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SHORT COMMUNICATION

Textile characteristics of fiber from Huacaya alpacas (*Vicugna pacos*)

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Abstract

Fiber from alpacas represents a substantial component of economic output for South American countries. In this study it determined the textile characteristics of fibers obtained from Huacaya alpacas raised at the South American Camelids Research and Development Center-Lachocc (CRDC-Lachocc) located at The National University of Huancavelica (UNH). Fleece samples were obtained from the mid-side rib area of 74 white alpacas (42 females and 32 males) of varying ages. The Average Fiber Diameter (AFD), Standard Deviation of the Average Fiber Diameter (SDAFD), Fiber Diameter Coefficient of Variation (FDCV), Comfort Factor (CF) and Staple Length (SL) were measured as textile characteristics and related to sex and age group. Most of the fleece samples could be classified as baby alpaca fleece according to the Peruvian Technical Standard classification (231.301.2014). Sex had no influence on any textile characteristic ($p > 0.05$). Meanwhile, age affected only AFD and CF ($p < 0.05$). Together the results indicated that alpacas farmed at CRDC-Lachocc had good potential to produce high quality fibers.

Keywords: alpaca; fiber; textiles; camelids.

1. Introduction

Peru has the largest population of alpacas in the world and is also the largest producer of alpaca fiber based on information from the Instituto Nacional de Estadística e Informática (INEI, 2012). The alpaca population in Peru increased by 50.2% in 2017 relative to previous years. At 308,586 animals, the Huancavelica region has the third-highest concentration of alpacas in Peru, and the Huacaya breed predominates in this area (Mayhua, 2011). According to De Los Ríos (2006), at least 1.5 million people are engaged in South American camelid breeding in the Huancavelica highlands. In this area, alpacas represent an important socioeconomic resource for meat, skin, employment and especially highly valuable fiber. Alpaca farming allows extensive

natural pastures, which are otherwise unsuitable for crops or other livestock, to be productive (Iñiguez and Alem, 1996). Alpacas have adapted to available dietary resources in areas where they are raised (Li *et al.*, 2008) and thus are productive even in the absence of nutritional supplementation (Moore *et al.*, 2012).

Among South American camelids, alpacas were domesticated more than 6,000 years ago (Wheeler, 2004) and have been used for fiber production for more than 3,000 years (Wang *et al.*, 2003; Wuliji *et al.*, 2000). The textile industry considers alpaca fiber to be a specialty fiber, and clothes produced from alpaca fibers are highly valuable luxury items (Wang *et al.*, 2003). Given the high market value for alpaca fiber, efforts to improve fiber quality and output have increased (Morante *et al.*, 2011).

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One of the most important factors to classify and determine the price of alpaca fleece is the Average Fiber Diameter (AFD). Fleece having lower AFD tends to command higher prices (Quispe, 2010). AFD is also associated with product appearance and comfort, as well as the performance of the fiber during textile processing (Mayo *et al.*, 1994).

Fiber quality is also defined by the Standard Deviation of the Average Fiber Diameter (SDAFD), which describes the degree to which average fiber diameter values vary and Fiber Diameter Coefficient of Variation (FDCV), which describes the relative amplitude of the fiber diameter around the average value for a given fleece sample. Fibers exhibiting lower FDCV have more uniform diameters (Manso, 2011). Another important textile characteristic is the Comfort Factor (CF) that can be defined as the percentage of fibers having diameters of $< 30 \mu\text{m}$ in a fleece sample. Fleece that has a lower fiber diameter is perceived to be more comfortable and garments produced from fleece having a higher CF are less likely to induce itch (Quispe *et al.*, 2013). Staple Length (SL) is another textile feature that can be used to determine the industrial fate of the fiber, such as combing or carding (Solis, 1991).

Both quantity and quality as defined by AFD, SDAFD, FDCV and CF of alpaca fibers are affected by many internal and external factors (Lupton, 2006). Knowledge of these factors is crucial to develop strategies to improve alpaca fleece using genetic modification. In this study we examined the textile characteristics of fibers collected from alpacas farmed at CRDC-Lachoc and investigated the influence of age and sex on these characteristics.

2. Materials and methods

It worked with fiber samples from Huacaya alpacas farmed at the Research and Development Center of South American Camelids-Lachoc at the National University of Huancavelica. The study involved 74 animals (42 females and 32 males) that had similar feeding, handling and health conditions. The fleece samples were obtained

from the middle rib area and placed in labeled polyethylene bags. Analysis of the textile characteristics in terms of Average Fiber Diameter (AFD), Standard Deviation of the Average Fiber Diameter (SDAFD), Fiber Diameter Coefficient of Variation (FDCV), Comfort Factor (CF) and Staple Length (SL) was carried out in the Textile Fibers area of the Genetic Improvement Laboratory of the National University of Huancavelica using an OFDA 2000 optical analyzer. The five variables were evaluated by an analysis of variance (ANOVA) according to a randomized design, with a factorial arrangement of 2×4 that took into account the sex factor at two levels (H = females, M = Males) and the age factor at 4 levels. A Tukey test ($\alpha = 0.05$) was used to compare mean values. The Pearson correlation was used to evaluate correlations between textile characteristics. Data processing and analysis were carried out using software R version 3.5.1.

3. Results and discussion

AFD values were $22.95 \mu\text{m} \pm 0.47$ for females and $23.54 \mu\text{m} \pm 0.40$ for males and were not statistically different ($p > 0.05$), suggesting that sex does not influence this characteristic (Table 1). This result is consistent with results reported in several earlier studies (Lupton *et al.*, 2006; Ormachea *et al.*, 2015; Quispe, 2016; Roque and Ormachea, 2018) as well as with Quispe *et al.* (2018) and Takashima *et al.* (2017), who found no significant sex-related differences in AFD values for highly valuable fleece from vicuñas, a related camelid.

However, age did significantly influence AFD values ($p < 0.05$), as seen by increasing AFD values with age (Table 2), which again is similar to earlier findings (Roque and Ormachea, 2018; Machaca *et al.*, 2017; Lupton *et al.*, 2006; Quispe, 2016; Mueller *et al.*, 2015; Laime *et al.*, 2016; Quispe *et al.*, 2018). Overall, older animals produced thicker fleece.

Both SDAFD and FDCV were not significantly influenced by either age or sex (Tables 1 and 2), which is similar to earlier findings of Machaca *et al.* (2017) and Quispe (2016; Tables 1 and 2)

Table 1

Average values and standard error for AFD, SDAFD, FDCV, CF, and SL as a function of sex for fleece from Huacaya alpacas raised at CRDC-Lachoc

Sex	N	AFD	SDAFD	FDCV	CF	SL
Female	47	$22.95^a \pm 0.47$	$4.2^a \pm 0.12$	$18.69^a \pm 0.41$	$92.27^a \pm 1.33$	$13.13^a \pm 4.05$
Male	33	$23.54^a \pm 0.40$	$4.5^a \pm 0.11$	$19.57^a \pm 0.35$	$90.38^a \pm 1.13$	$11.81^a \pm 3.45$
Total	80	23.25 ± 0.31	4.43 ± 0.08	19.13 ± 0.27	91.32 ± 0.87	12.47 ± 2.66

*The same letters in the same column indicate the absence of significant statistical differences ($p > 0.05$, Tukey).

Table 2

Average values and standard error for AFD, SDAFD, FDCV, CF, and SL as a function of age for fleece from Huacaya alpacas raised at CRDC-Lacchoc

Age (yr)	N	AFD	SDAFD	FDCV	CF	SL
2	42	21.35 ^a ± 0.32	4.32 ^a ± 0.08	19.80 ^a ± 0.28	95.72 ^a ± 0.92	15.12 ^a ± 2.81
4	14	23.82 ^b ± 0.55	4.64 ^a ± 0.15	19.55 ^a ± 0.48	88.69 ^b ± 1.55	12.06 ^a ± 4.71
7	9	24.70 ^b ± 0.68	4.55 ^a ± 0.18	18.51 ^a ± 0.60	88.49 ^b ± 1.92	11.42 ^a ± 5.85
8	9	23.12 ^b ± 0.81	4.31 ^a ± 0.22	18.66 ^a ± 0.71	92.34 ^b ± 2.30	11.28 ^a ± 7.00
Total	80	23.25 ± 0.31	4.43 ± 0.08	19.13 ± 0.27	91.32 ± 0.87	12.47 ± 2.66

*The same letters in the same column indicate the absence of significant statistical differences ($p < 0.05$, Tukey).

The CF significantly decreased with age ($p < 0.05$) consistent with previous studies (Ormachea *et al.*, 2015, Vásquez *et al.*, 2015; Roque and Ormachea, 2018). On the other hand, as with other studies, sex did not influence CF (Lupton *et al.*, 2006, Quispe *et al.*, 2009, Ormachea *et al.*, 2015; Tables 1 and 2).

The lack of influence of sex on SL seen here is consistent with some earlier studies (Pinazo, 2000; Roque and Ormachea, 2018; Quispe *et al.*, 2018; Takashima *et al.*, 2017), but differs from the 2016 study by Quispe. SL was also not related to age, as per findings by Pinazo (2000), but this result differed from those of the 2016 and 2018 studies by Quispe, who found higher SL values for older animals.

Table 3 shows the Pearson correlations among the 5 characteristics examined for this study. There was a very high negative correlation ($r = -0.94^{**}$) between the CF and AFD, wherein lower AFD (higher fineness) was associated with higher CF; this finding was consistent with previous reports (Lupton *et al.*, 2006; Cervantes *et al.*, 2010; Vásquez *et al.*, 2015; Machaca *et al.*, 2017). CF also had a negative correlation ($r = -0.75$) with SDAFD such that low SDAFD (indicating more uniform fibers) had higher CF.

A negative but low correlation was seen between AFD and FDCV, which is similar to that reported by Quispe *et al.* (2009) and Vásquez *et al.* (2015), who obtained values of -0.09 and -0.03 respectively.

The correlation between FDCV and CF (0.02), was similar to that seen by Vásquez *et al.* (2015). Correlations between the other variables under study were not determined in this study.

Table 3

Pearson correlations between textile characteristics of fleece fibers from Huacaya alpacas raised at CRDC-Lacchoc

	AFD	FDCV	SDAFD	SL	CF
AFD	1				
FDCV	-0.19	1			
	0.11				
SDAFD	0.68 ^{**}	0.59 ^{**}	1		
	0.00	0.00			
SL	-0.12	0.17	0.02	1	
	0.33	0.15	0.88		
CF	-0.94 ^{**}	0.02	-0.75 ^{**}	0.07	1
	0.00	0.84	0.00	0.55	

4. Conclusions

The evaluation of textile characteristics of CRDC-Lacchoc alpaca fibers in this study showed that these animals produce good quality fiber according to the current Peruvian Technical Standard (PTS) 231.301.2014 classification. Sex had no influence on any of the 5 characteristics studied. Age influenced only AFD and CF, wherein older animals had a higher AFD and a lower CF. Information about these factors will allow the effective selection of animals that produce the best fleece.

Meanwhile, the correlations between AFD, CF and SDAFD variables indicated that changes in one variable would likely also indirectly affect the other two.

Future research on characteristics of alpaca fiber should explore additional variables using current fiber analysis equipment and determine how they correlate with the factors examined in this study.

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