Wool Characterization of Sheep Breeds in different ecological zones

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Abstract: Wool characteristics of Lohi, Kajli, Sipli, Thalli, Kachi and Pak karakul sheep breeds were evaluated in different ecological zones of Pakistan. Fifty wool samples of sixty gram each from adult and yearling sheep were randomly collected and transferred to wool laboratory of Small Ruminants Research Program, Animal Sciences Institute, National Agricultural Research Centre (NARC), Islamabad for analysis. Significant effect on wool bulk and staple length were observed for breed, fiber crimp/cm and age of sheep. The breed and age of sheep had significant effect on fiber crimp/cm, fiber diameter, Fiber diameter, Staple length and Clean wool yield %. Results indicated the breed and age of sheep had significant effect on clean wool yield % and Fiber diameter. Clean wool yield % of adult Lohi, Sipli, Kajli, Thalli, Kachi and Pak-Karakul was 66.175 ± 10.937, 61.188 ± 7.517, 70.079 ± 12.266, 71.182 ± 8.025, 65.802 ± 3.314 and 63.822 ± 5.492, respectively . Staple length of Lohi, Sipli, Kajli, Thalli, Kachi and Pak-Karakul yearling was 7.070 ± 0.909, 6.862 ± 1.201, 6.994 ± 1.124, 5.904 ± 1.141, 4.370 ± 0.523 and 5.738 ± 0.670 cm, respectively. Fiber diameter of Lohi, Sipli, Kajli, Thalli, Kachi and Pak-Karakul adult was 38.672 ± 7.636, 37.238 ± 3.149, 41.544 ± 8.061, 45.335 ± 3.126, 35.005 ± 3.003 and 30.310 ± 4.745 µ, respectively. Fiber diameter of Lohi, Sipli, Kajli, Thalli, Kachi and Pak-Karakul yearling was 29.166 ± 4.815, 33.34 ± 3.746, 34.885 ± 3.079, 33.156 ± 4.056, 28.322 ± 1.660 and 22.307 ± 2.298 µ, respectively.
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1. Introduction

Livestock sector share is 55.4 percent to the agricultural while 11.9 percent in national GDP. (Economic Survey, 2012-13). Almost 40 million people are engaged in livestock enterprise in different ways and are maintaining 172.2 million heads of livestock in Pakistan, out of which there are 91.7 million small ruminants that provide 0.838 million tons of milk, 0.643 million tons of mutton, 10,873 million skins, 0.043.6 million tons of wool and 0.0244 million tons of hair. The population of sheep in Pakistan is 28.4 million (Economic Survey, 2012-13). Twenty eight breeds of sheep have been defined in Pakistan. On the basis of their tail, these breed of sheep can be grouped into fat or thin tail. Sheep serve as major source of livelihood for millions of livestock farmers especially in the arid regions where the crop and dairy production is not feasible (Mackintosh, 1993). Sheep were the first animal to be domesticated in 10000 B.C. Sheep was first domesticated in Iran and Balochistan. Domesticated sheep existed in Harappa and Mohenjodaro. Most of the present breeds of sheep have traces of Mediterranean as well as Asian wild sheep. The Pakistani sheep breeds descended from Urial (*Ovis vignei*), the wild sheep of Balochistan, Afghanistan and Soviet Central Republics as well as from Argali (*Ovis ammon*), the Marco Polo sheep of China (Hasnain, 1985). Sheep production as a part of agriculture system plays a major role in economy of any country. It transforms vegetation on poor grazing lands to useful products like mutton, wool, milk and skin (Zubair *et al.,* 2006). Wool is a natural fiber grown on the body of sheep. It is largely a protein called keratin, which is basically nitrogen, carbon, hydrogen, oxygen and sulfer compound. These elements are contained in the 14 amino acid that are the building blocks of keratin. One particular amino acid, cysteine, makes up nearly 12.7% of wool fiber. (Ross, 1989).

On the basis of their wool characteristics, sheep breeds can be classified into fine, medium, long, and carpet (coarse) or mixed wool breeds. Fine wool breeds include the Merino of Australia and New Zealand and American Merino, Delain Merino and Rambouillet of the United States of America with fineness of 25µ or less and with average staple length of about 100 mm. Medium wool or crossbred wool breeds are Corriedale, Comeback and Pollworth developed from crosses between long wool and fine wool breeds and have wool fiber diameters ranging from 22 to 30µ and staple lengths up to 150 mm (Wuliji *et al.*, 1999). Other medium wool breeds such

as Southdown, Shropshire and Suffolk have wool ranges in diameter from 25-30µ and staple length of 78 mm. Long wool breeds (Cotswold, Leicester, Lincoln and Roney Marsh) are mainly raised for mutton production. Their fleeces have long staple of heavy and coarse fibers. Average fiber diameter ranges between 35-40µ, while the length is above 150 mm. Carpet wool breeds have mostly coarse fleeces with average fiber diameter of 35-45µ and average length ranges between 50-200 mm depending on frequency of shearing (once or twice a year). Such type of wool is suitable for making carpets, rugs and blankets. They are found in Russia, Asia and North Africa (Mackintosh, 1993). Majority of sheep breeds in Pakistan yield coarse wool. The quality of wool produced in Pakistan is not useful for making good quality thread for garments industry. It is an important source for making thread used in carpet manufacturing. (Munir *et al.,* 2010). Pakistan is producing 0.042 million tons of greasy wool annually which is worth of 340.375 million rupees. The quantity of raw wool exported from the country is estimated to be 3162 tons which is worth 234.178 million rupees (FAOSTAT, 2010). Age of sheep also influences the wool production and quality (Tabbaa *et al*., 2001). Sheep are commonly shorn once a year. However, shearing is done two times in a year in some parts of the world. Wool production and quality was improved if sheep were shorn more than one time in a year. Wool production is directly affected by shearing season and feed provided. Wool breeds of Australia have low level of dark fiber found in the wool as compared to the UK and Asian coarse and carpet wool breeds. Their wool production is greatly affected by season and the pattern of shearing which is maximum in summer and minimum in winter similar to Romney sheep breeds (Champion and Robards, 1999).

Animals raised in arid and semi-arid regions are generally subjected to period of under nutrition during extreme hot environment. Low production of wool is due to poor pasture and non-availability of feed. Feed intake directly affects the wool production, (Naqvi and Rai, 1990; Jafari *et al.*, 2005). Level of nutrition affects animal production; better the nutrition more will be the production, (Pleasants *et al.,* 1995). Fiber diameter and staple length are affected by the season of shearing. The wool obtained from different sheep breeds is different in its characteristics and utility. The wool produced by most breeds of Pakistan is coarse and carpet type. It is mainly used in the manufacture of carpet yarn, carpets and rugs (Khan *et al*., 2007). There is little information on wool characterization of sheep breeds of Pakistan. Therefore this study was planned to investigate the average clean wool yield and wool characterization of some important sheep breeds and effect of breed and age of sheep on wool characteristics i.e., average clean wool yield, fiber diameter, staple length, crimp and wool bulk.

2. Materials and Methods

Study was planned to analyze wool of six sheep breeds of Pakistan for various wool characteristics. Fifty wool samples each from yearling and adult Lohi, Kajli, Sipli, Thalli, Kachi and Pak karakul sheep breeds maintained at Livestock Production Research Institute (LPRI), Bahadurnagar, Okara, Livestock Experimental Station (LES), Khoshab, Livestock Experimental Station, Haroonabad and Livestock Experiment Station, Rakh Khaire wala Distt. Layyah respectively were collected.

Sampling

Wool samples were obtained from each experimental animal as described by Khan *et al.* (1994). About 60 gram of wool sample was obtained from left mid side of yearling and adult sheep. Location of mid side was ascertained by measuring of full hand span from back bone down the last rib. Samples were clipped using hand shearer or electric clipper having 200–300 mm long blades. Wool samples were immediately placed in a sealable polythene bag along with an identification tag for analysis in the laboratory.

Wool analysis procedures

Wool samples were analyzed at Wool Laboratory of Small Ruminants Research Program, Animal Science Institute, National Agriculture Research Center (NARC) Islamabad. The following parameter were recorded. Clean wool yield (%), Wool bulk, Fiber diameter, Staple length (cm) and Crimp.

Statistical analysis

Data was statistically analyzed using analysis of variance technique (ANOVA) under CRD (Steel *et al*., 1996) using statistical package for social sciences version 17.0 (SPSS Inc. 2007).

3. Result And Discussion

I. Clean wool yield %

There was a significant effect of breed and age on clean wool yield. Breed × age interaction had a non-significant effect on clean wool yield ($p \leq 0.05$) (Table 1). Clean wool yield % of adult Lohi, Sipli, Kajli, Thalli, Kachi and Pak-Karakul was 66.175 ± 10.937, 61.188 ± 7.517, 70.079 ± 12.266, 71.182 ± 8.025, 65.802 ± 3.314 and 63.822 ± 5.492, respectively (Fig.1). Clean wool yield % of yearling Lohi, Sipli, Kajli, Thalli, Kachi and Pak-Karakul was 63.959 ± 5.173, 60.060 ± 8.391, 65.130 ± 4.499, 66.295 ± 4.792, 63.048 ± 7.386 and 61.891 ± 8.187, respectively (Fig.1). The results of the present study

are in line with those of Selcuk *et al*. (2005) who found that there was significant effect of breed on wool production. These results are in agreement with the finding of Gloag *et al*. (2002) who found the same results in his study. Thalli yearling and adult showed the maximum wool production as compare to Sipli, Kajli, Kachi and Pak-Karakul breeds. Similar results were reporte by Gupta *et al*. (1995) who found the significant effect of age in wool yield in grazing sheep. Contrary to the present finding Qureshi *et al*. (2013) reported that year of shearing, breed and sex had non-significant effect on clean wool yield %. Clean wool yield is the weight of clean wool expressed as percentage of the greasy or raw wool after the removal of impurities. Wool is very hygroscopic fiber (picking up and losing moisture with change in the atmospheric condition). The percentage clean wool yield estimation is important for commercial reasons, as this measure is used in determining the price of greasy wool.

II. Staple length

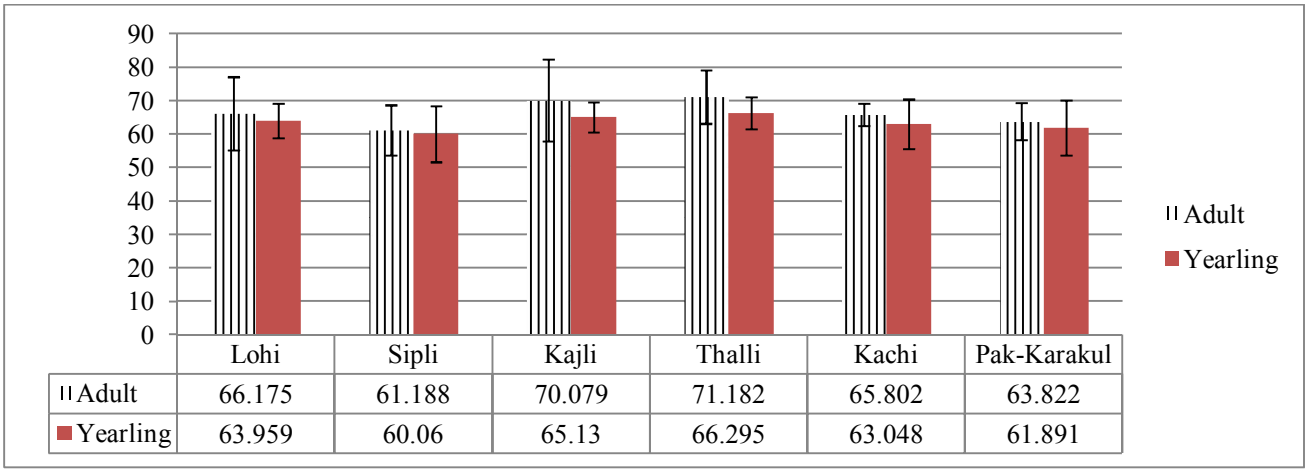
Analyses of variance showed that there was a significant ($p \leq 0.05$) effect of breed and age on staple length of fiber (Table 2). Breed × age interaction had a significant effect on staple length (Table 4.3). Staple length of Lohi, Sipli, Kajli, Thalli, Kachi and Pak-Karakul adults was 5.985 ± 0.893, 5.750 ± 1.168, 4.530 ± 0.801, 4.134 ± 0.694, 3.460 ± 0.578 and 4.624 ± 0.873 cm, respectively (Fig. 4.2.) Staple length of Lohi, Sipli, Kajli, Thalli, Kachi and Pak-Karakul yearling was 7.070 ± 0.909, 6.862 ± 1.201, 6.994 ± 1.124, 5.904 ± 1.141, 4.370 ± 0.523 and 5.738 ± 0.670 cm, respectively (Fig. 2). The results of this study showed that among six breeds the maximum staple length was 8.609 cm in Lohi and minimum was 4.37 cm in Kachi. These results are agreement with Zubair *et al*. (2006) who reported that staple length in sheep breed averaged 5.6 cm. According to the results of present study staple length was affected by the age and breed of the animal. They found that major variation in staple length was associated with breed difference. The present study showed that the effect of the animal's age on staple length was significant. These results are also similar with the study of Thiagarajan (2013) who found the animal's age had significant effect on staple length. This study is in accordance to Thiagarajan and Jayashankar (2012) who found that the breed and animal's age had significant effect on staple length. Thiagarajan and Jayashankar (2012) reported that the animal's age had a significant effect on fiber staple length these results coincide with those of preset study.

Contrary to the present finding Krishnamurthy *et al*. (1975) in Nilagiri and its crosses and Krishnappa (1979) in Corriedale X Deccani and Deccani reported that age had non-significant effect on staple length.

Table 1. Analysis of variance showing the effect of breed and age on clean wool yield %

Source	DF	SS	MS	F	P
Breed	5	4476.2	895.24	15.47	0.00
Age	1	1330.0	1329.97	22.99	0.00
Breed*Age	5	317.0	63.41	1.10	0.36
Error	588	34020.0	57.86		
Total	599	40143.2			

$p \leq 0.05$



	Lohi	Sipli	Kajli	Thalli	Kachi	Pak-Karakul
Adult	66.175	61.188	70.079	71.182	65.802	63.822
Yearling	63.959	60.06	65.13	66.295	63.048	61.891

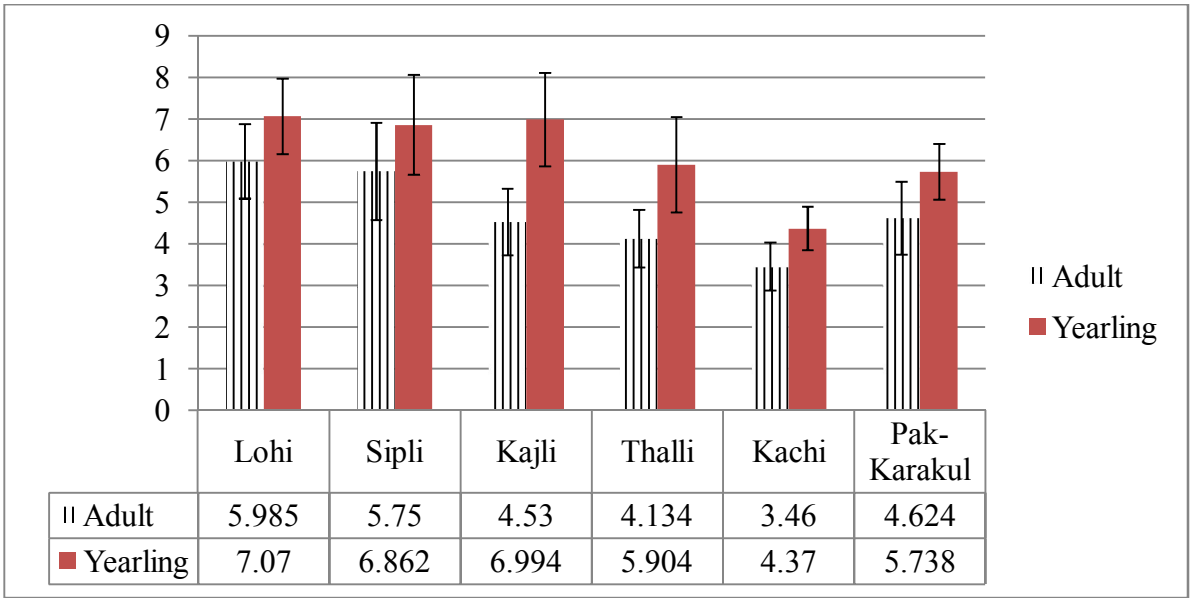
Fig. 1: Mean clean wool yield % of different sheep breed

Fiber length is another parameter which, along with fiber diameter determines the value and use of the wool. As for instance, the worsted yarn manufacturing employs fine wool having fiber length within a specified range. Wool with shorter or longer length is put to many other uses, of course, with due consideration to the fiber diameter. Staple length provides reasonably good estimate of the fiber length

and is easier and time saving to measure. This parameter also influences the spinning performance and the yarn yield.

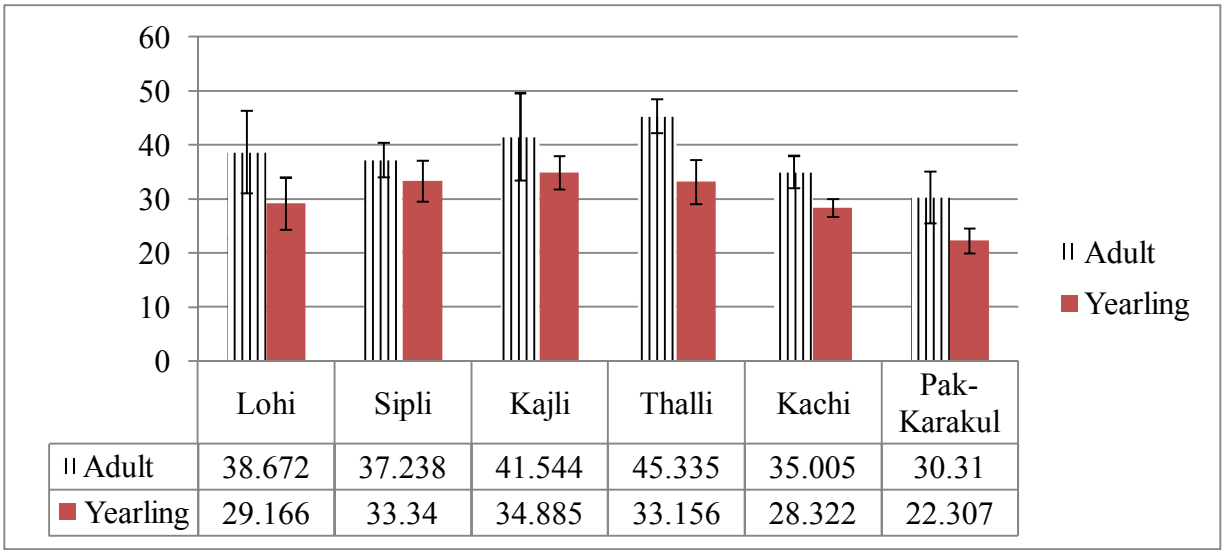
III. Fiber Diameter

The thickness of the wool is known as diameter that is measured in micron. Fiber fineness is one of the most important parameter of the wool as it determines how the wool is to be used. It assumes special significance for the wool spinning and textile industry. The fiber diameter was significantly affected by breed, class of animal and year while the effect of sex is non-significant. The overall appearance of the product could be affected by the fineness of wool. Average fiber diameter and its standard deviation, measured for six breed of Pakistan. Analyses of variance showed that there was significant ($p \leq 0.05$) effect of breed and age on fiber diameter (Table 4). Breed × age interaction had significant effect on fiber diameter (Table 5). Fiber diameter of Lohi, Sipli, Kajli, Thalli, Kachi and Pak-Karakul adult was 38.672 ± 7.636, 37.238 ± 3.149, 41.544 ± 8.061, 45.335 ± 3.126, 35.005 ± 3.003 and 30.310 ± 4.745 µ, respectively. Fiber diameter of Lohi, Sipli, Kajli, Thalli, Kachi and Pak-Karakul yearling was 29.166 ± 4.815, 33.34 ± 3.746, 34.885 ± 3.079, 33.156 ± 4.056, 28.322 ± 1.660 and 22.307 ± 2.298 µ, respectively (Fig. 3).



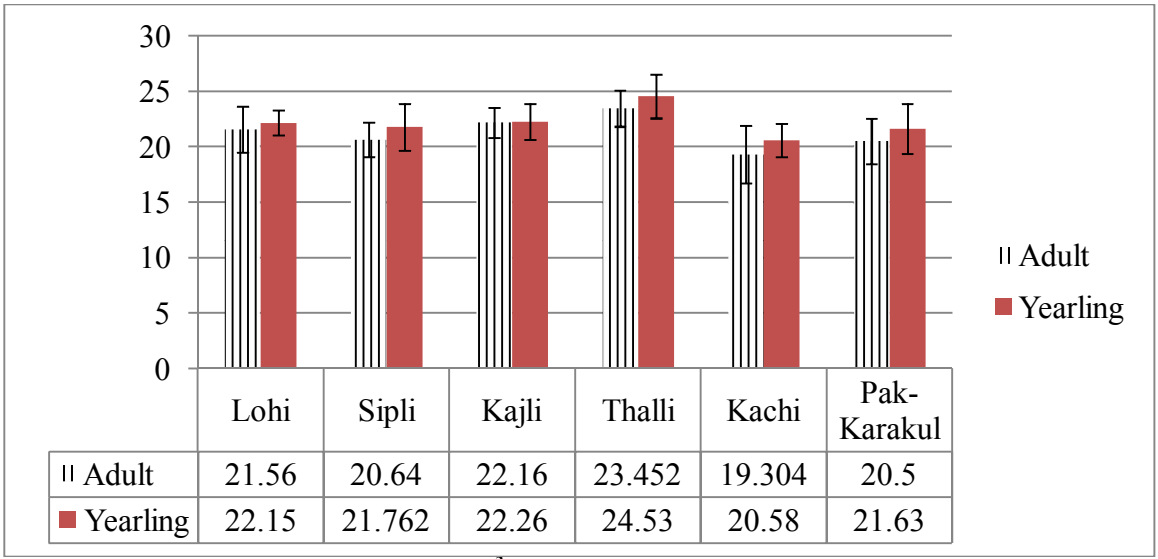
	Lohi	Sipli	Kajli	Thalli	Kachi	Pak-Karakul
Adult	5.985	5.75	4.53	4.134	3.46	4.624
Yearling	7.07	6.862	6.994	5.904	4.37	5.738

Fig.2: Staple length (cm) of different adult and yearling sheep breeds.



	Lohi	Sipli	Kajli	Thalli	Kachi	Pak-Karakul
Adult	38.672	37.238	41.544	45.335	35.005	30.31
Yearling	29.166	33.34	34.885	33.156	28.322	22.307

Fig.3: Fiber diameter (µ) of different adult and yearling sheep breed.



	Lohi	Sipli	Kajli	Thalli	Kachi	Pak-Karakul
Adult	21.56	20.64	22.16	23.452	19.304	20.5
Yearling	22.15	21.762	22.26	24.53	20.58	21.63

Fig.4: wool bulk (cm^3/g) different yearling sheep breeds.

Table 2. Analysis of variance showing the effect of breed and age on staple length (cm)

Source	DF	SS	MS	F	P
Breed	5	460.56	92.113	111.14	0.00
Age	1	297.85	297.849	359.36	0.00
Breed*Age	5	44.32	8.863	10.69	0.00
Error	588	487.36	0.829		
Total	599	1290.08			

p≤0.05

Table 3. Significant Interaction for Staple length (cm)

Breed	Age		S.D
	Adult	Yearling	
Lohi	5.985	7.070	1.049
Sipli	6.862	5.750	1.304
Kajli	4.530	6.994	1.573
Thalli	4.134	5.904	1.294
Kachi	3.460	4.370	0.714
Pak-Karakul	5.738	4.624	0.955

P ≤0.05

Table 4. Analysis of variance showing the effect of breed and age on fiber diameter

Source	DF	SS	MS	F	P
Breed	5	11150.0	2230.01	108.90	0.00
Age	1	9176.0	9175.99	448.08	0.00
Breed*Age	5	997.5	199.50	9.74	0.00
Error	588	12041.2	20.48		
Total	599	33364.8			

p≤0.05

The results of this study are in line with the McGregor and Butler (2004) who found that the animal's age had the significant effect on fiber diameter. The younger animals had the lower diameter than the adult animals. McGregor and Butler (2004) also concluded that the animal's age had significant effect on fiber diameter. Fiber diameter of younger animal is fine as compared to old animal. These results are similar to the present study. Contrary to the present finding Qureshi *et al.* (2013) reported that breed had non-significant effect on fiber diameter. Tabba *et al.* (2001) and Ashmawi and El-Azzawy, (1980) concluded that age of sheep had non-significant effect on fiber diameter. These finding do not coincide with those of present study. Fiber fineness is one of the most important parameter of the wool as it determines how the wool is to be used. It assumes special significance for the wool spinning and textile industry. The overall appearance of the product could be affected by the fineness of wool. Less the average fiber diameter of a wool sample, more would be fineness of it. A clear price differential exists for fineness, as the price increases with decrease in fiber diameter. The finer wools are also used to produce worsted yarns which, in turn, are used for the manufacture of valuable apparel. Not only the way of handling the wool depends on its fineness, the visual appearance of the finished product or the fabric is also influenced by the degree of fineness of the wool.

Table 5. Significant Interaction for wool fiber diameter (µ)

Breed	Age		S.D
	Adult	Yearling	
Lohi	38.672	29.166	7.947
Sipli	37.238	33.341	3.961
Kajli	41.544	34.885	6.932
Thalli	45.335	33.156	7.101
Kachi	35.005	28.322	4.136
Pak-Karakul	30.310	22.307	5.471

P ≤0.05

Table 6. Analysis of variance showing the effect of breed and age on wool Bulk

Source	DF	SS	MS	F	P
Breed	5	927.35	185.470	53.52	0.00
Age	1	116.83	116.830	33.72	0.00
Breed*Age	5	25.22	5.045	1.46	0.20
Error	588	2037.48	3.465		
Total	599	3106.89			

Table 7. Significant Interaction for wool bulk (cm^3/g)

Breed	Age		S.D
	Adult	Yearling	
Lohi	21.560	22.150	1.680
Sipli	20.640	21.762	1.920
Kajli	22.160	22.260	1.484
Thalli	23.452	24.530	1.880
Kachi	19.34	20.580	2.200
Pak-Karakul	20.500	21.630	2.217

P ≤0.05
P ≤0.05

Table 8. Analysis of variance showing the effect of breed and age on Fiber Crimp

Source	DF	SS	MS	F	P
Breed	5	114.787	22.957	234.26	0.00
Age	1	21.101	21.101	215.297	0.00
Breed*Age	5	59.365	11.873	121.15	0.00
Error	588	57.624	0.098		
Total	599	368.580			

P ≤0.05

Table 9. Significant Interaction for crimp/cm

Breed	Age		S.D
	Adult	Yearling	
Lohi	2.360	3.050	0.502
Sipli	1.736	3.128	0.766
Kajli	2.090	2.730	0.483
Thalli	1.140	2.190	0.599
Kachi	1.750	3.730	1.033
Pak-Karakul	1.688	1.710	0.249

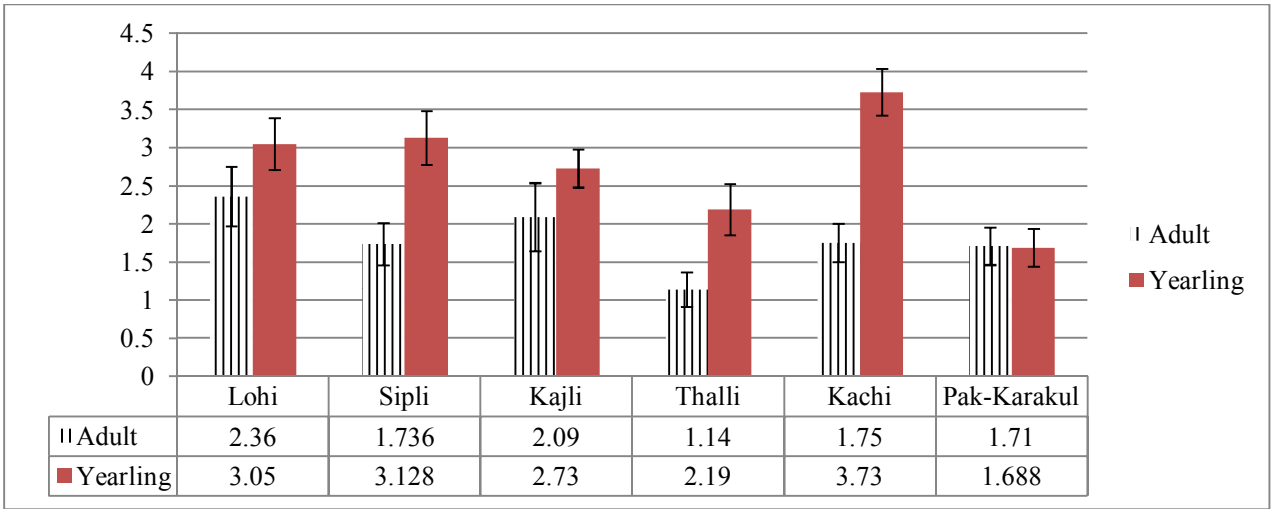
P ≤0.05

IV. Wool Bulk (cm^3/g)

Wool bulk is of primary interest in the carpet industry. It is defined as "wool's space filling ability". Wools with higher bulk result in bulkier yarn, which in turn produces thicker carpet cover. Analysis of variance showed that effect of breed and age had significant effect (p≤0.05) on wool bulk (Table 6). Breed × age interaction had significant effect on wool bulk (Table 7). Figure 4 depicts that wool bulk of adult Lohi, Sipli, Kajli, Thalli, Kachi and Pak-Karakul adults was 21.560 ± 2.069, 20.640 ± 1.548, 22.160 ± 1.360, 23.452 ± 1.640, 19.304 ± 2.581 and 20.500 ± 2.057 cm^3/g, respectively. Wool bulk of yearling Lohi, Sipli, Kajli, Thalli, Kachi and Pak-Karakul yearling was 22.150 ± 1.116, 21.762 ± 2.101, 22.260 ± 1.610, 24.530 ± 1.965, 20.580 ± 1.513 and 21.630 ± 2.247 cm^3/g, respectively. Average bulk values and their standard deviation for wools from six breeds of sheep (Lohi. Sipli, Kajli, Thalli, Kachi and Pak-Karakul) showed that wool bulk differs significantly (p≤0.05) among breeds which is in line with the results reported by the Khan *et al.*, (1994) who found that the wool bulk significantly differ among different sheep breeds. Contrary to the present finding Qureshi *et al.* (2013) and Zubair *et al.* (2006) reported that breed had non-significant effect on wool bulk.

V. Crimp

Analysis of variance showed breed and age of sheep had significant (p ≤0.05) effect on wool crimp (Table 8). It was depicted from table 9 that breed × age interaction had significant effect on number of crimps/cm. Crimps/cm of adult Lohi, Sipli, Kajli, Thalli, Kachi and Pak-Karakul was 2.360 ± 0.391, 1.736 ± 0.276, 2.090 ± 0.448, 1.140 ± 0.226, 1.750 ± 0.252 and 1.688 ± 0.247, respectively whereas crimps/cm of Lohi, Sipli, Kajli, Thalli, Kachi and Pak-Karakul yearling was 3.050 ± 0.338, 3.128 ± 0.351, 2.730 ± 0.251, 2.190 ± 0.333, 3.730 ± 0.306 and 1.710 ± 0.249, respectively (Fig. 5). Crimp is another wool characteristic highly related to fiber diameter. Crimp is the waviness of the wool. High-crimp wools that are very uniform are normally the higher quality wools. However, wool with too much crimp can cause problems in the processing the same as wools with very little crimp. Low-crimp wools tend to tangle and felt during scouring while high crimp wools can form balls or naps during carding and combing. Crimp is the term used to describe the wavy appearance of looks of raw wool. . Crimp frequency (no. of crimp per unit of length) is used as an indicator in the visual assessment of grade because coarser wool tends to have fewer crimps per unit of length than finer wool. The diameter of wool varies anywhere 0.0008 to 0.0002 inch and the number of crimps from 5 to 36 per inch (Ensminger 1970). The number of crimps had been significantly affected by breed and age of sheep. Ensminger 1970 reported that coarse wool has less number of crimps/cm. His findings are in agreement with the result of present study.



	Lohi	Sipli	Kajli	Thalli	Kachi	Pak-Karakul
Adult	2.36	1.736	2.09	1.14	1.75	1.71
Yearling	3.05	3.128	2.73	2.19	3.73	1.688

Fig.5: Fiber Crimp/cm of different adult and yearling sheep breeds.

VI. Conclusions

It was concluded that significant effect on wool bulk and staple length were observed for breed, fiber crimp/cm and age of sheep. The breed and age of sheep had significant effect on fiber crimp/cm, fiber diameter, Fiber diameter, Staple length and Clean wool yield %.

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VIII. Authors' contributions

This work was carried out in collaboration between all authors. "Authors Dilshad Gouri, Muhammad Lateef, Muhammad Iqbal Mustafa, Ghulam Muhammad and Muhammad Khalid Bashir managed the literature search. All authors read and approved the final manuscript."

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