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Qualitative characteristics of cashmere fiber of Chyangra goat of Nepal

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ABSTRACT

This study assesses the different physical characteristics of cashmere fiber quality in Chyangra goats as wax percentage, length of pashmina fiber, fineness (diameter) of fiber obtained from different body parts (neck, belly, and back) in different locations of Mustang district of Nepal. In mid-March to mid-April 2022, cashmere samples were collected from thirty-four unrelated animals. Twenty-two animals were sampled from Upper Mustang and twelve were sampled from Lower Mustang; of which, 22 were male and 12 were female of 1, 2, 3, 4, and greater than 4 years of age. Cashmere fiber length was measured using measuring pad and ruler and fiber diameter was analyzed using the optical projection microscope method. The fixed effect model was used to analyze the least square mean for fiber length, diameter and wax percentage of Chyangra cashmere fiber considering various factors such as location, sex and age. The overall least square mean and standard error for fiber quality parameters namely wax percentage, fiber length and fiber diameter were 9.49±2.2%, 45.97±0.14 mm and 15.36±0.19 µm respectively. Even though there is a significant difference in the considered parameters by location, the fineness and length of the fiber of both locations was within the finest fiber ranging from 13-16 µm diameter and more than 40 mm length. The present study has evidenced that Chyangra goat of Nepal can be characterized as one of the finest Cashmere goats however some management steps must be taken to improve the quality (cleanliness) of fiber and the volume of fiber production. Significant differences were found in location, sex, and trend of difference in age of the animals indicating the potential to improve cashmere quality by adopting proper management and selection methods through selection of goats with larger body size and confirmation to obtain more quantity of fiber per animal.

Keywords: Cashmere, goat, fiber diameter, wax percentage, fiber length

सारांश

यस अध्ययनमा नेपालको मुस्ताङ जिल्लाका विभिन्न स्थानमा रहेका च्याङग्राहरुको काश्मिरी भुवा, शरीरका विभिन्न अंगहरू (घाँटी, पेट र पछाडिको भागको) बाट नमुना लिई पस्मिनाको मैन प्रतिशत, भुवाको लम्बाइ, भुवाको मोटाई (व्यास) लगायतका विभिन्न भौतिक विशेषताहरूका आधारमा गुणस्तर मूल्याङ्कन गरिको छ । लेखकहरूको जानकारीमा भए अनुसार, नेपालमा पहिलो पटक काश्मिरी भुवाको गुणस्तरको वैज्ञानिक रूपमा अध्ययन गरिएको छ । सन् २०२२ को मार्चे मध्य देखि अप्रिल मध्य सम्म, ३४ ओटा काश्मिरी भुवाका नमूनाहरू मुस्ताङका विभिन्न स्थानमा पालिएका च्यांग्राहरुबाट सङ्कलन गरिएको थियो । १, २, ३, ४ र ४ वर्ष भन्दा माथिका माथिल्लो मुस्ताङका २२ ओटा र तल्लो मुस्ताङका १२ च्याङ्गाबाट नमूना सङ्कलन गरिएको थियो जस मध्ये २२ ओटा बोका र १२ ओटा बाखी थिए । काश्मिरी फाइबरको लम्बाइ मापनप्याड र रुलर प्रयोग गरी मापन गरिएको थियो र फाइबरको व्यास अप्टिकल प्रोजेक्सन माइक्रोस्कोप विधि प्रयोग गरी मापन (विश्लेषण) गरिएको थियो । स्थान, लिंग र उमेर जस्ता विभिन्न कारक तत्वले प्रभाव पार्ने हुँदा भुवाको लम्बाइ, मोटाई (व्यास) र मैन प्रतिशतको न्यूनतम वर्ग औषत (Least Square Means) विश्लेषणका लागि निश्चित प्रभाव मोडेल (Fixed Effect Model) प्रयोग गरिएको थियो । फाइबर गुणस्तर मापनको परिणाम जस्तै मैन प्रतिशत, भुवाको लम्बाइ र भुवाको मोटाई (व्यास) क्रमशः ९.४९+२.२, ४५.९७+०.१४ मिलिमिटर र १५.३६+०.१९ माईक्रो मिटर रहेको छ । स्थान अनुसार फरक परिणाम आएता पनि, दुवै तल्लो र उपल्लो स्थानको भुवा १३

देखि १६ माईक्रो मिटर मोटाई (व्यास) र ४० मिलिमिटर भन्दा बढी लम्बाइ थियो । यस अध्ययनले नेपालका च्याङ्गालाई उत्कृष्ट काश्मिरी बाखाको रूपमा चिनाउन सकिने कुराको पुष्टि गर्दछ तर गुणस्तर (सर-सफाई) सुधार र फाइबरको परिमाण वृद्धि गर्न केही व्यवस्थापनका कदमहरू चाल्नैपर्छ । स्थान बिशेष, लिङ्ग र उमेर अनुसार भने गुणस्तर र उत्पादनमा महत्वपूर्ण भिन्नताहरू रहेका थिए । ठूलो शरीर भएका बाखाहरू छनोट गरि उचित व्यवस्थापन र छनौट प्रजनन विधि अपनाएमा काश्मीरी भुवाको गुणस्तर सुधार गर्न सक्ने सम्भावनाहरु प्रशस्त रहेको कुरा संकेत गरेको छ र प्रति च्याङग्राबाट अधिक परिमाणमा भुवा प्राप्त गर्न सकिने कुराको यस अध्ययनले पुष्टि गर्दछ ।

INTRODUCTION

Cashmere production and marketing provides additional economic benefit for livestock producers who are under a traditional goat farming system. It is known to be amongst the world's finest, most delicate, softest, warmest and lightest refined wool. Cashmere industries prefer to use these light and fine fibers with a soft appealing handle and with added comfort to the consumers. Among many goat breeds in the world – only distinct breed possesses the ability to produce cashmere. Chyangra goat is the only goat in Nepal to produce cashmere. Chyangra cashmere fiber also known as pashmina fiber or *Khu-lu* (in native language: *Khu-* inner, *Lu-* fiber) is the inner coat obtained from Chyangra goat which roam in the highest altitudes from 2500-5000 masl. Less than 4% by the national demand of Chyangra cashmere is met by domestic production and the the rest is met through imports (DLS 2016). Pashmina is one of the major export commodities of Nepal and the national earning from pashmina product export was more than 3.19 billion rupees in year 2016 (DLS 2016). Though Chyangra goats are popular for its cashmere fiber, they are not fully ultilized due to various reasons such as (i) the owners generally raise Chyangra goat for meat purpose and rituals; (ii) many goat owners were not aware of the cashmere producing potential of their goats and only now they are beginning to learn; (iii) the average Chyangra cashmere fiber yield per goat is not economically attractive (150-200 g/goat per year)- warrants the genetic improvement of the Chyangra goat (Bhattarai 2017); and (iv) since the quality of the cashmere is not known, local buyers price very low. It is, therefore, imperative for Nepal to utilize its existing potential of the indigenous Chyangra goats to the fullest by improvement in terms of meat and fiber quantity. Fiber diameter is the most important factor to define the value per unit weight of cashmere fleece, selection strategies are thus needed to maximize quantity of fiber without affecting fiber quality. Similarly, fiber length is important to producers as longer length obviously weighs heavier so directly contributes to the price. Moreover, mean fiber length determines the system on which the fiber will be spun worsted or woolen. Prior to improving national Chyangra population genetically, fiber quality needs to be determined which is yet to be done. The cashmere fiber quality varies according to genetic and environmental factors. Variation due to environment includes such factors as photoperiod, reproductive status of the female (pregnant and lactating), birth type, live weight, age, gender, animal health as well as nutrition (Restall and Pattie 1989, Summer and Bigham 1993).

The present study thus aimed at assessment of different physical characteristics of Chyangra cashmere fibers such as wax percentage, length of pashmina fiber, fineness (diameter) of fiber obtained from different body parts (neck, belly and back) in different locations of Mustang district of Nepal. In addition, various other factors such as age and gender of the animal affecting the quality of the fiber were also considered. Moreover, the present study is considered the first of its type in Nepal.

MATERIALS AND METHODS

Location

Chyangra cashmere fiber (pashmina) mixed with a few guards' hair of goat from Mustang (Lower Mustang: Kagbeni and Upper Mustang: Charang and Lomanthang) were collected **(Figure** 1).

Climatic conditions

Upper Mustang has a trans-Himalayan climate and lower Mustang has sub-alpine to alpine climate (Barnekow Lilles et al, 2005). Mustang in general is cool and semi-arid with precipitation in the range of 250–400 mm (9.8–15.7 in).

Figure 1. Map of Mustang (sampling sites are indicated by blue stars)

Animals

Twenty-two animals and twelve animals from Upper Mustang and Lower Mustang were sampled respectively; of which, 22 were male and 12 females. From each goat separate sample from different body parts (neck, belly and back) were collected and age and gender of the animal were recorded for each sample. Sampled animals were assumed to be unrelated and were from one to four years of age. Fiber samples were collected from different parts of the body (neck, belly, back). 34 samples were from the neck region, 27 from belly and 22 from back. Sampling was conducted in early spring (mid-March to mid-April 2022), prior to the seasonal molt and regular annual shearing. Two samples each from China, Mongolia and Afghanistan provided by Sabir, Scientist from Kyrgyzstan, were used for the comparison (**Table** 1).

Table 1. Sample number to determine different parameters

	Individual	Neck	Belly	Back	Overall samples/ observations
Overall	34	34	27	22	83
Location					
Lower Mustang					
Kagbeni	12	12	11	10	33
Upper Mustang					
Lomanthang	12	12	9	10	31
Charang	10	10	7	2	19
Parameters					
Fiber length (cm)	83	34*5=170	27*5=135	22*5=110	83*5=415
Fiber diameter (µm)	81	32*10=320	27*10=270	22*10=220	81*10 = 810
Wax percentage	81	32	27	22	81
Countries					
China	2				
Afghanistan	2				
Mongolia	2				

Production system

Production system information were collected based on the observation and interviewing key informants. The difference in objective of the Chyangra keeping in Upper and Lower Mustang made the production system different.

Lower Mustang

In Lower Mustang, the main objective of Chyangra farming is to produce meat, socio-economic purposes and manure and seldom for cashmere fiber. The people from this region prefer black colored Chyangra as they believe that white colored Chyangra can be easily spotted by predators. Herd sizes range from 25 to 50 and 100 to 200 heads.

Breeding management: Chyangra are crossed with Sinhal goat (indigenous goat of Nepal) for meat purpose while some are kept purebred and breed with Tibetan goat which is having similar genetic background for improving the herd. **Feeding management:** Buck, weaned kids and all does are taken for grazing during daytime. Chyangra does were not given any supplementation of feed. Only breeding does and kids were provided with supplement of maize and salt. Bucks and castrated males are provided with year-round supplementation of feed. Water resource is enough for animals. **Forage:** No cultivation practice was found for fodder and forage. Common roughages are maize stover, buck wheat straw, barley, naked barley and Bains, Dhimchhi (fresh and hay), Kothey, Furcha, Buki grass, thorny bush were common grass. **Health management:** Dipping is done in March-April and deworming is usually practiced. **Husbandry Management:** Weak animals were segregated and given more nutritious fodder; brewery waste. Diseased animals and unweaned kids are not taken for grazing. Unweaned kids were allowed to suckle milk twice a day. **Housing system:** Housing system is mainly traditional type which consists of enclosed room, open paddock and separate room for kids. **Fattening system:** The main fattening season is during July-September when green flush fodder and pasture are found naturally and abundantly. The market season for meat is mainly during Dashain (Oct – Nov). **Manure management:** Rs. 600 per sack (35 kg capacity) of manure in year 2023. Chyangra manure is used in apple orchards thus Chyangra goat and apple farming are interlinked.

Upper Mustang

In Upper Mustang, the main objective of Chyangra farming is to produce meat, Chyangra cashmere fiber and manure. As Upper Mustang is bordering to China, people grasp the opportunity to sell Chyangra cashmere fiber across the border. The people from this region does not have preference in color therefore they rear both white and black colored Chyangra. Herd size is much larger from 100 to 500.

Breeding system: Chyangra are kept purebred and/or breed with Tibetan goat which is having similar genetic background for improving the herd. **Feeding system and health management:** These systems are similar as that of Lower Mustang but in minimal level. Feed supplementation is only provided when the animal cannot go grazing. Water resources, feed and grass are limited in this region. **Forage:** Common roughages are Kotey, Ramjhang, Heyo, Dhypkyo, hay (buck wheat straw and barley straw), buki grass and thorny bush.

Knowledge of factors affecting quality and quantity among Chyangra raisers

Chyangra raisers believed good quality pashmina are fine, light weight and porous fiber. Molting season in Upper Mustang is from March to May whilst earlier in Lower Mustang and it depends on age, sex, and health and nutrition status of the animal. In Lower Mustang, combing is seldom practiced, and animals are found with matted cashmere fiber. Chyangra raisers were aware of various factors affecting molting such as location, age, sex, season, temperature, breed, daylight hours, herd size, breeding season, and nutrition. They believe fineness increases with higher altitude; animals from 2 to 5 years produces better quality fiber; male produces better quantity fiber than female; molting time coincides with the flowering of thorny bush which associates with snow melting; nutrition means availability of fodder and good nutrition fastens molting; lower temperature increases fineness. In Upper and Lower Mustang, these factors are not considered and collect fiber by herd due to the convenience of the herder. Chyangra raisers have observed a negative correlation between fineness and length of fiber. A long time back, Chyangra were sheared as sheep. Later iron comb that is meant to collect fiber from yak is used for combing Chyangra cashmere fiber which hurt and create irritation on skin of the animals and sometimes also blood oozes from the skin thus making animals (especially does) weak after combing. Due to these mis-techniques for cashmere fiber

collection, Chyangra farmers had shown reluctance to keep Chyangra for pashmina production thinking that it is sin to collect cashmere fiber.

Sample collection by combing

In Mustang, March to May is the season for molting. Coinciding with the molting season, cashmere samples were collected using special combing device for cashmere goats (**Figure** 2). Five grams of samples was collected from each part of the body.

Figure 2. Collection of Chyangra fiber (a) combing (b) collection of information and (c) collected cashmere on the comb

Figure 3. (a) Weighing before dewax (b) Dewaxing and (c) Air drying samples

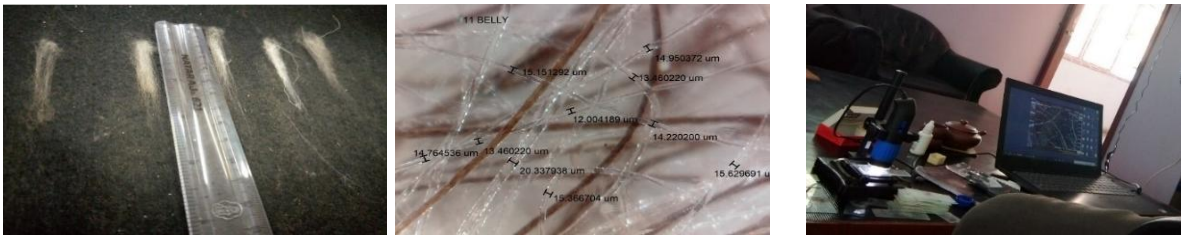

Figure 4. (a) Measurement of fiber length (b) Fiber diameter of Chyangra cashmere (c) Measurement of fiber diameter using e-scope software

Following characteristics were studied related to quality of fiber:

A. Weight of hair before dewaxing and weight after dewaxing using weighing scale
B. Staple length of pashmina using simple measuring scale of 24 inches.
C. Diameter of pashmina using digital microscope (e-scope)

Calculation of wax percentage

Wax percentage refers to total greasy fiber yield minus wax, suint, dust and vegetable matter contaminations expressed as a percentage (Thornberry and Atkins, 1984). Wax is naturally present in the pashmina fiber, removing of the wax is normal process, which is done by using non-ionic detergent in the water for few minutes till it dewaxes the fiber.

1. All collected samples were examined for any gross dirt particles present such as seeds of weed, weed, grass, faces etc. and those particles were removed.
2. Individual sample was weighed using a sensitive weighing scale and the value (a) was recorded (**Figure** 3).
3. Wax is naturally present in cashmere fiber. Dewaxing is done by using non-ionic detergent in the water for few minutes.
4. The samples were left overnight for air dry.
5. Each sample was weighed separately using the sensitive balance and the value (b) was recorded.
6. The same process was repeated for all samples separately taking precaution to avoid mixing of among samples.

*Wax percentage = value a/ value b *100*

Measurement of fiber length

1. Each Chyangra cashmere fiber sample was separated into three bunches.
2. Using the measuring pad, the fiber bundles were spread on the pad and the small fiber were removed (**Figure** 4a).
3. The length of the longest fiber was measured and noted, the process was repeated for five times for every bunch. The average of three bunch was to make one value. For each sample, there will be altogether five measurements per bunch.
4. The same process was repeated for all samples separately taking precaution to avoid mixing of among samples.

Fiber diameter analysis

The Optical Projection Microscope (OPM) method is used to determine the fiber diameter and undertaken in private laboratory of Gayatri Pashmina Pvt. Ltd., Kathmandu, Nepal (**Figure** 4b, 4c). The Optical Projection Microscope (OPM) method was regarded as the primary method for measuring fiber diameter (Wood 2000). Before 1920, this method has been widely used for measuring mean fiber diameter (MFD) and is still considered the standard method. The OPM defines mean fiber fineness in terms of the mean width of the projected image of fiber (Sommerville 2000). An image of the fiber is magnified and projected onto a screen, from which the apparent diameter is measured using e-scope program software. Because of the large variation in the diameter of wool fibers, it is necessary to measure a lot of fibers to get a reasonably precise result (Wood 2000). In this study, we have considered ten measurements for each sample. Since the sample quantity was very less, we have used national accredited laboratory, Nepal Bureau of Standards and Metrology (NBSM), to reconfirm the results where recent technology **"Optical Fiber Diameter Analyzer (OFDA)"** is used. There was no significant difference between the data obtained from two laboratories.

Statistical analysis

Gene Stat version 19 (VSN 2019) was used for analysis of data of fiber quality and Duncan's Multiple Range Test (DMRT) was used for mean comparison. Additional samples from different countries – China, Mongolia and Afghanistan was also used for comparison. To overcome the difficulty of disproportionate sub-class number, data were analyzed statistically using mixed model least square and maximum likelihood method. The fixed effect model was used to analyze least square mean for fiber length, diameter and wax percentage of Chyangra cashmere fiber considered various factors such as location, sex and age.

The fixed effect model is

$Y_{ijkl}=\mu+a_i+b_j+c_k+e_{ijkl}$

Y_{ijkl}=LSM (fiber length, diameter, wax percentage)

μ=overall mean

a_i=fixed effect of ith location (i=Lomangthang, Charang, Kagbeni)

b_j=fixed effect of jth sex (j=male, female)

c_k=fixed effect of kth age(l=1yr,2yr,3yr,4yr,>4yr)

e_{ijkl}=random error

All values were expressed as least square means ± SEM with P<0.05 was considered to be statistically significant.

RESULTS

Wax percentage

Average overall wax percentage was found to be 9.49±2.2% (**Table** 2). There was no significant difference on wax percentage by goat body areas (neck, belly and back) and further analysis was done based on only location. From the samples studied, the finding revealed significant difference in different altitude of the location. However, there is no significant difference in two locations of high altitude: Lomangthang and Charang. Wax percentage was lower in samples from Upper Mustang (Lomangthang and Charang) than from Lower Mustang (Kagbeni). From Lomangthang and Charang, it was found to be 6.704±1.635 and 8.729±2.520 respectively whereas that from Kagbeni was 13.153±1.943. Even though, there is no significant difference, the wax percentage was low in samples from neck region while high from the belly region. With respect to sex and age, there wasn't any significant difference in the wax percentages.

Table 1. Least square mean and standard error for wax percentage in different location, sex and age

Wax percentage			
Factors		**Number of samples (n)**	**LSM±SE**
Overall		81	9.49±2.2%
Location			P<0.05 LSD= 6.092
	Lomangthang	32	6.704±1.635[a]
	Charang	27	8.729±2.520[ab]
	Kagbeni	22	13.153±1.943[b]
Sex			NS
	Male	54	8.708±1.351
	Female	27	10.500±1.843
Age			NS
	1	15	6.807±2.512
	2	6	9.219±3.792
	3	27	9.523±1.708
	4	12	13.582±2.685
	>4	21	8.007±2.344

n=total number of samples, NS=Non-Significant, p=p value, LSD=least significant difference, different alphabet in superscription signifies significance

Fiber length

The average length of fiber out of total 415 fiber measured was found to be 45.97±0.14 mm (**Table** 3). There was significant difference on fiber length by goat body areas (neck, belly and back); there was no significant difference in samples collected from neck and belly region. The finding showed significant difference from the samples collected from neck region in upper Mustang and lower Mustang. However, there is high significant difference in two locations of high altitude: Lomangthang and Charang. There was no significant difference in the samples from belly region whereas samples collected from back region showed significant difference: samples from Charang was the longest followed by Lomangthang and Kagbeni. With respect to age, Chyangra of three years old (3-year old) were having longest fiber than younger and older group. Samples from all the body parts (neck, belly and back) showed significant difference with respect to sex. Unvaryingly, the samples collected from male animals were comparatively superior in terms of length

Table 3. Least square mean and standard error for fiber length in different location, sex and age

			Fiber length(mm)		
Factors		**N**	**LSM±SE**		
			Neck (n=170)	**Belly (n=135)**	**Back (n=110)**
Overall	45.97±0.14	415	45.95±0.18	47.71±0.09	44.05±0.13
Location			P <.001 LSD=0.2993	NS LSD=0.2429	P <.001 LSD=0.5133
	Lomangthang	155	47.62±0.08^{a}	47.78±0.06	46.69±0.08^{b}
	Charang	95	48.51±0.11^{a}	49.26±0.09	57.76±0.28^{a}
	Kagbeni	165	41.32±0.10^{b}	46.56±0.08	39.67±0.10^{c}
Sex			P<0.05 LSD=0.2328	P<0.05 LSD= 0.1924	P<0.01 LSD=0.2812
	Male	270	46.88±0.06^{a}	48.76±0.05^{a}	46.05±0.07^{a}
	Female	145	44.29±0.08^{b}	46.34±0.06^{b}	41.93±0.09^{b}
Age (yrs)			NS LSD= 0.3901	NS LSD= 0.3528	NS LSD=0.4111
	1	75	46.07±0.13	45.66±0.11	42.55±0.13^{c}
	2	30	43.17±0.20	46.51±0.20	39.89±0.19^{d}
	3	135	46.59±0.09	48.32±0.07	46.85±0.10^{a}
	4	75	48.03±0.12	48.53±0.10	45.84±0.13^{b}
	>4	100	43.82±0.11	47.60±0.09	42.53±0.14^{c}
CV (%)		11.83	12.71	9.06	11.73

n=total number of samples, NS=Non-Significant, p=p value, LSD=least significant difference, different alphabet in superscription signifies significance

Fiber diameter

The diameter of samples from neck, belly and back was found to be 15.23±0.30 μm, 15.27±0.33 μm, 15.67±1.38 μm respectively (**Table** 4). In the present study, the overall diameter was calculated to be 15.36±0.19 μm and there is no significant difference on fiber diameter by goat body areas (neck, belly and back). With respect to age and sex, there was no significant difference in the fiber diameter from different body region (neck, belly and back) measured from collected samples whereas with respect to location, samples from neck region collected from lower Mustang (Kagbeni) were significantly different than that from upper Mustang (Lomangthang and Charang). The two locations from upper Mustang did not show any significant difference.

Table 4. Least square mean and standard error for fiber diameter in different location, sex and age

			Fiber diameter(μm)		
Factors		**n**	**LSM±SE**		
			Neck(n=330)	**Belly(n=260)**	**Back(n=220)**
Overall	15.36±0.19	810	15.23±0.30	15.27±0.33	15.67±1.38
Location			P<.001 LSD=0.7767	NS LSD=0.8739	NS LSD=5.139
	Lomangthang	310	15.55±0.2152^{ab}	15.39±0.2444	15.95±0.813
	Charang	180	15.65±0.3187^{ab}	15.20±0.3733	15.67±2.995
	Kagbeni	320	14.42±0.2685^{c}	15.25±0.2741	15.66±1.016
Sex			NS LSD=0.6283	NS LSD=0.8131	NS LSD=2.886
	Male	5540	14.98±0.1849	15.32±0.1927	16.00±0.8296
	Female	2270	15.62±0.2402	15.26±0.3242	15.56±1.0129

Fiber diameter(µm)				
Factors	n	LSM±SE		
		Neck(n=330)	Belly(n=260)	Back(n=220)
Age		NS LSD=0.9994	NS LSD=1.065	NS LSD =5.139
1	119	14.75±0.4251	15.37±0.4090	14.55±1.735
2	90	15.60±0.4364	16.31±0.4231	15.79±1.538
3	270	15.18±0.2457	15.04±0.2864	16.94±1.051
4	154	15.46±0.3285	14.50±0.4170	14.69±1.353
>4	177	15.13±0.3160	15.47±0.3280	15.89±1.472
CV (%)	29.35	14.65	13.69	48.89

n=total number of samples, NS=Non-Significant, p=p value, LSD=least significant difference, different alphabet in superscription signifies significance

Comparison of down fiber of cashmere goats in different countries

During the study, samples of pashmina fiber from different countries were also studied, same process was followed for measuring the staple length and diameter of pashmina fiber, two samples from China, Mongolia and Afghanistan were studied, which revealed that the staple length of Nepal was the longest among them, whereas the fineness (diameter) of Nepali fiber was also similar to that of the samples studied from other finest cashmere producing countries (**Table** 5).

Table 2. Comparison of average length and diameter of cashmere fiber

Country	Fiber length	Fiber diameter
Nepal	45.97 (n=415)	15.36 µm (n=810)
China	40.8 (n=10)	15.10 µm (n=20)
Mongolia	35.7 (n=10)	15.50 µm (n=20)
Afghanistan	37.3 (n=10)	15.15 µm (n=20)

Note: n =number of observations

DISCUSSION

The results of this investigation indicated a strong and significant effect of location, age, sex on fiber length whereas there is no significant different on diameter of cashmere fiber. Earlier research has shown significant difference on fiber diameter by goat body areas shown (Antonini et al 2016, Tuncer 2018) but the present study had shown significant difference in Chyangra goat only on fiber length whereas the fiber diameter did not have any effect of any factors.

The result of the present investigation shows wax percentage in Chyangra goat fiber is in accordance to earlier research findings on other cashmere goats (McGregor 2007, Shakyawar et al 2013) where wax, skin flakes, squint and dirt were considered. The farming system plays a vital role in the quality and quantity of down fiber which is compromised in Chyangra goat as they are kept in complete grazing system and also taken in migration based on the season (Gorkhali et al 2021). In Lower Mustang, the Chyangra are not reared for down fiber but for meat. They are not normally combed during the molting season which is reflected on the cleanliness of the fiber thus increasing wax percentage in this region than in Upper Mustang.

Fiber length is important to producers as longer length obviously weighs heavier so directly contributes to the price. Moreover, mean fiber length determines the system on which the fiber will be spun worsted or woolen. Cashmere fiber shorter than 40 mm in length cannot be processed on the worsted system therefore the longer the fiber better the quality (Ryder 1987). The finding of the Chyangra cashmere fiber ranges between 44.05±0.13 mm (back) to 47.71±0.09 mm (belly) which is of international standard for worsted system. Length of the fiber in females is shorter than in males due to the better feeding given to males (Khan et al 2012) and females are supplemented with concentrates only during the milking stage. Earlier research

have clearly stated that nutrition plays a vital role in the quality of the cashmere fiber (Summer and Bigham 1993). Our finding also aligned with the finding reported by Bhattacharya et al (2004).

In the present study, the fiber length is not affected with respect to the age of the animal whereas earlier studies claim wool production is influenced by the age and sex of animals, and by reproduction in the ewe (Khan et al 2012, Tuncer 2018) and depending on source, origin/ecotype and grade (Shakyawar et al 2013). Less wool is grown by young animals per unit of feed intake, presumably due to competition for nutrients between follicles and other tissues. The population of females considered might be during their late pregnancy and early lactation as the kidding season coincides with molting season in Mustang which is around March to May that can be the reason for substantial reduction of fiber growth rate (Khan et al 2012). Increased feed intake can compensate for the effects of pregnancy and lactation on wool growth (Oddy and Annison 2000).

Fiber diameter is the single most important characteristic of cashmere, because the finer the fiber the higher the price (Petri 1995). Cashmere fiber is described as the fiber that has a down diameter of up to 18 µm (Couchman and McGregor 1983). Cashmere is down when fiber diameter is between 11 and 18 microns and fiber above 18 microns is not considered as down. Processors prefer the finer, 15 -16 µm cashmere and this range attracts a premium price. A diameter of 15.5 µm is considered as the standard for cashmere. The present study has proven that the Chyangra cashmere fiber is amongst the finest fiber diameter ranging from from 13-16 µm like finest cashmere which is produced by Chinese and Mongolian cashmere goats (14.5-16.5 µm) (Gürkan et al 2023). Chyangra fiber is accordance to diameter of the samples of Chinese, Mongolian, Afghanistan cashmere goats which 15.1 µm, 15.5 µm, 15.15 µm respectively (Couchman and Mcgregor 1983). Fiber with a mean diameter of 16.5 µm is used in knitwear (Ryder 1987). A mean of 15.5 µm is a much-quoted desirable figure for qualities to be used into cloth for such garments as overcoats, and for this purpose the cashmere is frequently blended (mixed) with wool. The major producers include China and Mongolia yield fiber with diameters ranging from 14.5 to 16.5 micrometers; that of Iranian goats is 17.5 to 19.5 micrometers (Gürkan et al 2023). Gokmen and Boztepe (2004) found that average fiber diameter of Turkish goat was 16.6±0.1 µm whereas 16.2 µm, 17.3 µm, 16.3µm was the fiber diameter for the samples from different location. Bhattacharya et al (2004) reported that diameter of pashmina fiber in male (µ) as 12.9± 2.6 and diameter of pashmina fiber in female as (µ) 13.0± 3.0 in Changthangi goats bred in the Ladakh region of India where sex dimorphism was not observed. Chyangra goat also did not show quality characteristics differences in terms of fiber diameter from male and female cashmere goat as expected however the length of fiber is significantly affected. Many previous research have shown the significant effect on quality of fiber by the different management system (Shamsaddini-Bafti et al 2012). The impact of age could not be observed significantly however the trend of fiber diameter of older goat seems increases with larger body size and reduced skin follicle density and competition for nutrients enabling the follicles to increase in size (Ansari-Renani 2013).

Beside the above-mentioned factors, there are other major factors which the scope of the present research did not cover is the influence of the genotype which set the maximum rate at which an animal can produce cashmere. Many characteristics of the fiber and follicle are highly heritable and significant changes can be made by selection for the desired characteristics. Since Chyangra are kept in grazing, they are obviously affected by various microbial infections and external parasites to some extent which can reduce fiber production. Research is needed to quantify the losses due to parasites and diseases to make the raisers aware of the precautions. Temperature and photoperiod also affect the fiber growth rate. As per the shared experience of the raisers, low temperature increases fineness of fiber of Changra cashmere fiber and research is warranted to know the scientific basis for the same. The previous research findings, however, indicated that fiber length growth rate retarded by low temperatures (Bottomley 2001). The photoperiod effects cyclic activity of follicles which will subsequently impact on wool growth. These effects are mediated through

hormonal secretions, most likely from the pineal gland, thus fiber growth is markedly hormone dependent. Seasonal cycles of molting and the annual rhythm of wool growth rate are controlled by day-length so, any change in day-length is probably the important factor (Ryder 2000, Hutchinson 1999). In trans-himalayan region of Nepal, most of sheep and goat are kept under grazing conditions and quantity and quality of feed available to them may vary considerably throughout the year affecting the characteristics of the fiber which is evident by our research. Further controlled feeding experiments need to do to improve the quantity and quality of the fiber.

CONCLUSION

The present study has evidenced that Chyangra goat of Nepal can be characterized as one of the finest Cashmere goats however some management steps must be taken to improve quality (cleanliness) of fiber and volume of fiber production. Significant differences were found in location, sex and trend of difference in age of the animals indicating the potential to improve cashmere quality adopting proper management and selection methods through selection of goats with larger body size and confirmation to obtain more quantity of fiber per animal.

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