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Morphobiometric characterization of hair fibers from Sahraoui and Targui dromedaries in the region of Ouargla (Algeria's Northern Sahara)

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Abstract

The aim of this study was to investigate the characteristics and factors influencing the diameter and length of camel hair (Camelus dromedarius) fibers in the Ouargla region (Algeria). In order to achieve this objective, 30 subjects from two camel populations, Targui and Sahraoui, were sampled representing different age categories, and subjected to hair sampling located in 4 body zones (the back of the neck, the front of the neck, the shoulder and the hump). Colour was also taken into account, to assess it from both macroscopic and microscopic points of view. The results revealed that, in general, the average length of coarse fibers in dromedaries ranged from 6.60±0.29cm Safra color (Tan yellow) to 11.07±0.903cm Zarka color(Brown with black), with significant differences depending on the population, color, age and body part (site) and that of fine fibers varies from 2.56±0.22cm Chaala color (Dark yellow) to 3.74±0.21cm Zarka color (Brown with black) with significant differences according to population, sex, color and body part (site) and the mean diameter of coarse fibers varies from 9.75±0.44µm (young age category) to 11.26±0.52µm Safra color (Tan yellow) with no significant differences between the factors all studied and that of fine fibers from 4.07±0.17µm (young age category) to 5.26±0.22µm (old age category) with significant differences according to age and body part.

Our results show that the majority of mean coarse and fine fiber lengths, as well as mean fine fiber diameters, comply with the standards recommended for spinning by the American Association of Textile Chemists and Colorists, copyright 2006. However, the mean diameters of coarse fibers significantly exceed the 10 micrometer upper limit, potentially posing challenges for spinning operations.

Keywords: *Camelus dromedarius*, Fiber, Diameter, Characteristics, Ouargla (Algeria).

Introduction

The dromedary, an animal without which nomadic civilization would never have existed, plays a crucial role in the economic and social life of communities living in desert regions. It is one of the Sahara's greatest riches, yet its least well-known. Considered a resource bank, this indigenous species numbered almost 19 million head worldwide in 1992, confined to the desert and semi-arid regions of Africa and Asia (Senoussi,2010). In addition, current statistics show a significant increase at global and national level, estimated respectively at 41 million and 772,353 head in 2022(F.A.O., 2023).

In Algeria, the dromedary remains a major player in the camel economy, transforming poor vegetation into vital products presumed to be biological and offering authentic services (Senoussi,2010).

In this sense Bessahraoui and Kerrache., (1998), have revealed that camel breeding has always played a crucial role in the development of the local economy in Algeria's arid regions, due to its capacity for versatility, offering a variety of products such as milk, meat, hair and skin, as well as numerous services such as saddling, pack saddling and leisure.

However, Harizi et al., (2006). reported that fine fibers are considered one of the most popular fibers for high-end garments due to its fineness, elasticity, softness and thermal properties. The characteristics of camel hair, notably its fineness and length, enabled us to spin it into worsted yarns. The quality of the yarns obtained (regularity and mechanical properties) is comparable to that of cashmere yarns and fine wool.

The similarity between dromedary and cashmere hair lies more in the fibers, which are relatively fine (9 to 40 microns in diameter) but much smoother than wool, making them difficult to spin (C.I.R.A.D., 2006). Zootechnical criteria for fiber production include individual hair quantity, fineness, length and fleece purity (Allain and Thébault, 1992). (Semenova et al., 2020), tried to add that camel drivers consider the color of dromedary fibers to be an essential criterion for classifying and identifying populations, although these colors have no major impact on the animal's physiology and productivity.

According to (Appleyard, 1978), dromedary hair has two basic characteristics: internal fine hairs and external coarse fibers. The latter have a diameter of 20 to 120 microns meter and a length of about 37.5 cm while the former have a diameter of 19 to 24 microns meter and a length of about 2.5 to 12.5cm (cited in Abu shulukh et al., 2017).

While Harizi et al.,(2011), reported that dromedary hair has an average diameter of around 19.5microns meter, it is almost similar to that of Asian cashmere which has an average diameter of around 15.5 microns meter. Mahmoud Mokhtar and Ibrahim Moussa .,(2019) have shown through their study that the diameter of dromedary fibers in the province of Afif (Saudi Arabia) varies between 24.5 and 29 microns meter and their length between 3.5 and 25.5 cm.

Moreover, (Abu shulukh et al., 2017) noted that dromedary hair fibers had a relatively small average diameter in camels. This measurement increases with age, so that the hair fibers of camels can be used for handicrafts (weaving clothing products), while the fleece of adult dromedaries can be used to make tents.

This study aimed to demonstrate the morphological, qualitative and quantitative features, along with the factors influencing the hair fibers of individuals from the Sahraoui and Targui populations of Algerian dromedaries. By considering the variables of age and sex, as well as the color and body part of the subjects, we can evaluate how the actors involved in the entire value chain exploit this co-product.

Material and methods

Our work is based on a methodological approach combining field investigations, laboratory analysis and statistical processing. Initially, a camel hair collection campaign was carried out in the field in the Ouargla region. The samples collected were then sent to the laboratory to undergo a series of in-depth macro and microscopic analyses. Finally, all the data collected was entered into a database and analyzed using SPSS 25 statistical software.

1. Location of study area

The study was carried out in the province of Ouargla in Algeria's northeastern Sahara, more specifically in the northern part of the Algerian Sahara, which covers an area of 304942.150482 km2 (C.D.A.R.S., 2024).

This study was carried out in the regions of Rouissat, Hassi Messaoud and Ouargla (Figure 1). This choice is not fortuitous, but stems from considerations that make this area a land where the Camelin is the embodiment of breeding tradition, with 23,911 head in 2022 (D.S.A Ouargla., 2022).

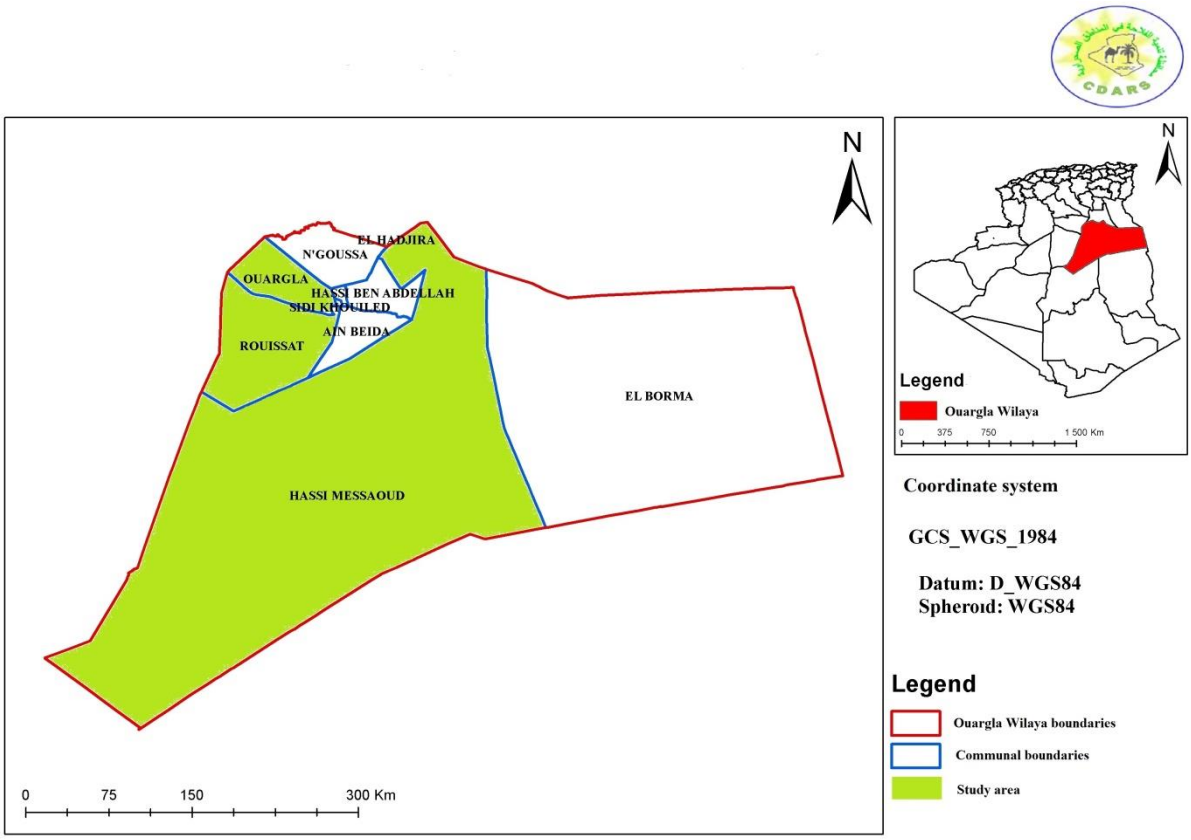

Figure 1*. Geographical location of the study are (C.D.A.R.S., 2024).*

2. Exploratory phases

2.1. On site phase

2.1.1. Animal management

Thirty (30) subjects from two camel populations (Camel fiber samples were collected from living camels), *Sahraoui* and *Targui*, underwent fiber hair sampling. They belonged to two distinct populations, that of the *Sahraoui* and that of the *Targui* (see Figure 2 and 3). Within this sample, subjects included both males and females of different age categories (Young, Adult and Old). A wide phenotypic diversity was observed in their coat color, with hues ranging from Hammra (Dark red) to Safra (Tan yellow), Zarka (Brown with black), Baidha (White), Chaala (Dark yellow) and Chahlaa (Brown to dark brown) (Table 1).

The collection of dromedary hair samples for our study was carried out with the explicit consent of the animal owners. Prior to collection, we obtained verbal permission from each owner, explaining to them the objective of our research and the non-invasive nature of the collection procedure.

Figure 2. Sahraoui Population

Figure 3. Targui Population

Table 1. Sample characteristics

N	Breed	Age Class	Sex	Color
1	Sahraoui	Young	Female	Dark Red
2	Targui	Adult	Female	Brown To Dark Brown
3	Targui	Old	Female	White
4	Sahraoui	Adult	Female	Brown With Black
5	Targui	Young	Female	Tan Yellow
6	Sahraoui	Adult	Male	Brown With Black
7	Sahraoui	Adult	Male	Dark Red
8	Sahraoui	Adult	Female	Brown With Black
9	Sahraoui	Adult	Female	Brown With Black
10	Targui	Old	Male	White
11	Sahraoui	Old	Female	Dark Red
12	Targui	Young	Female	Brown To Dark Brown
13	Sahraoui	Old	Female	Dark Red
14	Sahraoui	Old	Female	Dark Red
15	Sahraoui	Old	Male	Dark Red
16	Sahraoui	Old	Female	Dark Red
17	Targui	Adult	Male	Dark Yellow
18	Sahraoui	Young	Male	Dark Red
19	Sahraoui	Young	Male	Dark Red
20	Targui	Old	Female	Tan Yellow
21	Sahraoui	Young	Female	Dark Red
22	Sahraoui	Young	Male	Dark Red
23	Targui	Adult	Male	Dark Yellow
24	Targui	Adult	Female	Brown To Dark Brown
25	Targui	Young	Male	White
26	Sahraoui	Young	Female	Brown With Black
27	Sahraoui	Adult	Female	Dark Red
28	Sahraoui	Old	Male	Dark Red
29	Targui	Young	Female	Tan Yellow
30	Targui	Old	Male	Tan Yellow

2.1.2. Fiber sampling

The most abundant areas were selected for the hair fiber sampling. These are the back of the neck, front neck and shoulder, respectively and on the thigh (Figure 4). Targeting these sites implies recovering the maximum amount of fleece.

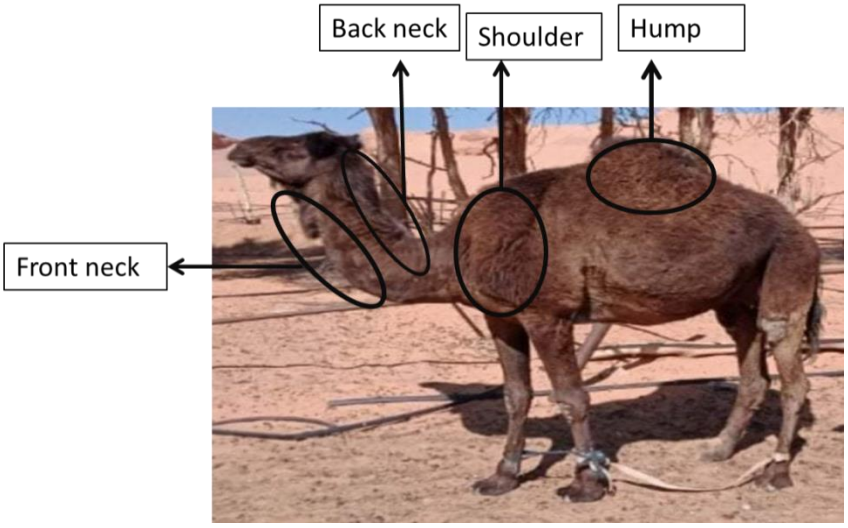

Figure 4. Location of camel hair fibers on the animal's body

Sampling dromedary hair fibers requires certain precautions to minimize stress to the animal. A crucial preliminary step is to approach the dromedary with caution, given its high sensitivity to strangers. As an operator, it is essential to take the animal's behavior into account and allow it to become accustomed to our presence at its own pace, so that it feels secure in its environment. Once the animal had been tamed and put at ease, and far from any stress, the expression of calm behaviors facilitated retrieval. This progressive approach, respectful of the animal's well-being, is essential to obtain samples in optimal conditions.

However, certain aspects have been taken into account in order to achieve this:

- Create calm, reassuring environment for the animal.
- Let the animal come to you for their own free will, rather than approaching it intrusively.
- Be attentive to behavioral signals indicating that the animal is ready for contact.
- Adopt a non-threatening attitude, with soothing gestures such as stroking the animal's cheek.
- By voluntarily sniffing your hand, the animal shows its final acceptance of your presence.

This gradual approach, respecting the animal's behavioral signals and rhythm, helps to establish a bond of trust prior to sampling in optimal conditions of well-being.

Dromedary hair sampling comprises three main stages:

- The animal is immobilized in a restrained position, requiring the collaboration of two operators to ensure its restraint.
- After precisely identifying the target area where the hair is abundant, the operator gently uses a pair of scissors to cut the base of the hair while holding it firmly in the hand.

- Once the sample has been taken, it is packaged in a plastic bag, labelled and informed (region, identification code, sex, age, population/flock, coat color, anatomical area sampled, collection date).

N.B. The present study covered a total of 120 coarse fibers taken from dromedary subjects. For fine fibers, which are not uniformly present throughout the body of dromedaries, their effectiveness was 91 fibers. Indeed, some of the subjects' body parts contained only coarse fibers and lacked fine fibers, explaining the lower effectiveness of coarse fiber.

2.2. Laboratory phase

Once the process of collecting the various hair fiber samples has been completed, the next step is to observe and analyze them. This phase is carried out at the Laboratory Saharan Bioresources (BRS) through various manipulations aimed at characterizing the qualitative and quantitative properties of the hair fiber. The analyses carried out at the BRS laboratory enable the morphological and biometric characteristics of the hair collected from dromedaries to be assessed, providing essential data for their in-depth study.

2.2.1. Macroscopic observations

In the preliminary evaluation of dromedary hair fiber, the first important qualitative criterion is the color, which is appreciated by simple visual observation.

In addition to the qualitative aspects, quantitative characteristics are also taken into account, including hair length. This is determined by measurements made using a decimeter, allowing precise biometric values to be obtained.

This first phase of evaluation by examining the color and length measurements is a key step in the initial characterization of this dromedary by-product, providing basic data essential for its in-depth study.

2.2.2. Microscopic observation

Photomicroscope observation**:** We use a photonic microscope of the LEICA brand in conjunction with LASEZ image analysis software to accurately evaluate the characteristics of hair fibers. This system allows you to obtain a clear representation of fiber samples, both fine and rough, directly on a computer screen. The main objective is to accurately estimate the diameter of the different types of fibers by measuring their basal, median, and apical parts (Figure 5, 6 and 7). We apply a 0.22x10 magnification for this purpose, which provides sufficient resolution for reliable micrometric measurements at these three levels. We then calculate the average diameter of each fiber from these three measurements, enabling a comprehensive dimensional characterization.

Note: We converted the diameter lenses used in the other works to correspond to a range of 100 micrometers to 20 micrometers in order to compare the results with those of previous studies.

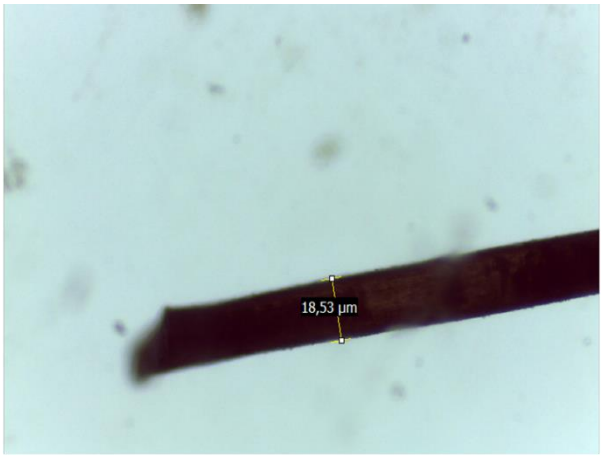

Figure 5. Basic Part Diameter

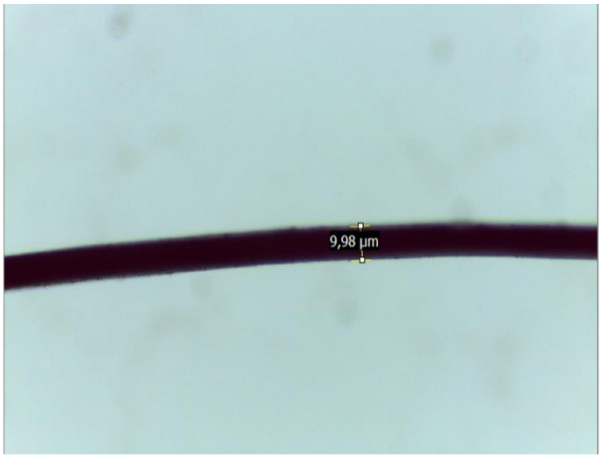

Figure 6. Middle Part Diameter

Figure 7. Apical Part Diameter

2.3. Statistical analysis

Following the macro- and microscopic characterization of dromedary hair fibers in the laboratory, the collected data underwent extensive statistical processing. We compiled all measurements and observations into a database and analyzed them using the IBM SPSS Statistics 25 software. (Statistical Package for the Social Sciences). The variance analysis (ANOVA) was the preferred statistical test to characterize the hair of dromedaries and evaluate the influence of the different factors studied (population, sex, dress color, age, body part) on the key parameters of rough and thin fibers (length and diameter). The Fisher test determined whether the differences observed between the groups' averages were statistically significant or not at the threshold of 5%.

Results and discussion

The analysis of the statistical data produced the following results (Table 2 and 3).

Table 2. Least squares mean ± SE values for dromedary coarse fibers quality parameters

		Length CF		**Diameter CF**	
		Mean CI	P-value	Mean CI	P-value
Breed	Sahraoui (72)	9.30 ± 0.40^{a}	0.000	10.00 ± 0.33^{a}	0.085
	Targui (48)	6.98 ± 0.21^{b}		10.80 ± 0.26^{a}	
Sex	Male (48)	7.81 ± 0.37^{c}	0.09	11.05 ± 0.27^{b}	0.009
	Female (72)	8.75 ± 0.37^{c}		9.84 ± 0.32^{c}	
Coat Color	Dark Brown (52)	8.62 ± 0.39^{e}	0.000	9.82 ± 0.37^{d}	0.398
	Brown with Black (20)	11.07 ± 0.90^{d}		10.46 ± 0.69^{d}	
	White (12)	6.80 ± 0.37^{e}		10.89 ± 0.52^{d}	
	Ten Yellow (16)	6.60 ± 0.29^{e}		11.26 ± 0.52^{d}	
	Dark Yellow (8)	8.20 ± 0.43^{e}		10.68 ± 0.18^{d}	
	Brown to Dark Brown (12)	7.58 ± 0.41^{e}		10.19 ± 0.60^{d}	
Age	Young (40)	7.61 ± 0.36^{g}	0.02	9.75 ± 0.44^{e}	0.139
	Adult (40)	9.35 ± 0.55^{f}		10.36 ± 0.32^{e}	
	Old (40)	8.16 ± 0.46^{gf}		10.86 ± 0.39^{e}	
Site	Front Neck (30)	8.05 ± 0.43^{ih}	0.03	10.80 ± 0.43^{f}	0.563
	Back Neck (30)	8.69 ± 0.68^{ih}		10.44 ± 0.44^{f}	
	Shoulder (30)	7.00 ± 0.37^{i}		9.95 ± 0.55^{f}	
	Hump (30)	9.80 ± 0.64^{h}		10.10 ± 0.39^{f}	

(a,b…): Homogeneous subset (72, 48 …): Effective

Table 3. Least squares mean ± SE values for dromedary coarse fibers quality parameters

		Length FF		**Diameter FF**	
		Mean CI	P-value	Mean CI	P-value
Breed	Sahraoui (62)	3.54 ± 0.11^{a}	0.012	4.48 ± 0.15^{a}	0.154
	Targui (29)	3.01 ± 0.17^{b}		4.86 ± 0.19^{a}	
Sexe	Male (30)	3.04 ± 0.19^{d}	0.018	4.87 ± 0.22^{b}	0.133
	Female (61)	3.53 ± 0.10^{c}		4.47 ± 0.14^{b}	
Coat Color	Dark Brown (46)	3.47 ± 0.13^{e}	0.033	4.57 ± 0.19^{c}	0.608
	Brown with Black (16)	3.74 ± 0.21^{e}		4.21 ± 0.27^{c}	
	White (8)	3.41 ± 0.27^{e}		4.98 ± 0.42^{c}	
	Ten Yellow (11)	2.73 ± 0.36^{f}		4.98 ± 0.31^{c}	
	Dark Yellow (5)	2.56 ± 0.22^{f}		4.68 ± 0.56^{c}	
	Brown to Dark Brown (5)	3.52 ± 0.20^{e}		4.58 ± 0.31^{c}	
Age	Young (33)	3.22 ± 0.16^{g}	0.507	4.07 ± 0.17^{e}	0.000
	Adult (27)	3.44 ± 0.15^{g}		4.48 ± 0.19^{e}	
	Old (31)	3.47 ± 0.19^{g}		5.26 ± 0.22^{d}	
Site	Front Neck (18)	2.97 ± 0.19^{i}	0.033	5.23 ± 0.34^{f}	0.015
	Back Neck (17)	3.14 ± 0.17^{ih}		4.63 ± 0.22^{gf}	
	Shoulder (26)	3.39 ± 0.16^{ih}		4.70 ± 0.21^{gf}	
	Hump (30)	3.72 ± 0.19^{h}		4.11 ± 0.12^{g}	

(a,b…): Homogeneous subset (62, 29 …): Effective

1. Length

1.1. Coarse fiber

The mean length of coarse fibers in the Sahraoui population is (9.30±0.40) cm, which is significantly longer than that in the Targui population (6.98 cm ±0.21) cm. This difference is statistically highly significant, meaning that the population has a very big impact on the length of rough fibers (P_{Breed}=0.00). The mean length of females (8.75±0.379) cm is greater than that of males (7.81±0.374) cm; however, the value P_{Sex}=0.09 indicates that this difference is not statistically significant at the threshold of 0.05; in other term sex has no

effect on the length parameter. The Zarka color (brown with black) has the largest mean length of the coarse fibers, and the Safra color (tan yellow) has the smallest mean length (6.60±0.29) cm. The P_{Color} value=0.00 indicates that these differences observed between the different colors of the dromedary dress are statistically very significant. The adult age category has the highest mean length of rough fibers (9.35±0,55) cm compared to the other two age groups (the P_{Age}= 0.02 value indicates that there is a significant difference in the mean lengths of coarse fibers between the different age categories, in other terms is a factor that significantly influences length. The hump body part has the greatest mean length (9.80±0.64) cm, and the shoulder has the lowest mean longitude (7.00±0.37) cm. P_{Site}=0.03 indicates that the difference observed between the different body parts is significant at the threshold of 5%. In other words, the body part is a factor that significantly influences the mean length of the rough fibers.

1.2. Fine fiber

According to Table.2, dromedaries from the Sahraoui population have a mean fine fiber length of 3.54±0.11 cm, significantly longer than that of the Targui (3.01±0.17) cm. Females are significantly longer (3.53±0.10) cm than males (3.04±0.19) cm. The Zarka (brown with black) color has on mean the longest fine fibers (3.74±0.21) cm, while the Safra (tan yellow) and Chaala (dark yellow) colors have the shortest fibers. Mean lengths vary slightly by age category, with the older age group having the longest fibers (3.47±0.19) cm and the younger age group having the shortest (3.22±0.16) cm.However, this variation is probably not statistically significant. For the dromedary body parts, the hump reaches the maximum mean length at 3.72 cm, followed by the shoulder at 3.39 cm, and the front neck (2.97cm) and back neck (3.14cm) exhibit the shortest lengths.

According to research conducted by Mokhtar and Ibrahim Moussa .,(2019), fibers from dromedaries in the Afif region of Saudi Arabia have an mean length of fibers ranging from 3.8 to 25.5 cm, and the colors of the dromedary's dress are: brown, bright, light beige, and a dark beige. (Yadav et al., 2000), the Bikaneri population of the Indian region has the longest fibers with 6.89±0.20 cm, followed by the Jaisalmeri and Kachhi populations, and the hump body part holds the longest fibers with 11.60 cm, followed by the shoulder, middle side, and neck. Other study of Bhakat et al., (2001), Indian dromedaries from the Bikaneri population have a higher mean fiber length than those from the Jaisalmeri and Kachhi populations. The humped part of the body has the highest fiber length value, followed by the shoulder, while the neck has the lowest. With regard to the age factor, four-year-old dromedaries had the highest fiber length at 6.49±0.27cm, while one-year-old dromedaries had an average fiber length of 5.47±0.28 cm.

Otherwise, (Agamy et al .,2024), conducted the study in the arid region of Egypt. Females have a mean fiber length of 13.4 cm longer than males 11.9 cm. **Iniguez et al ., (2013),** the fine fiber length of dromedaries from Kazakhstan and Uzbekistan is significantly higher than that of Bactrian camels and hybrids. The mean fiber length of dromedaries is 50.5 mm (5.05 cm), followed by Bactrian camels at 44.4 mm (4.44 cm) and

hybrids at 45.8 mm (4.58 cm). Females had a higher mean length of 47.7 mm (4.77 cm) than males, at 46.1 mm (4.61 cm). The coat colors of the subjects studied were brown, gray, and straw, with brown predominating at 78.1%. In terms of mean length, white fibers had the highest value at 48.5 mm (4.85 cm). The study of **(Semenova et al.,2020)** showed that the characteristics of the hair fibers of the Bactriane camels (two-tailed camels) evolve with the age of the animal. The mean length of the bacterian camel's fibers increases significantly, from 4.90 cm in young individuals to 8.3 cm in adults.

That refers to our research, population, sex, color, and body part (site) have a significant effect on fine fiber length (whose significance P values are respectively as follows: P_{Breed}=0.012, P_{Sex}=0.018, P_{Color}=0.033, and P_{Site}=0.033), while age has no significant effect on fine fiber length (with P_{Age}=0.507). which opposite the findings by Agamy et al., (2024), Sex does not appear to have a significant influence on the length of Sudanese dromadary fibers in the Egyptian arid region. Also for (Bhakat et al., 2001), sex has no significant effect, but other factors such as population, body part (site), and age have a significant effect on the average fiber length of Indian dromedaries.

With accordance to Yadav et al., (2000), which indicate that population, body part, and age factors have a significant effect and that sex has a highly significant effect on the average fiber length of dromedaries. Which contradict to to the research of (Iniguez et al., 2013); sex and hair color factors have no significant effect on the length of thin fibers.

2. Diameter

2.1. Coarse fibers

As illustrated in Table 1, the Targui population has a mean diameter of 10.80±0.26 µm, slightly higher than that of the Sahraoui population. The mean diameter of males (11.05±0.27) is higher than that of females (9.84±0.32 µm). The mean diameter values of rough fibers range from 9.82±0.37 to 11.26±0.52 µm, with the Hammra color (Dark Red) having the smallest diameter and the Chaala color (Tan Yellow) having the largest diameter. The older age category has the largest mean diameter (10.86±0.39) µm, and the young age category has the smallest mean diameter (9.75±0.44) µm. The front neck body has the largest mean diameter (10.80±0.43) µm, followed by the mean diameter of the back neck and then the mean hump diameter, and the shoulder has the smallest value of the average diameter (9.95±0.55) µm.

All the factors (population, sex, color, age, and site) do not have a significant effect on the parameter (diameter of coarse fibers), whose significance P values are respectively as follows: P_{breed}=0.085; P_{sex}=0.09; P_{age}=0.139; P_{color}=0.398; and P_{site}=0.563.

2.2. Fine fibers

According to the results in Table.2, the Sahraoui population has an average diameter of (4.48±0.15 µm), slightly lower than that of the Targui population (4.80±0.19 µm). For males, the average diameter is 4.87±0.22 µm, higher than that of females (4.47±0.14) µm. The Baidha (white) and Safra (tan yellow) colors have the largest diameters of 4.98 µm, and the Zarka (brown with black) color has the smallest value of 4.21 µm of fine fiber diameter. The factors population (P_{breed}=0.154), sex (P_{Sex} = 0.133), and color (P_{color} = 0.608) have no impact on the fine fiber diameter parameter at the 5% threshold.

The fine fibers' average diameters get bigger as the dromedaries in the study get older. The youngest age group had the smallest average diameter (4.07±0.17) µm, followed by adults (5.26±0.22) µm. The value P_{Age}=0,00 means that there is a very big difference between the average diameters of the different age groups, which means that age is what changes the diameters of the thin fibers.

Concerning the body part, the front neck has the highest mean diameter (5.53±0.34) µm, while the smallest mean diameter is observed at the hump (4.11±0.12) µm. The P_{Site}=0.015 value indicates that there is a significant difference between at least two groups for fine fiber diameter depending on body part, and this explains that the latter is a factor that acts on fine fiber diameter.

Concerning the body part, the front neck has the highest mean diameter (5.53±0.34) µm, while the smallest diameter is observed at the hump (4.11±0.12) µm. The P_{Site}=0.015 value indicates that there is a significant difference between at least two groups for fine fiber diameter depending on body part, and this explains that the latter is a factor that acts on fine fiber diameter. According to (Agamy et al., 2024), females have an average fiber diameter of 32 µm less than that of males (43.5µm); sex does not have a significant effect on the fiber diameter of Sudanese dromedaries.

In the finding of Mahmoud Mokhtar and Ibrahim Moussa., (2019), dromedary fibers vary in mean diameter from 25.5 to 29 micrometers (or 4.5 to 5.8 µm). In terms of coat color, these dromedaries sport hues ranging from brown to beige, with light and dark shades. Also (Yadav et al.,2000), reported that the mean fiber diameter of Indian dromedaries varies from 25.66 µm (one-year-old) to 31.45 µm (four-year-old) (either 5.13 to 6.29 µm). Population, sex, body part, and gender have a highly significant impact on the mean fiber diameter of dromedaries.

The study of Semenova et al., (2020), reveals that the mean fiber diameter of two-humped camels is increasing from 18.4 m (either 3.68 m) in young camels to 22.1 m (either 4.42 m) in adults. The aging and developmental stages of Bactrian camels appear to directly influence these changes in the physical properties of the fibers. The Indian Bikaneri population has the smallest mean fiber diameter at 32.76 µm (or 6.55 µm) compared to those of the other two populations, Jaisalmeri and Kachhi. Females thus have a smaller mean fiber diameter than males. The fibers of the middle body part have a mean diameter of 32.98 µm (or 6.59 µm) smaller than those of the other parts. The hair of one-year-old dromedaries (camels) has the smallest mean

diameter (26.08 µm) (either 5.21 µm), followed by that of four-year-old dromedaries (31.72 µm) (either 6.34 µm), then the mean fiber diameter of eight-year-old subjects (48.70 µm) (or 9.74 µm). They found that all factors (population, body part, sex, and age) did not have a significant effect on mean fiber diameter (Bhakat et al., 2001).

Harizi et al ., (2011), reported that the fine structure of Tunisian dromedary fibers has an average diameter of 19.5 µm (or 3.9 µm). According to the study by (Iniguez et al .,2013), the fine fibers of Bactrian camels have the smallest mean diameter at 17.6 µm (or 3.52 µm), while those of dromedaries have the largest mean diameter at 20.6 µm (or 4.12 µm). Females have a slightly larger mean diameter of 18.9 µm (or 3.78 µm) compared to 18.8 µm (or 3.76 µm) for males. In terms of color, gray fibers have the smallest mean diameter at 18.4 m (or 3.68 m). However, sex and color have no significant effect on the mean diameter of fine fibers.

AATCC Technical Manual., (2006), stipulates that to process into yarns, the length of filaments intended for spinning must be between 3 cm and 28.5 cm. The recommended diameter for these filaments should range from 11 to 50 micrometers. When we compare our results to the spinning standards established by the association, we discover that the vast majority of the mean lengths of both coarse and fine fibers (with the exception of the tan yellow and dark-yellow fine fibers, which are slightly below the recommended lower limit of 3 cm for spinning) comply with the established standards. Similarly, the mean diameters of fine fibers comply with the set criteria. However, the majority of coarse fiber mean diameter values surpass the recommended upper limit of 10 micrometers for spinning.

Conclusion

This study assessed the impact of various factors on the characteristics of coarse and fine camel hair fibers in two distinct populations, Sahraoui and Targui. The results revealed significant effects of sex, population, coat color, age, and body part on certain key parameters.

The length of coarse fibers varied greatly depending on the dromedary population, coat color, age, and the part of the body from which the samples were taken. This means that the factors mentioned had a big effect on the length of coarse fibers. However, none of these factors, including the animal's sex, appeared to have a significant impact on coarse fiber diameter. In fact, the measurements showed that male or female sex had no influence on the length or diameter of these fibers. With regard to fine fibers, significant variations in length were observed according to the dromedary population, sex, coat color, and body part from which the samples were taken (in other words, population, sex, coat color and body part all had a significant impact on fine fiber length). The diameter of the fine fibers was strongly influenced by the age of the individuals and by the body parts sampled, but showed no link with the population, sex, or coat color. Thus, the factors affecting the dimensional characteristics of fine fibers differed in part from those affecting coarse fibers, highlighting the importance of taking these variables into account when characterizing and exploiting this natural fiber resource.

Our results show that the majority of mean coarse and fine fiber lengths, as well as mean fine fiber diameters, comply with the standards recommended for spinning by the American Association of Textile Chemists and Colorists, copyright 2006. However, the mean diameters of coarse fibers significantly exceed the 10 micrometer upper limit, potentially posing challenges for spinning operations. Process adjustments and optimizations should be considered for this category of fiber. Nevertheless, overall, the dimensional characteristics of the fibers studied seem promising for textile recovery.

This study underscores the significance of considering various factors when assessing the characteristics of dromedary hair fibers for industrial or handicraft applications. A thorough understanding of these variations will enable better exploitation of this precious natural resource and sustainable management of camel populations. Further investigations would be useful to better identify the mechanisms underlying these differences.

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