($p<0.01$) which is due to the genetic base and environmental differences between herds (Table 3). More recording programs in continuous years and generations would be required (to produce a large pedigree structure) for separating genetic and environmental effects. Sex and age effects had not any significant effect on the length of fiber ($p>0.05$). Thus, it could be concluded that Animal's age and sex do not play very important roles on the fiber length of Naeini sheep. Results of the effect of age on staple length was inconsistent with the results of Siah-Kamari (1998) on Sanjabi sheep, Salehi and Taherpoor (1991) on Sangsari breed and Brown *et al*. (1966) on Merino sheep. who found the effect of age to be meaningful on staple length. However, the results of the

Table 2: Descriptive statistics for the measured wool parameters

Traits	N*	Mean	SD	CV	Min	Max
Shoulder staple length (cm)	110	10.80	2.36	21.85	4.00	17.00
Side staple length	135	9.71	3.14	32.34	2.50	17.00
Britch staple length	105	10.99	2.49	22.66	4.00	18.00
Tenacity (cN/dtex)	30	1.22	0.20	16.39	0.75	1.58
%Elongation at break	30	28.60	7.70	26.92	11.00	42.30
Breaking strength§	30	13.76	2.26	16.40	8.46	17.82

*: Each observation on the staple length and the fiber strength traits is based on 4 and 30 fiber measurements, respectively; §: centi-Newton

Table 3: MSs and dfs for the fiber length from different body parts

	Shoulder		Side		Britch	
Sources	df	MS	df	MS	df	MS
Herd	10	25.42**	14	62.23**	9	23.99**
Sex	1	0.56	1	0.59	1	0.73
Age	6	3.62	6	6.27	6	5.10
Residual	82	3.46	103	3.20	78	4.58

**p<0.01

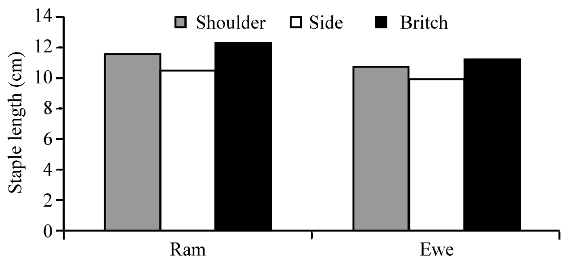

Fig. 2: Mean comparisons between different sexes for staple length of different body parts

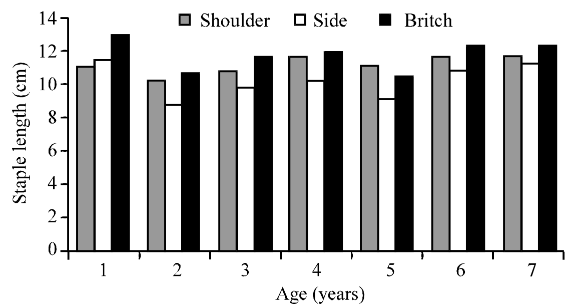

Fig. 3: Mean comparisons between different ages for staple length of different body parts

present study were in agreement with the results of Hasani (1992) on Lori-Bakhtiari sheep. Figure 2 and 3 provide comparisons of staple length in different body parts between different sexes and ages, respectively.

Staple length of different body parts differed considerably between different herds. It seems that animals in herds with better pastural and nutritional conditions, like herds in Ardestan and villages surrounding Isfahan city have higher fiber growth rates than animals living in herds of Naein and herds close to desert boundaries, which have lower fiber growth rates and more fiber loss. Staple length has a high correlation with fleece weight. The longer the staple length, the higher the fleece weight would be (Botkin *et al.*, 1988).

Table 4 shows the results of the analyses of variances for the fiber resistance traits against tension. Herd and age effects were not significant on the fiber physical attributes (breaking strength, elongation at break and tenacity) concerned (p>0.05). However, considerable variations observed within samples of individual animals, which had a significant effect on %elongation at break (p<0.05). Because the majority of diameter variation among fibers in a fleece occurs between fibers within locks (Botkin *et al.*, 1988), high variation of fiber diameter in each sample may be responsible for this effect.

To evaluate the effect of age, animals were assigned to young (<3 years) and old (>3 years) subclasses. Because in the primary model, sex was found as a

Table 4: Results of the analyses of variance for some physical characteristics of fibers

Sources	df	Breaking strength§	%Elongation at break	Tenacity¤
Herd	5	540.44	139.84	0.95
Age	1	134.90	60.75	0.02
Sampling error	3	188.29	24.62*	0.28
Residual	988	99.12	9.61	0.41

*p<0.05; §: (centi-Newton); ¤: (cN/dtex);

non-significant effect with a negligible influence on the fiber strength traits, it was not considered in the final model. Although, differences were insignificant (p>0.05), wool fibers of young animals (<3 years) were more resistant relative to older animals (>3 years), which were 14.73 vs. 12.46 centi-Newton for breaking strength, 29.55 vs. 28.20 for %elongation at break and 1.24 vs. 1.20 (cN/dtex) for tenacity. Results of the Animal's age and sex on fiber resistance traits against elongation are in consistent with the results of Drummond *et al.* (1982) and Robert *et al.* (1986).

Fiber characteristics of Naeini sheep for using in textile industries

Geometric characteristics: Fiber diameter is the most important assigning factor for the wool quality, which is measuring by either Micron (μm) or Spinning count systems. The range of variation in fiber diameter and the relative frequency of each range are presented in Table 5 for Naeini sheep. The frequency of fibers with lower than 25 μm diameter was more than a half of the total fibers which shows that most of the Naeini wool fibers are of a fine quality and by conducting selection programs on Naeini sheep wool, the frequency of true fibers would be increase and fiber diameter mean would be decrease.

According to Table 5, as fiber diameter increases, its relative frequency decreases. In textile industries the wool value-determining factor is the spinning count score, which is determining by the D3992 system (Klein, 1986). Because a minimum number of fibers are required for yarn to be strong enough for weaving or knitting, more yarn can be spun from finer wool than coarser one. Spinning count system provides 16 categories for describing fleece grade (Botkin *et al.*, 1988). Based on the total fiber diameter mean and standard deviation (28.51±4.33 μm) reported for Naeini sheep by Dashab *et al.* (2006), on average, the spinning count score (fleece grade) of Naeini sheep was predicted 54's regarding the specifications for grades of wool (Botkin *et al.*, 1988), which indicates an intermediate fleece grade for Naeini sheep wool. It seems that the reason for this quality loss may be due to the percentage of fibers with more than 40 μm diameter (%13.4 of the total fibers). This shows the importance of selection against coarse fibers including

Table 5: The frequency of fibers in different ranges of diameter

Fiber diameter (μm)	Frequency (%)
d<25	51.5
25<d<30	17.6
30<d<40	17.5
40<d<50	7.8
50<d<60	3.1
d>60	2.5

modulated and heterotype fibers with 65.8 and 46.7 μm diameter mean for Naeini sheep (Dashab *et al*., 2006), respectively.

Spinning count scores between 58's and 80's or finer is useful for Fustian systems (Klein, 1986). It shows that there is a short lag between Naeini sheep fleece grade and the fleece grades applicable in Fustian system. This lag can be removed easily by selection against coarse fibers. Current researches on Naeini sheep have shown that fibers with more than 40 μm diameter are mainly consisted of kemp and heterotype fibers which are about 5.93 and 4.38% of the total fibers, respectively (Dashab *et al*., 2006). Thus, by reducing the percentage of kemp and heterotype fibers and improving the spinning count score from 54's to 60's which is simply applicable in Fustian textile system it would be possible to produce finer and tender stuffs from Naeini sheep wool. Fleeces with 23.5-24.94 μm fiber diameter mean are specified as 60's grade (Botkin *et al*., 1988). Thus, by 3.6 to 5 μm decline in fiber diameter mean of Naeini sheep it would be possible to enhance its grade from 54's to 60's. The reason of using finer fibers for producing of finer yarns is that finer fibers have higher impact surfaces and compactness in yarns and as a result the less vacant spaces between fibers would be. It makes it possible to produce finer yarns with necessity strength.

Scales accumulation in the length of fiber is another geometric characteristic of fibers, which is associated with fiber strength and polish (Von Bergen, 1963). Scales accumulation had light negative correlations with staple length (-0.09, -0.05 and -0.18 for shoulder, side and britch, respectively). Also, the correlations between scales accumulation and the fiber strength traits were estimated negatively (-0.03, -0.22 and -0.51 for tenacity, %elongation at break and breaking strength, respectively). So, it can be concluded that fibers with higher number of scales in length are shorter and tender. Dashab *et al*. (2006) reported that lower scales accumulation is associated with finer fibers with a better handle character. No reports were observed for the suitable number of scales in the length of fiber. However, on average the number of scales was estimated 6.2 per 100 μm length of fiber for Naeini sheep (Dashab *et al*., 2006).

Longer fibers require fewer swings to make yarn and so the spinning constancy increases. Fiber length and staple length are directly correlated and as fiber length increases staple length increases (Botkin *et al*., 1988; Von Bergen, 1963). On average, the staple length of Naeini sheep was estimated 10.5 cm regardless of the body part, which is relatively shorter than the most Iranian native breeds (Taherpoor, 1988). However, this length is satisfactory for textile industry.

Fiber strength traits: Fiber strength is particularly important to processors that comb wool in preparation for the manufacture of worsted yarns. In the present study, the mean of fiber tenacity and breaking strength were estimated 12.2 mN/dtex and 13.76 centi-Newton, respectively (Table 2) which are more than the required thresholds of the spinning line. Wool fibers using in textile industries should have at least 6 mN/dtex tenacity to withstand against physical and mechanical tensions and breaking (Klein, 1986). So, it could be concluded that wool fibers of Naeini sheep have a desirable tenacity and breaking strength for using in textile industry. None of the studied effects were significant on the both traits ($p>0.05$). Among the reported breaking strengths for Iranian breeds (Taherpoor, 1988), only Zandi breed had a higher breaking strength (14.76 centi-Newton) relative to Naeini breed.

The desirable percentage of elongation at break for wool fibers is between 40-50% (Klein, 1986); this value was estimated 28.95% for Naeini sheep in the present study (Table 2). Therefore, it seems that wool fibers of Naeini sheep have an adequate but not a desirable grade in this physical point of view. It seems that there is a high potential for improving physical strength of Naeini sheep wool fibers through genetic and nutritional improvements. Energy and protein (the Sulfur containing amino acids) content affecting wool traits considerably. The Sulfur containing amino acids (particularly Cystine) are especially important because of their contribution in the chemical structure of wool (Botkin *et al*., 1988). Cooper is directly involved in the formation of wool fibers and its metabolism is closely related to dietary level of Molybdenum and Sulfate, so their balance may be more important than their absolute levels (Botkin *et al*., 1988). According to the reported %elongations for Iranian breeds (Taherpoor, 1988), only Makooi breed with 33.1% elongation at break was superior to Naeini breed. High positive correlations were found between %elongation of fibers with tenacity and breaking strength (0.84 and 0.52, respectively) which indicates that fibers with high elongation character have a more tenacity and needs more strength to break.

Although these physical experiments are relatively cost and time consuming, the frequency of desirable genes contributing in fiber strength could be increased in the population by conducting measurement and recording programs on breeding rams, because each individual ram is mated to more than one ewe and so, rams have a more contribution in the gene follow to the next generations.

According to the results of this study, Naeini sheep has suitable wool fibers applicable in the semi-Fustian system. Improving wool quality helps sheepmen earn more returns, facilitates the development of textile industry and finally may lead to a national economization. In addition, Naeini sheep has an ability to produce finer fibers with more uniformity and there is a high capacity to work on this Iranian native breed. By conducting more breeding programs, improving management and modifying environmental effects, much finer fibers with more strength will be obtained from Naeini sheep to reach the Fustian system qualifications. By conducting well planned designs, Naeini sheep can supply the wool needed for Fustian and fine textile industries and there would be less need for wool importation for this section of textile industry.

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REFERENCES

ASTM., 1997. Annual Book of ASTM Standards. Textiles Section Volume 7.1. American Society for Testing and Materials, West Conshohocken, PA.

Botkin, M.P., R.A. Field and C. LeRoy Johnson, 1988. Sheep and Wool: Science, Production and Management, Prentice-Hall, Englewood, pp: 321-416.

Brown, G.H., H.N. Turner, S.S.Y. Young and C.H.S. Dolling, 1966. Vital statistics for an experimental flock of Merino sheep, 3. Factors affecting wool and body characteristics, including the effect of age of ewe and it's possible interaction with method of selection. Aust. J. Agric. Res., 17: 557-581.

Coop, L.E., 1986. Sheep and Goat Production, World Animal Science Series, Elsevier Science, Publishing Co., New York.

Dashab, G., M.A. Edriss, A.A. Ghare Aghaji, H. Movasagh and M.A. Nilforooshan, 2006. Wool fiber quality of Naeini sheep. Pak. J. Biol. Sci., 9: 270-276.

Drummond, J., R.A. O'Connell and K.L. Colman, 1982. The effects of age and finn sheep breeding on wool properties and processing characteristics. J. Anim. Sci., 54: 67-89.

Food and Agricultural Organizations of the United Nations FAO., 2000. Economic and social department. The statistics division, 2006. Major food and agricultural commodities and producers. www.fao.org/es/ess/top/commodity.jsp?lang=EN&commodity=987&CommodityList=987&year=2004&yearLyst=2004

Hasani, S., 1992. Estimation of genetic and phenotypic parameters and study the effect of some genetic and environmental factors on wool traits for Lori-Bakhtiari sheep. M.Sc Thesis. Karaj Azad University, Iran.

Klein, W., 1986. The Technology of Short-staple Spinning, The Textile Institute, Academic Press. New York, pp: 180-240.

Robert, H.S.G. and C.F. Parlier, 1986. Processing characteristics of Polypay wool. J. Anim. Sci., 63: 692-699.

Salehi, M. and N. Taherpoor, 1991. Wool technological characteristics of Iranian native sheep breeds. 2-Sangsari sheep. Research Magazine of Heidar-Abad Animal Sciences Research Center, No: 63.

SAS©, 1997. SAS User's Guide: Statistics, (Version 6.12 Ed.). SAS Inst., Inc., Cary, NC.

Siah-Kamari, G., 1998. Estimation of genetic and phenotypic parameters and study the effect of some genetic and environmental factors on wool traits for Sanjabi sheep. M.Sc Thesis. Khorasgan Azad University, Iran.

Taherpoor, N. and M. Salehi, 1987. A study on technological characteristics on the wool of Iranian native sheep. Research Magazine of Heidar-Abad Animal Sciences Research Center, No. 53.

Taherpoor, N. and M. Salehi, 1992. Wool technological characteristics of Iranian native sheep breeds. 3-Sanjabi sheep. Research Magazine of Heidar-Abad Animal Sciences Research Center, No. 67.

Taherpoor, N., 1988. A research on the major studies conducted on the wool of Iranian native sheep. Technical Magazine of Heidar-Abad Animal Sciences Research Center, No: 44.

Thornton, M.A. and H. Pearson, 1973. The WIRA Textile Data Book, Bradford, England.

Von Bergen, W., 1963. Wool Hand Book, Wiley-Interscience, New York, Vol. 1, pp: 142-146.