INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 16, No. 1, p. 272-278, 2020

RESEARCH PAPER OPEN ACCESS

Assessment of the quality of wool from different sheep breeds of Pakistan

Faisal Ashfaq[*1], Muhammad Fatah Ullah Khan[2], Muhammad Iqbal Anjum[1], Munib Hussain[1], Javed Iqbal[1], Agha Waqar Yunus[1], Munir Hussain Khan[1]

[1]*Animal Sciences Institute, National Agricultural Research Center, Park Road, Islamabad, Pakistan*

[2]*Livestock and Dairy Development Board, Park Road, Islamabad, Pakistan*

Key words: Quality, Pakistan, Sheep, Wool

http://dx.doi.org/10.12692/ijb/16.1.272-278 Article published on January 25, 2020

Abstract

The present study was conducted in Pakistan to determine the wool characteristics of important sheep breeds and Rambouillet crossbreds in the country. In total, 4733 wool samples from 22 sheep breeds, and three crossbreds were analyzed. The clean wool yield was maximum ($P < 0.05$) in case of Kail, Pahari, Kairi, and Chitrali while lowest ($P < 0.01$) in case of Harnai, Khadali, Sipli and Manghali. The maximum ($P < 0.05$) fiber dimeter noted was 37.7µm in Lohi and Kajli, while the lowest ($P < 0.001$) fiber diameter noted was 20.1µm in Rambouillet. The second lowest ($P < 0.001$) fiber diameter was 23.0 and 23.7µm in Kairi and Chitrali breeds, respectively. The lowest ($P \leq 0.01$) medullation noted in local breeds was 5.9%, in case of Kairi. The highest ($P < 0.001$) medullation was found to be 60.9% in Manghali breed. The shortest ($P < 0.01$) staple noted was 2.71cm in Pahari, while the longest ($P < 0.001$) staple was found to be 14.1cm in Harnai breed. Comparison of crossbreds with Rambouillet rams indicated that two consecutive crosses with Rambouillet were necessary to bring the wool quality of Kaghani sheep at par with Rambouillet. Present results highlighted Kairi and Chitrali breeds to have lesser bulk than Rambouillet. The values of fiber diameter of these two breeds, and medullation in wool from Kairi were closer to Rambouillet, making these a preferred target for further research on fine wool in the country.

[*] **Corresponding Author:** Faisal Ashfaq ✉ ashfaq.faisal.pk@gmail.com

Introduction

Sheep production as a part of agricultural system plays a vital role in economy of any country, as it has the ability to transform non-productive vegetation to useful products including mutton, wool, milk, and skins (Zubair *et al.,* 2006). The wool obtained from different sheep breeds is different in its characteristics and utility. In general, the breeds found in hilly and mountainous tracts produce comparatively fine wool. The wool produced by plain area sheep breeds is coarse and of carpet type. Sheep wool is used in manufacturing of clothes, overcoats, tweeds, blankets and felts depending upon the quality and quantity characteristics of wool.

There are about 28 well defined sheep breeds in Pakistan which are well adapted to specific regions (Isani and Baloch, 1996). There are well recognized differences in body weight, and milk production among different breeds. However, the wool characteristics of local sheep breeds have not been well studied. The studies conducted to date in the country were implemented on a small scale and did not include most of the local breeds (Khan *et al*., 1994; Farmanullah *et al*., 2019). In general, the local Pakistani breeds are considered as coarse wool breeds. The wool is not only used for making tents, rugs, and other household items by sheep raisers, but also used in manufacturing carpets (Munir *et al*., 2010). These products, especially the hand knotted carpets have considerable demand in international market. The exports of carpets, rugs, and mats from Pakistan has been valued at $ 61.2 million (Anonymous, 2017). On the other hand, fine wool for cloth production is imported at the expense of foreign exchange. In this scenario government of Pakistan imported Rambouliet, a fine wool breed, from USA in 1990's to improve wool quality of sheep in hilly areas. The impact of such crossbreeding on wool quality of the crossbreds has not been evaluated. The present study was therefore conducted to evaluate the wool quality of the major sheep breeds of Pakistan and compare these with locally reared Rambouillet using state of the art methods. We analyzed 4733 samples from 22 pure breeds and three crossbreds in the country.

Materials and methods

Sheep Breeds and their Location for Wool Sampling

Wool samples (n = 4392) from individual animals were obtained from both the private and government farms located in different provinces. Samples of Lohi, Kajli, Sipli, Thali and Khadali breeds were obtained from Punjab province. Samples of Awassi, Dumbi, Kachi and Kooka breeds were obtained from Sindh province. Samples of Kairi, Khutta, and Chitrali breeds were obtained from Khyber Pukhtunkhwa (KPK) province and Gilgit. Samples of Balochi, Harnai, Rakhshani, and Manghali breeds were obtained from Balochistan province while the samples of Kail and Pahari breeds were obtained from Azad Jammu and Kashmir.The exotic Rambouillet breed was also included for comparison purposes.

Rambouillet sheep breed was introduced in Pakistan in 1990's, for crossbreeding targeted to uplift local breeds in the hilly area of Malakand and Hazara divisions of Pakistan. Currently, Rambouillet is regarded as the only fine wool sheep breed in Pakistan. A nucleus herd of Rambouillet has been kept at Livestock Research Station, Mansehra from where rams were distributed among local farmers for crossbreeding with local Kaghani sheep breed. The F1 offspring from crossing of Rambouillet with Kaghani is called Ramghani. The Ramghani has been further crossed with Rambouillet to get an offspring with 75% Rambouillet blood. Wool samples of Rambouillet were collected from Livestock Research Station, Mansehra while samples of its crosses were collected from farmers in Mansehra.

Wool Sample Collection

Wool samples were collected in autumn and spring seasons, following the normal shearing routine in Pakistan. To obtain wool samples, over 60g of wool was sheared from left mid-side of the sheep. Location of mid-side was ascertained by measuring of full hand span from back bone down the last rib. Second cuts were carefully avoided. The sample was immediately placed in a polythene bag along with identification tag secured at

top using a rubber band. The sample bags were also externally marked and sent to laboratory for analysis.

Assessment of Wool Quality

Clean wool yield is the weight of clean wool expressed as a percentage of the greasy or raw wool after the removal of impurities. Before determining clean wool yield, samples were washed with neutral detergent, and dried at 75°C. As wool is very hygroscopic fiber, it is a standard procedure to take into account a moisture regain of 16% for the oven dried wool sample. Hence a factor of 116 is used in the formula for computing the percentage yield.

Staple length was measured manually and wool bulk with the help of a bulkometer. Wool quality variables including fiber diameter and medullation were determined using Optical Fiber Diameter Analyzer (OFDA 2000, BSC Electronics, Ardross, Australia). The wool samples were prepared using a minicuring machine and blended on a glass slide and then measured on whole slide basis using OFDA. All analyses were conducted in wool laboratory of the National Agricultural Research Centre, Islamabad.

Statistical Analysis

Data are presented as arithmetic means, which were statistically analyzed applying ANOVA and least significance difference test using IBM SPSS Statistics 20 (IBM Corp., Armonk, New York, NY, USA, 2011).

Results and discussion

The percentage clean wool yield is used in determining the price of greasy wool, and is perhaps one of the oldest bases employed for the purpose. Data regarding clean wool yield are presented in Table 1. The clean wool yield was maximum ($P < 0.05$) in case of Kail, Pahari, Kairi, and Chitrali. The clean wool yield in case of these breeds was over 20% higher than the lowest ($P < 0.01$) yield noted in case of Harnai, Khadali, Sipli and Manghali.

Table 1. Clean wool yield of different sheep breeds in Pakistan.

Breed	*n*	Mean ± SD
Kail	203	79.36±15.22 [a]
Pahari	78	76.5±10.62 [a]
Balochi	598	71.64±13.75 [b]
Dumbi	17	73.79±16.49 [abc]
Kachi	763	69.38±13.73 [c]
Kooka	166	71.52±13.39 [bc]
Awasi	145	61.67±12.09 [d]
Kairi	35	82.72±6.79 [a]
Chitrali	151	81.52±12.25 [a]
Khutta	98	70.88±14.74 [bc]
Lohi	501	69.13±13.60 [c]
Kajli	268	71.52±13.96 [b]
Harnai	93	62.15±10.69 [d]
Rakhshani	81	74.39±11.35 [b]
Khadali	439	63.86±18.21 [d]
Sipli	260	62.71±14.63 [d]
Manghali	66	62.65±9.62 [d]
Karakul	12	65.95±14.86 [bcd]
Thali	21	71.80±11.84 [bc]
Rambouillet	191	69.70±8.45 [bc]
Non-descript crossbreds	142	73.83±11.23 [b]
Total	4328	69.84±14.62
F value		27.264
P value		0.001

[abcd] means bearing different superscript differ significantly in a column at $P < 0.001$.

Similar to our results, Devendran *et al.*, 2008 reported 81.4% clean wool yield from Coimbatore sheep, which is a woolly breed of Tamil Nadu producing coarse carpet wool suitable for making rough blankets (*Kamblis*).

In the present study, the clean wool yield ranged from 62.65 to 82.72%. However, Contrary to our findings Siddiqi (1982) reported clean wool yield to range from 38.5 to 91.5% in different sheep breeds of Pakistan. Overall, the clean wool yield is influenced by the environment in which sheep are reared (Munir *et al.*, 2010). Therefore wools from different area and rearing systems are expected to differ.

Fiber fineness (diameter)

Fiber diameter defines the fineness of wool and it is the most important factor that dictates its use (Gouri *et al.*, 2014). Wool with higher diameter is regarded as coarse and used in carpet manufacturing. The wools with less fiber diameter are regarded as fine and fetch higher price due to suitability in apparel manufacturing. In the present study, Lohi and Kajli, ($P < 0.001$), and nondescript crossbreds ($P < 0.05$) had higher fiber diameter than other breeds (Table 2). As expected, Rambouillet had the lowest ($P < 0.001$) fiber diameter of 20.07 µm. This was followed by 22.99 and 23.71 µm in Kairi and Chitrali breeds, respectively which had lower ($P < 0.001$) fiber diameter than rest of the other breeds. Fiber diameter for some Pakistani sheep breeds has been reported using conventional microscopy by many workers (Shah, 1982; Siddiqi, 1982; Khan *et al.*, 1994). Several authors in recent years however, studied fiber diameter of selected Pakistani sheep breeds using OFDA facility of our laboratory (Khan *et al.*, 1994; Qureshi *et al.*, 2013; Gouri *et al.*, 2014; Farmanullah *et al.*, 2019). Use of OFDA excludes chances of human error and generates more accurate and reliable results than the conventional microscopy. In this regard, the presently found 23.7µm fiber diameter in Kairi sheep is comparable with 23 and 24µm reported for the same breed by Ahmad *et al.* (2010) and Farmanullah *et al.* (2019), respectively. Similarly, the 33.3 µm fiber diameter noted presently for Khutta breed is comparable with the 27µm reported by Farmanullah *et al.* (2019). Using our laboratory facility, Gouri *et al*, 2014 found 38.7, 37.2, 25.0 and 30.3µm fiber diameter for Lohi, Sipli, Kachi, and Karakul breeds which are comparable with the presently found 37.7, 38.1, 36.0, and 33.3µm for these breeds, respectively. However, these authors found 41.4, and 45.3 µm fiber diameter for Kajli, and Thalli breeds which are higher than the presently found 37.7, and 37.3µm, respectively for these breeds. Some differences in fiber diameter reported in various studies are expected due to differences in shearing season and feed availability in different years. These factors along with age of experimental animals are recognized to effect fiber quality variables (Arnold *et al.*, 1984; Gouri *et al.*, 2014).

Our data on fiber diameter of wool is in line with the reports from other countries. In this regard, Edriss *et al.*, 2007 reported that the fiber diameter of Naeini sheep wool was 28.5 µm. Similarly, Akraim *et al.*, 2008 in a study on the wool characteristics of Libyan Barbarey sheep in north-eastern Libya reported mean fiber diameter of 38.4µm. Devendran *et al.*, 2008 reported that the fiber diameter was 45.8µ in Coimbatore sheep.

Table 2. Wool quality characteristics[1] of different sheep breeds in Pakistan.

Sheep breed	Medullation (%)		Staple length (cm)		Fiber diameter (µm)		Wool bulk (cm³/g)	
	n	Mean±SD	n	Mean±SD	n	Mean±SD	n	Mean±SD
Kail	212	7.91±9.87 ^{j}	213	5.43±1.51 ^{g}	213	28.87±2.97 ^{f}	203	24.38±2.87 ^{b}
Poonchi	22	18.84±10.19 ^{h}	-	-	22	28.93±4.14 ^{ghi}	-	-
Pahari	106	8.63±5.78 ^{ij}	78	2.71±1.25 ^{j}	106	27.14±3.92 ^{i}	78	21.01±1.47 ^{de}
Balochi	598	25.91±12.61 ^{g}	597	5.87±2.22 ^{f}	598	32.63±5.01 ^{e}	524	19.72±2.75 ^{h}
Dumbi	17	21.56±6.87 ^{gh}	17	8.07±2.36 ^{b}	17	32.82±4.18 ^{ef}	17	19.00±1.26 ^{gh}
Kachi	762	31.27±12.52 ^{f}	763	4.82±2.25 ^{h}	763	36.03±4.72 ^{bcd}	763	21.38±3.49 ^{d}
Kooka	166	35.76±14.52 ^{de}	166	5.19±1.75 ^{gh}	166	36.49±5.54 ^{bcd}	166	20.24±2.24 ^{efg}
Awasi	145	26.62±11.55 ^{g}	145	5.95±1.92 ^{f}	145	35.54±3.65 ^{cd}	144	20.58±1.71 ^{e}
Kairi	35	5.91±2.30 ^{jk}	35	5.41±0.89 ^{fgh}	35	23.71±2.42 ^{j}	35	16.21±1.03 ^{i}
Chitrali	151	11.86±16.46 ^{i}	151	3.63±1.41 ^{i}	151	22.99±2.37 ^{j}	150	16.86±1.90 ^{hi}
Khutta	98	25.55±25.66 ^{g}	98	3.59±1.33 ^{i}	98	30.33±4.80 ^{fg}	37	18.27±1.49 ^{gh}
Lohi	501	41.19±16.07 ^{b}	501	5.95±2.45 ^{f}	501	37.69±7.32 ^{a}	501	22.13±3.87 ^{d}
Kajli	268	39.76±11.97 ^{bc}	268	5.88±1.98 ^{f}	268	37.75±5.52 ^{a}	268	24.85±2.94 ^{b}
Harnai	93	33.38±11.31 ^{ef}	93	14.07±5.80 ^{a}	93	36.89±4.55 ^{ab}	81	26.29±2.92 ^{a}

Sheep breed	Medullation (%)		Staple length (cm)		Fiber diameter (µm)		Wool bulk (cm³/g)	
	n	Mean±SD	n	Mean±SD	n	Mean±SD	n	Mean±SD
Rakhshani	81	19.30±9.78 ^{h}	81	6.27±2.49 ^{cdef}	81	29.92±3.28 ^{gh}	79	20.05±1.17 ^{fgh}
Khadali	440	40.49±15.43 ^{b}	440	6.03±1.95 ^{ef}	440	34.20±6.00 ^{e}	437	22.35±2.88 ^{c}
Sipli	260	41.43±11.66 ^{b}	260	6.76±2.45 ^{cd}	260	38.07±4.28 ^{a}	260	22.75±3.24 ^{c}
Manghali	66	60.92±20.72 ^{a}	66	5.43±1.55 ^{fg}	66	34.32±5.53 ^{de}	64	22.73±4.65 ^{cd}
Karakul	12	44.34±13.57 ^{bc}	12	8.22±2.07 ^{b}	12	33.27±3.31 ^{def}	12	18.25±1.59 ^{gh}
Thali	21	39.17±9.16 ^{bcde}	21	7.28±1.89 ^{bc}	21	37.27±3.38 ^{abd}	21	26.95±2.11 ^{a}
Rambouillet	191	1.76±1.98 ^{k}	191	3.65±1.55 ^{i}	191	20.07±1.45 ^{k}	189	21.52±2.53 ^{d}
crossbred nondescript	142	37.39±13.63 ^{cd}	142	6.83±1.91 ^{c}	142	37.64±5.41 ^{a}	142	20.75±1.93 ^{ef}
Total	4387	30.22±18.11	4338	5.66±2.71	4389	33.75±6.88	4171	21.59±3.55
F value		173.24		108.13		179.34		85.55
P value		0.001		0.001		0.001		0.001

[1] Quality variables determined using Optical Fiber Diameter Analyzer.

^{abcd} means bearing different superscript differ significantly in a column at $P < 0.001$.

Medullation

The medulla is an air-filled cell in the cortex of the fiber (Crawshaw, 1990) which can be a short with only a thin shell of cortex surrounding the medulla (Ross *et al.*, 1980), a fine interrupted medulla (Ross *et al.*, 1980; Crawshaw, 1990), or continuous through the length of the fiber. The latter continuous coarse type medulla is desirable for manufacturing some types of carpets. However, medullation is an undesirable characteristic of apparel wools.

As presented in Table 2, Rambouillet was found to have 1.7% medullation in wool which was the lowest ($P < 0.001$) among all breeds except for the 5.9% noted for Kairi. The wool from Manghali breed was found to have 60.9% medullation which was the highest ($P < 0.001$) noted in this study. Our results for the coarse wool type breeds are in agreement with Devendran *et al.* (2008), who found 48.8% medullation in Coimbatore sheep.

Staple length

Staple length is an easy, and therefore the preferred, way to estimate the length of wool fibers (Qureshi *et al.*, 2013). As length of wool fiber influences yarn yield and spinning, wools with shorter or longer length are put to different uses.

In the present study, the staple length in different breeds ranged from 2.7 to 14.1cm (Table 2). Among all the breeds, the shortest ($P < 0.01$) staple was found in Pahari breed, while the longest ($P < 0.001$) staple was noted in Harnai breed.

This was followed ($P < 0.05$) by the staple length in Karakul and Dumbi breeds. The staple length of Harnai breed was 5 times longer than in case of Pahari, while almost twice the length in case of Karkul and Dumbi. These data are in line with the report of Shah, 1982, who found staple length to range from 4.0 to 10.0cm in different sheep breeds of Pakistan. Our findings regarding staple length of wool in Lohi and Sipli breeds are in agreement with the report of Gouri *et al.*, 2014. However, the presently found 3.65cm staple length for Rambouillet is much lower than 9cm reported by Qureshi *et al.*, 2013 while the 8.2 cm noted for Karakul is higher than the 4.6cm reported by Gouri *et al.*, 2014 for these breeds. Apparently these differences are attributable to differences in shearing time and collection areas.

Lupton *et al.*, 2004 in a study on evaluation of Dorset, Finnsheep, Romanov, Texel, and Montadale breeds of sheep reported that Romanov-sired ewes produced the longest fleece with 9.1cm staple. Edriss *et al.*, 2007 studied wool characteristics of Naeini sheep from 6 regions of Isfahan province. Staple length from shoulder, side, and britch were found to be 10.8, 9.7, and 11.0cm, with a total average length of 10.5cm. Akraim *et al.*, 2008 reported 12.2cm staple length in Libyan Barbarey sheep. Devendran *et al.*, 2008 reported 5.5cm staple length for the annual coarse type fleece obtained from Coimbatore sheep.

Wool bulk

Wool bulk is defined as wool's space filling ability or compressibility of a mass of unprocessed fibers (Gouri

et al., 2014; Sumner *et al.*, 2009). Yarn made from wools with higher bulk values are bulky, a desirable characteristic for making thick carpets. The bulk value of wools is dependent upon the type and level of crimps in the fiber. Highly crimped finer wools have less bulk, as recognized for Rambouillet, are preferred for scouring. Wool bulk values of 16 to 20cm^3/g are considered low, 21 to 24cm^3/g are considered average and 25cm^3/g or above are considered high.

In the present study, wool bulk values ranged from 16.2 to 26.2cm^3/g (Table 2). Harnai ($P < 0.001$) and Karakul ($P < 0.05$) had the highest wool bulk, while Kairi ($P < 0.05$) and Chitrali ($P < 0.01$) had the lowest wool bulk among all the studied breeds. Our results are 2.6 to 13% higher than the values of wool bulk reported by Gouri *et al.* (2014) for Sipli, Kajli, Thali, and Kachi breed while 12.3% lower for Karakul breed.

Assessment of the Rambouillet crosses

Data regarding the crossbreds of Rambouillet are presented in Table 3. There was an apparent effect of crossbreeding on staple length, fiber diameter, and wool bulk. Since the introduction of Ramboiullet, crossbreeding has been practiced to the extent that pure Kaghani sheep (local breed of the area) is nonexistent.

Table 3. Wool yield and quality of Rambouillet and its crossbreds in Pakistan.

Sheep breed	Clean yield (%)		Medullation (%)		Staple length (cm)		Fiber diameter (µm)		Wool bulk (cm^3/g)	
	n	Mean±SD	n	Mean±SD	N	Mean±SD	n	Mean±SD	n	Mean±SD
Rambouillet	191	69.70±8.45 ^{b}	191	1.76±1.98 ^{b}	191	3.65±1.55 ^{a}	191	20.07±1.45 ^{b}	189	21.52±2.53 ^{a}
Ramghani	64	74.07±4.89 ^{a}	64	8.06±3.20 ^{a}	64	3.04±1.73 ^{b}	64	20.43±1.47 ^{a}	64	19.20±1.88 ^{b}
Ramb. x Ramghani	277	65.44±8.85 ^{c}	277	1.27±2.23 ^{c}	277	2.78±1.15 ^{b}	277	20.13±1.85 ^{b}	120	21.02±1.81 ^{a}
Total	532	68.00±8.83	532	2.26±3.14	532	3.13±1.44	532	20.27±1.72	373	20.96±2.36
F value		34.03		236.61		22.61		17.78		26.012
P value		0.001		0.001		0.001		0.001		0.001

Ramghani is the crossbred of Rambouillet and local Kaghani breed; Ramb. = Rambouillet.

^{abcd} means bearing different superscript differ significantly in a column at $P < 0.001$.

Crossbreeding has previously been reported by other authors to improve wool quality variables. Lupton *et al.*, 2004 in a study on Evaluation of Dorset, Finnsheep, Romanov, Texel, and Montadale breeds of sheep reported that Romanov-sired ewes produced the finest fleece with 24.9µm diameter. Similarly, Farahvash *et al.*, 2007 in a study on comparison of wool characteristics of Arkhamerino x Ghezel and Arkhamerino x Moghani sheep crossbreds with their parents concluded that wool quality of half-breds was better than Iranian native sheep parents. In the present study, no statistical differences were found between second cross and Rambouillet regarding fiber diameter ($P = 0.716$) and wool bulk ($P = 0.057$). Medullation was higher ($P < 0.001$) in Ramghani, while the second crossing resulted in lower ($P < 0.001$) medullation compared to Rambouillet.

Crossbreeding resulted in decrease ($P < 0.01$) in staple length in both the crossbreds compared with Rambouillet. These data indicate that at least two crossings with Rambouillet are required to improve the wool quality to the level of Rambouillet.

Conclusions

Overall, present results highlighted Kairi and Chitrali breeds to have lesser bulk than Rambouillet. The values of fiber diameter of these two breeds and the medullation of the wool of Kairi were found to be closer to Rambouillet. These finer wool types are not expected to impart the desired bulky effect to the carpets, but may be blended with coarser wools to give special effects to the finished carpet. The other local breeds exhibited the property of bulkiness to the extent that makes them suitable for carpet manufacturing. Keeping in view the diameter and medullation of the wool of Kairi and Chitrali breeds, and their longer staple compared to Rambouillet, these may be suitable targets for breed improvement in future. Regarding the crossbreeding program using Rambouillet, the present results indicate that two consecutive crossings with Rambouillet rams are necessary to bring wool quality at par with Rambouillet. Present results and the availability of the type of wool samples from Mansehra indicate that the Rambouillet crossbreeding has been a success. However, the local Kaghani sheep has diminished.

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