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Cashmere quality of Raeini goats kept by nomads in Iran

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ABSTRACT

The income of the nomads in Kerman Province depends mainly on Raeini goats that produce meat, milk and cashmere. This paper assesses the cashmere quality and its variation in Raeini herds to determine the scope for improvement. In April 2010 fleece weights (FW) and midside fleece samples were taken from a total of 686 male and female cashmere goats of 1, 2 and 3 years of age belonging to 29 herds. The herds were randomly chosen in the summer grazing area of nomads within 20 km of the city of Baft, province of Kerman, South of Iran, the main cashmere producing area in Iran. Cashmere yield (CY) was determined from the weight of dehaired cashmere to weight of shorn fiber. Cashmere fibers were analyzed using an OFDA instrument. A general mixed linear model including sex, age and sex by age interaction as fixed effects and herd as random effect was used to analyze the data and measure the relationships between different cashmere characteristics and fleece attributes. The overall means ± standard deviations were for fleece weights (FW) 507 ± 183 g, cashmere yield (CY) 56.5 ± 12.2%, mean fiber diameter (MFD) 19.7 ± 1.5 μm, fiber diameter standard deviation (FDSD) 4.5 ± 0.6 μm, fiber curvature (FC) 62.9 ± 8.5°/mm and staple length (SL) 54.2 ± 7.0 mm, respectively. Herd effect was significant for all traits except for SL and sex by age effect was only significant for MFD. One year old males and females had finer cashmere than older goats. FW and FDSD were higher in males and CY and FC was higher in young animals. Pearson correlation between MFD and FC, FDSD and MFD, MFD and FW was −0.647, 0.399 and 0.211 respectively. Raeini cashmere is white, has an excellent SL and FC but is relatively coarse. Given the differences between and within herds there seems to be substantial scope to improve the commercial value of Raeini cashmere.

1. Introduction

Of the 25 million goats in Iran 40% are kept by nomads in a habitat of about 59% of the total area of the country (Ministry of Agriculture, 2004). Goats are mainly kept for selling live animals to local markets, and for home consumption of meat but cashmere is also a major source of income for Raeini, Nadushan, Birjandi, Abadeh and Abasabadi goat breed keepers (Ansari-Renani et al., 2011). Iran together with Afghanistan is the third largest producer and exporter of cashmere in the world, after China and Mongolia (FAO, 2009). More than 50% of the Iranian cashmere is produced by Raeini goats in Kerman province.

Dehaired cashmere is one of the finest and softest luxury natural fibers of the world used mainly for clothing providing warmth and lightness (Watkins and Buxton, 1992). The

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world demand for cashmere represents less than 0.01% of the international textile market but it is growing, for both fine and coarse cashmere, the latter due to the introduction of cashmere blend garments in the market. Processors pay according to origin, color and length of cashmere. Origin refers to Chinese, Mongolian or Afghan/Iranian and is usually associated to differences in fiber diameter (Schneider, 2011). Iranian cashmere is generally designated as 2–3 μm coarser than Chinese and Mongolian cashmere (Petrie, 1995) and is therefore cheaper (Phan and Wortmann, 2000; Schneider, 2011). Ansari-Renani (2001) showed that cashmere produced by three different Iranian breeds, Raeini, Nadoushan and Birjandi, was indeed coarser but also longer than cashmere from China and Mongolia. This finding was confirmed by McGregor and Postle (2004) and McGregor (2007). They tested cashmere from different origins of the world, including 18 samples from Iran and found that the Iranian cashmere was coarser, longer and had more crimp than cashmere from Australia, China and Afghanistan. Beyond that, little additional information on Iranian cashmere characteristics is available.

This paper studies cashmere quality and its variation in Raeini herds in the main cashmere producing region in Iran in order to determine the scope for improvement, in particular of fineness which would increase the market price and thereby the income of the nomad producers depending on the income from their goat herds.

2. Materials and methods

2.1. Cashmere production system in the study area

Raeini goats are kept by nomads (*Ashayer*) that graze their herds in Kerman province in spring and summer and migrate to the southern Persian Gulf provinces of Hormozgan and Bushehr in autumn. The study was conducted in Kerman province, SE of Teheran, near the city of Baft (29°17′N 56°36′E). The area covers 12,030 km^2 and is the main cashmere goat production region in Iran. Altitude is about 2270 masl and annual precipitation varies from 180 to 320 mm. The climate in spring and summer is hot and relatively dry, with temperatures reaching 35 °C in summer. The altitude of the winter grazing area of Hormozgan province is about 3267 masl with a dry and warm weather and annual precipitation of 171.4 mm.

The study was part of a larger baseline study of Raeini producers conducted in the region (Ansari-Renani, 2010, unpublished) which showed that the nomad livestock production system is based on mixed herds with 79% of heads being goats, 10% sheep and 11% horses, mules, donkeys and sometimes camels used for transportation. Nomads prefer goats over sheep because goats have a higher survival rate during droughts, reproduce faster than other livestock species and their meat is readily marketable. A typical nomad family would run some 250 goats, of which adult female goats (does) constitute 44%; bucks, castrated adult males, male and female yearlings, and male and female kids represent 8%, 5%, 7%, 12%, 10% and 14% of the herd population, respectively. The nomads are completely dependent on livestock as a source of income and they have a substantial share in supplying the society with different livestock products. Major product of female and male goats is cashmere which constitute about 25% and 33% of sources of income, respectively (Ansari-Renani, 2010, unpublished). The goats are also kept for religious and ceremonial purposes, as well as assets and insurance. Raw cashmere (*Kork*) is sheared in mid spring, using double blade knives (*Docard*), stored in plastic bags and sold at the site to middlemen who in turn sell it to exporters or national dehairing industry.

2.2. Cashmere samples and measurements

Twenty-nine Raeini nomad herds were randomly selected within about 20 km of the city of Baft and a stratified fiber sampling was organized. The majority of the cashmere goats kept in the region are white in color which implies that farmers had been selecting against colored cashmere in the past. Hence, only white goats were sampled. Samples were collected from four randomly selected goats of each sex (females, males) by age (1, 2 and 3 years) combinations; in total 686 samples were obtained; Sampling was conducted in early spring (mid-April 2010), prior to the seasonal moult and regular annual shearing period. Thus, fiber growth was about 12 months and the environmental conditions during the fiber growth period were stated as normal. Kidding also takes place in spring, after the herds return to Baft from the winter grazing areas, where they stayed for 5–6 months. Thus 696 samples were expected. Eventually 686 samples were obtained and used; only 10 samples were discarded for different reasons. Fifty-three fleece weights could also not be taken because it was not possible to spot some of the nomad herds in the baseline study due to migration from hot climate areas of Persian Gulf Hormozgan province to cooler areas of Kerman province.

In order to facilitate sampling, goats were restrained in a lateral position and about 10 g of fiber containing both guard hair and cashmere from the left mid-side site was cut from a 4.0 × 4.0 cm^2 close to the skin using regular scissors. Double blade scissors were used to shear the goats at the end of April and fleece weight (FW, g) was measured to the nearest 50 g using a digital scale.

The raw cashmere samples consisting of undercoat and guard hair were sent to the Alrun Fiber Laboratory in Almaty, Kazakhstan for analyses. In the Laboratory about a quarter of each sample was weighed with a digital scale and then manually dehaired. The dehaired cashmere, hair fiber and contaminants were weighed separately in order to calculate the percentage of cashmere yield of the sample (CY, %).

The dehaired cashmere was minicored into 2 mm snippets, washed in solvent, dried, reconditioned and then tested using an optical fiber diameter analyzer (OFDA 4000 in the mode of an OFDA 100). Based on more than 4300 individual fiber measurements, mean cashmere fiber diameter (MFD, μm), fiber diameter standard deviation (FDSD, μm) and fiber curvature (FC,°/mm) was measured.

Cashmere staple length (SL, mm) was obtained as the mean of three staples. For each staple, a suitable portion of the dehaired sample was sorted by length onto a velvet board and cashmere staple length obtained as the average of the maximum, minimum and midpoint measures.

2.3. Statistical analysis

Analysis of variance was performed using a mixed linear model (Mixed Procedure of SAS, 2008). Herd effect was treated as random and sex, age and sex–age interaction were treated as fixed effects. The significance of including herd as a random effect in the model was tested by comparing the differences of the residual log-likelihoods of models with and without the random effect, with the corresponding Chi^2 (Molenberghs and Verbeke, 2007). Significance of fixed effects was tested with *F* tests and significance of estimated differences between least square means was tested considering adjusted Bonferroni probabilities. The full statistical model used for all traits was:

$$Y_{ij} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + F_k + \varepsilon_{ij},$$

where Y_{ij}, represents the dependent variable analyzed; μ, the overall mean; α_i, the effect of age (i = 1, 2 or 3 years old); β_j, the effect of sex (j = female or male); $(\alpha\beta)_{ij}$, the interaction between age and sex; F_k, the random herd effect assumed N (0, $\sigma_F{}^2$); ε_{ij}, the residual random error assumed uncorrelated and $N(0, \sigma_\varepsilon{}^2)$; Fixed effects estimates are expressed as least square means ± standard errors. Probabilities below 5% are considered to be statistically significant.

3. Results and discussion

Table 1 shows the overall means, standard deviations and ranges for the six traits considered across all sampled animals. These values include the between and within herd variation. Some of the extreme values probably correspond to Raeini looking crossbred animals. For example animals with less than 20% cashmere yield or less than 200 g fleece weight are probably meat goat crosses. In this case some of the variation may be due to different management, shearing dates, genetic quality, or other

Table 1
Overall means, standard deviations (s.d.) and ranges of fiber characteristics for Raeini goats.

Trait	No of animals	Mean	s.d.	Minimum	Maximum
Fleece weight (g)	643	507.3	182.6	100	1250
Cashmere yield (%)	686	56.5	12.2	9.5	87.1
Mean fiber diameter (μm)	686	19.7	1.5	14.9	25.2
Fiber diameter standard deviation (μm)	686	4.5	0.6	3	7.4
Fiber curvature (°/mm)	686	62.9	8.5	33.9	93.6
Staple length (mm)	686	54.2	7	40	79

Table 2
Means, standard deviations (s.d.) and ranges of fleece weight (FW), cashmere yield (CY), mean fiber diameter (MFD), fiber diameter standard deviation (FDSD), fiber curvature (FC) and staple length (SL) in different Raeini goat categories.

Sex	Age	Trait	No. of animals	Mean	s.d.	Minimum	Maximum
Females	1 year	FW (g)	107	443.2	152.3	150	950
		CY (%)	116	57.2	13.7	12.4	87.1
		MFD (μm)	116	19.2	1.4	16.4	23
		FDSD (μm)	116	4.3	0.5	3.3	6.8
		FC (°/mm)	116	64	8.3	45.8	89.4
		SL (mm)	116	54.4	7.5	40	76
	2 years	FW (g)	107	447.2	165.4	100	1150
		CY (%)	116	54.5	12.3	9.5	81.7
		MFD (μm)	116	19.9	1.4	16.6	24
		FDSD (μm)	116	4.5	0.6	3.1	6.2
		FC (°/mm)	116	61.9	8.7	33.9	84
		SL (mm)	116	54	7.5	40	79
	3 years	FW (g)	105	420.4	140.8	100	800
		CY (%)	115	54	10.4	30.2	84.2
		MFD (μm)	115	19.7	1.5	16.5	24.5
		FDSD (μm)	115	4.4	0.7	3.3	7.3
		FC (°/mm)	115	62.3	9.1	43.5	91.2
		SL (mm)	115	52.8	7.2	40	78
Males	1 year	FW (g)	103	574.8	189.9	150	1000
		CY (%)	109	59.3	13.1	10	85.7
		MFD (μm)	109	19	1.4	14.9	23.5
		FDSD (μm)	109	4.4	0.6	3	6
		FC (°/mm)	109	64.4	8.1	48.2	85.5
		SL (mm)	109	54.4	6.6	40	70
	2 years	FW (g)	110	559.8	190.5	150	1250
		CY (%)	115	57.7	11.1	15.7	84.4
		MFD (μm)	115	20	1.5	16.1	24.2
		FDSD (μm)	115	4.6	0.6	3.3	7.2
		FC (°/mm)	115	62.8	8.4	43.3	87.6
		SL (mm)	115	54.8	6.5	40	70
	3 years	FW (g)	111	594.5	168.3	200	1050
		CY (%)	115	56.6	11.7	16	86.1
		MFD (μm)	115	20.2	1.6	16.6	25.2
		FDSD (μm)	115	4.6	0.8	3.1	7.4
		FC (°/mm)	115	62.1	8.4	43	93.6
		SL (mm)	115	54.9	6.6	40	73

environmental or genetic factors between herds. As expected, across animal and across herd means are almost equal but standard deviations and ranges are smaller for herd averages. The herd averages not necessarily represent a typical Raeini herd because of the deliberate stratified sampling in our study. Using the herd structure data of Ansari-Renani (2010, unpublished) and the herd by age means of Table 2, it can be calculated that a typical Raeini herd has an average fleece weight of 472.8 g, cashmere yield of 55.7%, cashmere fiber diameter of 19.7 μm, fiber

Table 3
Significance of effects in the statistical model describing fleece weight (FW), cashmere yield (CY), mean fiber diameter (MFD), fiber diameter standard deviation (FDSD), fiber curvature (FC) and staple length (SL) in Raeini goats.

Trait	FW	CY	MFD	FDSD	FC	SL
Random herd effect (Chi^2)	143.0**	32.1**	43.7**	9.50**	39.8**	0
Fixed sex effect (*F*)	151.7**	8.74**	1.44	6.05*	0.37	3.39
Fixed age effect (*F*)	0.11	3.98*	30.2**	7.01**	4.39*	0.44
Fixed sex × age effect (*F*)	2.82	0.10	3.27*	0.74	0.30	1.29

* $P < 0.05$.
** $P < 0.01$.

Table 4
Least squares (LS) means ± standard error of fleece weight, cashmere yield, fiber diameter standard deviation (s.d.), and fiber curvature in Raeini goats.

Factors	Fleece weight (g)	Cashmere yield (%)	Fiber diameter s.d. (μm)	Fiber curvature (°/mm)
Age				
1 year	508 ± 19 a	58.3 ± 1.0 a	4.33 ± 0.05 b	64.2 ± 0.8 a
2 years	501 ± 19 a	56.1 ± 1.0 ab	4.52 ± 0.05 a	62.4 ± 0.7 b
3 years	506 ± 19 a	55.3 ± 1.0 b	4.51 ± 0.05 a	62.2 ± 0.7 b
Sex				
Females	435 ± 18 b	55.3 ± 0.9 b	4.40 ± 0.04 b	62.7 ± 0.7 a
Males	575 ± 18 a	57.9 ± 0.9 a	4.51 ± 0.04 a	63.1 ± 0.7 a

Different letters within fixed effect indicate significant differences with $P < 0.05$.

diameter standard deviation of 4.4 μm, fiber curvature 62.7°/mm and 53.9 mm fiber length. The significance levels of the herd, age and sex effects are shown in Table 3. Random herd effect was statistically significant for all traits except for fiber length. A large herd effect had also been detected in other breeds of cashmere goats (McGregor and Butler, 2008b; McGregor et al., 2009, 2011). Sex by age interaction resulted significant only for mean cashmere fiber diameter ($P < 0.038$). Least squares means are shown in Tables 4 and 5.

3.1. Fleece weight and cashmere yield

Males had on average 139.9 g ($P < 0.0001$) higher fleece weight than female goats but there was no significant difference in fleece weight between goats of different age. Males had also slightly higher cashmere yields than females (2.6%, $P < 0.003$) and there was a slight reduction of yields with age (58.3, 56.1 and 55.3%, $P < 0.019$). The between herd standard deviation after adjustment for the fixed effects for fleece weight and cashmere yield resulted in 90 g and 3.8% points, indicating a substantial variation between herds in these key components of cashmere production. Residual standard deviations are even higher (144 g and 12.5%, respectively) indicating the existence of uncontrolled sources of variation. This is because males, which have a higher fleece weight, are overrepresented in our samples. In typical Raeini herd, a shorn goat would produce on average 472.8 g × 55.7% = 273 g of dehaired cashmere and a farmer shearing 250 goats would produce 68 kg of dehaired cashmere.

Considering our samples the estimated average clean cashmere production was 286.4 g. This value is similar to typical improved goats in cashmere producing countries but almost twice the level of cashmere production (110–160 g) in unimproved Kyrgyz native goats but half of the production of goats on improved breeding farms in Inner Mongolia (Zhou et al., 2003). The weight and cashmere percentage of bucks were significantly greater than females which is probably due to larger body size of males.

Pearson correlation coefficients were calculated using residual covariances of the model (Table 6). There was a small positive (0.211, $P < 0.0001$) relationship between fleece weight and fiber diameter, but no relationship between fleece weight and cashmere yield.

Table 5
Least squares (LS) means ± standard error of mean fiber diameter in Raeini goats.

Sex	Age	Mean fiber diameter (μm)
Females	1 year	19.2 ± 0.2 b
Females	2 years	19.9 ± 0.2 a
Females	3 years	19.7 ± 0.2 a
Males	1 years	19.0 ± 0.2 b
Males	2 years	20.0 ± 0.2 a
Males	3 years	20.2 ± 0.2 a

Different letters within fixed effect indicate significant differences with $P < 0.05$.

3.2. Mean fiber diameter

Interaction between sex and age for cashmere fiber diameter showed that cashmere from one year old goats was significantly finer than cashmere from older goats (about 0.9 μm, $P < 0.0001$), but males tend to increase fiber diameter from 2 to 3 years of age whereas females tend to decrease it. The overall standard deviation of fiber diameter of cashmere was 4.5 μm, which is a coefficient of variation of 22.8% (Table 1). Females and one year old goats had smaller fiber diameter standard deviation (Tables 4 and 5).

Results indicate that overall cashmere diameter was 19.7 ± 1.5 μm. In a FAO publication Iranian cashmere was described as having a range of diameter of 17–21 μm and that it is chiefly used for weaving (Petrie, 1995). 22% of all cashmere samples were finer than 18.5 μm (Table 7) similar to low premium Chinese and Mongolian cashmere which is suitable for knitwear. A further 78% of the cashmere was coarser than 18.5 μm. A study of McGregor et al. (2009) indicated that 48% of cashmere samples tested from Osh and Naryn provinces of Kyrgyzstan had a fiber diameter of 16.0–18.0 μm suitable for either knitwear or weaving. A further 38 and 40% of the Raeini goat cashmere was between 18.51 and 20.0 and greater than 20.0 μm, respectively. Similarly in a study with goats in Murghab and Shugnan districts of Pamir region of Tajikistan, it was indicated that 57% of cashmere samples had a fiber diameter of 14.6–21 μm (McGregor et al., 2011).

Our finding that older goats had coarser cashmere than yearling goats corresponds to Zagdsuren (2007) who also reported that older Mongolian cashmere goats had significantly higher mean fiber diameter than younger animals. Younger goats of different regions of Osh and Naryn provinces of Kyrgyzstan and of Pamir mountain districts of Tajikistan (McGregor et al., 2009) had also significantly lower MFD than older goats. The tendency for younger cashmere goats to have lower incidence of fiber shedding than older goats (Ansari-Renani, 2001) as a result of secondary follicle inactivity (Ansari-Renani and Hynd, 2001, 2004) could have an impact on increasing FD of older

Table 6
Pearson correlation coefficients between cashmere traits using residual (co)variances from models including sex, age, sex by age as fixed effects and herd as random effect. $N = 643$ for correlations involving fleece weight and $n = 686$ for other correlations.

Trait	Cashmere yield	Mean fiber diameter	Fiber diameter SD	Fiber curvature	Staple length
Fleece weight	−0.056	0.211*	0.025	−0.145*	−0.040
Cashmere yield		0.046	0.042	−0.037	0.015
Mean fiber diameter			0.399*	−0.647*	−0.027
Fiber diameter SD				−0.241*	0.007
Fiber curvature					−0.013

* Significantly different from 0 ($P < 0.001$).

Table 7
Proportion (%) of sampled cashmere within defined quality classes of mean fiber diameter, staple length and fiber curvature.

Mean fiber diameter (μm)	Samples (%)	Staple length (mm)	Samples (%)	Fiber curvature (°/mm)	Samples (%)
14.90–18.50	22	40–49	38	34–60	17
18.51–20.00	38	50–60	46	61–75	61
>20	40	61–79	16	76–94	22

goats. Smaller secondary follicles which produce finer fiber, shutdown (inactivate) and shed their fiber prior to larger secondary follicles (Ansari-Renani et al., 2007) and this shed fiber is not collected by combing by nomads. The impact of age could also be associated with larger body size and reduced skin follicle density and competition for nutrients enabling the follicles to increase in size (Maddocks and Jackson, 1988) and therefore fiber diameter of older goats increases.

It was observed that cashmere of Raeini goats started a sequential, bilaterally symmetric pattern of shedding in the early spring commencing on the neck, chest and shoulders spreading to the back and rump. While shed fibers can be manually combed out reducing fiber loss and FD and increasing economic return, nomad goat owners usually do not comb but only shear their goats in mid-spring using double blade knives after shedding period. In terms of harvesting maximum weight of cashmere, the optimal time for a single shearing of cashmere goats would be at the end of winter season before follicle inactivity substantially starts or before onset of shedding. At this stage goats are in their poorest body conditions for the cold weather and very limited feed availability. It is important from the point of the welfare of the goats that some hair is left on the animal after cashmere harvesting as this hair provides an essential protective layer (McGregor, 1988) against adverse weather conditions. Use of either machine or hand shearing which removes the entire fleece pose a serious threat and is inconceivable under such conditions. In addition, the presence of unshed long hair and cashmere in the fleece help cashmere fiber loss once cashmere shedding has begun by acting as a physical barrier restraining the cashmere in its position (McGregor, 1988). This allows owners to time cashmere harvesting either using combs or by collecting the clumps of cashmere retained in the fleece. Use of combs reduces further cashmere loss during the shedding season. Unshed cashmere could be sheared in mid-spring when adverse weather conditions are over.

Males increase fiber diameter from 2 to 3 years of age whereas females did not. Previous studies (Millar, 1986; McGregor, 2004) have shown varied results regarding a sex difference for mean fiber diameter which could be due to differences in breed and environmental conditions.

3.3. Fiber curvature

All samples had a curvature greater than 34°/mm with 17% between 34 and 60°/mm, 61% between 61 and 75°/mm and 22% between 76 and 94°/mm. Compared with cashmere of China, Tajikistan and Kyrgyzstan with mean fiber curvature of 46, 46 and 58°/mm (McGregor et al., 2011, 2009); cashmere of Raeini goats would be considered as highly curved and long which is preferred for woven worsted yarn products. Short higher crimped, softer cashmere may be preferred for woolen spun yarns but longer, lower crimped, softer cashmere may be preferred for woven yarn destined for knitwear (McGregor, 2007).

Sex did not have any effect on fiber curvature. Effect of sex on curvature was also very small in Kyrgyz cashmere goats (McGregor et al., 2009) which may be due to live weight and/or selection practices of farmers rather than any genetic effect. On average cashmere from one year old goats had significantly 2.2°/mm more curvature than two and three year old goats.

3.4. Mean fiber diameter and fiber curvature

Significant strong negative relationship (−0.647, $P < 0.0001$) was found between mean fiber diameter and fiber curvature (Table 6; Fig. 1). This negative relationship in cashmere goats of Kyrgyzstan and Australia was 51 and

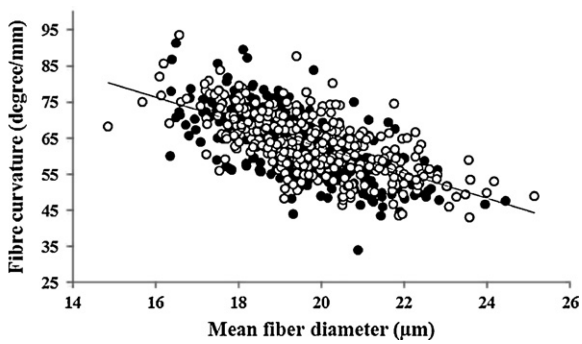

Fig. 1. The relationship between mean fiber diameter and fiber curvature from individual goats. Symbols: does (●); bucks (○).

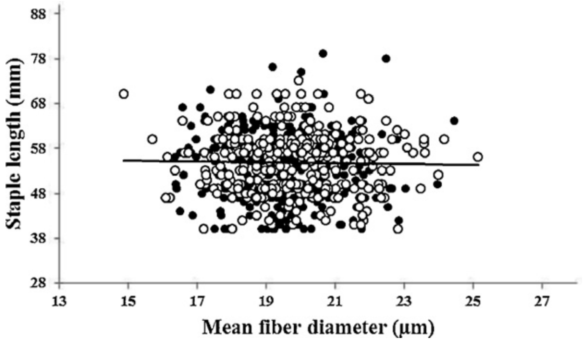

Fig. 2. The relationship between mean fiber diameter and staple length from individual goats. Symbols: does (●); bucks (○).

39% respectively (McGregor and Butler, 2009; McGregor et al., 2009). In all these goats finer cashmere has higher fiber curvature than coarser cashmere. As lower fiber curvature (crimp) can be easily observed, the association between fiber diameter and curvature can be used subjectively for classing of cashmere in the field. This criterion is of large commercial importance as cashmere buyers make purchase decisions on fiber curvature to assess not only FD and acceptability but also efficiency of mechanical dehairing (McGregor and Butler, 2008a) and increasing cashmere production (McGregor and Butler, 2008b). The actual distribution of fiber curvature and FD of samples is shown in Fig. 1. All cashmere samples had a curvature range greater than 34°/mm.

3.5. Mean fiber diameter and staple length

Average cashmere staple fiber length was 54.2 mm (Table 1) with no age or sex effects. All samples were longer than 40 mm with 38% between 40 and 49 mm, 46% between 50 and 60 mm and 16% between 61 and 79 mm (Table 7). As cashmere longer than 34–36 mm is used for worsted spinning (Anonymous, 2010), the results indicate that all samples of cashmere of Raeini goats would qualify for worsted and semi-worsted industry.

The actual distribution of staple length and FD of samples in Fig. 2 shows that there is no strong relationship between these two characteristics. Thus, a substantial proportion of the samples with a fiber diameter below 18.5 µm have a staple length above the average of 54 mm. All cashmere samples had a staple length longer than 38 mm, a threshold in Chinese cashmere market.

4. Development options for cashmere production and conclusion

Raeini cashmere can be characterized as long and highly curved however steps must be taken to improve fiber diameter to capture higher prices in the international markets. Significant differences were found between goats and between herds indicating the potential to improve cashmere quality and the need for adopting proper management and selection methods. This may be achieved through selection of goats with finer cashmere taking care of maintaining the excellent cashmere staple length and curvature. Moreover, sorting the clip in fiber diameter lines would certainly improve cashmere quality; cashmere fleeces from one year old goats and that of fine older goats should be kept separate from the coarser cashmere fleeces after harvesting and before packaging. Furthermore, nomad producers do not comb their goats to harvest shed fibers, instead they shear 1–2 months after onset of shedding. Results from previous studies indicate that 30% of cashmere is lost during shedding season and if not harvested it would be wasted (Ansari-Renani et al., 2011). Introducing combing would increase the weight and commercial value of cashmere.

However, at present no price differential is paid to the producers for fine cashmere, as a major portion of cashmere produced is exported without any added value through processing. Cashmere harvesting and buying takes place over a short period of time in spring. The nomad producers and small-scale domestic traders are not aware of world market prices for different cashmere quality classes. As a result of the current marketing system and lacking infrastructure nomad producers do not achieve good prices and have little incentive to produce better quality cashmere.

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