

WOOL YIELD AND QUALITY CHARACTERISTICS
OF AKKARAMAN BREED SHEEP

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Abstract

This study was conducted to determine the wool quality characteristics of sheep according to different age, sex, and live weight groups. The average wool quality parameters obtained in the Akkaraman sheep examined in the study were found to be as follows: wool yield 3.17 kg, ringlet length 10.00 cm, fibre length 15.48 cm, efficiency 57.33%, fineness 27.20 microns, elasticity 24.87%, and strength 19.95 Cn/Tex. Statistical analysis showed that wool yield, ringlet length, and fibre length were highly significantly affected by the sex factor ($p < 0.001$; $p < 0.01$). Live weight had a significant effect only on wool yield ($p < 0.001$), while it had no statistically significant effect on the other quality parameters. Age was found to have a significant effect on ringlet length and fibre length ($p < 0.001$). The correlation coefficient between fibre length and ringlet length was $r = 0.819$, and this relationship was found to be highly statistically significant ($p < 0.01$). This result indicates that fibre length increases in parallel with the increase in ringlet length, and therefore, ringlet length can be used as an effective and practical indicator of fibre length. This finding offers a significant advantage in terms of rapid and cost-effective assessment of wool quality. Wool is a valuable animal product with diverse industrial uses. Therefore, the factors affecting wool quality should be examined in detail through more comprehensive studies encompassing different environmental conditions.

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Introduction. Sheep breeding holds a significant place among animal production activities worldwide. Wool is an important product in sheep production and has the most important value among sheep-derived products after meat and milk [1,2]. Therefore, sheep and wool production takes place in many regions of the world. However, there are differences in product quantity, quality, and production methods. Approximately 1160 million kg of clean wool is produced annually from more than one billion sheep worldwide through sheep breeding, creating economic value through wool production [3,4]. A significant portion of the wool produced in Türkiye consists of coarse-mixed quality wool from domestic sheep breeds; the number of animals sheared was 44 080 584, and the amount of wool obtained was 84 269 tons. Approximately 85% of the wool produced comes from our domestic sheep breeds. In addition to its applications in apparel, home textiles, carpets, upholstery, medical textiles, geotextiles, agricultural textiles, and technical textiles, wool is also widely used in medical fields, including smart materials, protective clothing, insulation, organic fertilizers, dressings, pressure bandages, and wound dressings. The healthier nature of wool compared to textiles made from artificial fibres increases its use, particularly in apparel. The physical and chemical properties of wool, which are related to its structure, such as its ability to retain heat and cold, its breathability, its ability to absorb moisture and odour, and its flexibility, make it healthier and more desirable in textiles and weaving [2,5,6].

Wool production and the resulting fibre properties are complex biological processes that can vary depending on genetics, nutrition, health status, parasites, physiological period, nutrition during fetal development, sheep breed, age, sex, birth type, live weight, environmental grazing conditions, climatic factors, and local market requirements and can be affected by many factors [7,8]. The economic value of the wool depends on various parameters: fineness, length, strength, fibre elasticity, clean wool rate, and wool weight [8].

Both wool yield and wool quality traits in sheep are affected by the animal's rearing and feeding conditions. The Akkaraman sheep breed, a fat-tailed domestic sheep breed that can be raised in almost every region of Türkiye, is characterized by its ability to withstand extreme environmental conditions, survive under inadequate nutrition, and reproduce under adverse conditions. The Akkaraman is a resilient breed that thrives in the harsh climatic conditions of the region. The quantity and quality of products obtained from sheep can vary depending on genetic makeup and environmental influences. Environmental influences can positively or negatively affect product quantity and quality. This study aimed to investigate the wool yield and quality traits of Akkaraman sheep under breeding conditions and the factors influencing these traits.

Material and method. The animal material used in the study consists of 60 Akkaraman sheep of different ages raised under extensive conditions in

a private farm in the village of Esentepe, Bopazhyan district, Yozgat province (39°15'11.2"N, 35°15'3.64"E). Bopazhyan has an area of 2129 km², and its altitude is 1050 m a.s.l. Although the district's climate is continental, as is the case throughout the province, winds are more effective due to the district's location on a plain and the open environment. Winters are harsh and cold, and summers are hot and dry, and the rainy seasons are autumn and spring. Due to its semi-arid climate, the steppe covers a large area and depends on agriculture for its economy. In the district where the continental climate prevails, the average temperature of February, the coldest month, is -2 °C, and the average temperature of July, the hottest month, is +22 °C. The average annual precipitation is 472 mm. The village where the study was conducted has sufficient area in terms of pasture but does not have rich vegetation due to the continental climate.

There was no intervention in the care and feeding conditions on the farm where the research was conducted. Sheep were generally fed in barns in winter and on pasture in early spring and autumn. Pastures were generally of low or moderate quality. In summer, appropriate amounts of wheat straw, alfalfa, and sugar beet pulp were stored for feeding the pens throughout the winter. In addition to roughage, barley and concentrate were also used as feed materials. Generally, roughage (1–1.5 kg), barley grits (250–350 g), and concentrate (250–350 g, containing 2700 kcal/kg metabolic energy and 12% crude protein) were fed. The animals used in the study were treated for internal and external parasites and vaccinated against foot and mouth, smallpox, enterotoxemia, and brucellosis. Shearing was performed with a shearing machine in the second week of June. After shearing, the weight of the dirty coat was measured with a scale sensitive to 10 grams. After shearing, the live weight of each animal was determined by weighing it using an electronic digital scale sensitive to 50 grams. The wool samples were taken from the side rib region of the animals. Approximately 100 g of wool was taken from each animal, and the ear number, age, and sex information were recorded in sample bags and sent to the laboratory. Wool quality characteristics were examined for length, fineness, elasticity, strength, and fleece yield. Wool quality analyses were performed according to ASTM (American Society for Testing and Materials) and IWTO (International Wool Textile Organization) standards. Elasticity and strength (cN/tex) were determined using a Single Fibre Tensile Tester Favigraph device, and fineness was determined using a Uster Ofda 100 (Optical Fibre Diameter Analyzer) device [9]. For yield determination, dirty wool samples (30 g) were weighed and cleaned of foreign matter. The samples were then washed three times in warm water with 2% detergent and kept first in the open air and then in an oven set at 105 °C until their weights reached constant. As soon as the samples were removed from the oven, they were weighed using a precision balance sensitive to 0.01 g to determine their dry weight. The wool yield was then calculated using the formula reported by DÜZGÜNES and PEKEL [10]; $\text{Yield} = \frac{\text{Clean wool weight (g)} + \text{Clean wool weight (g)} \times 14\%}{\text{Wool sample weight (g)}} \times 100$. The

length of the locks was measured with a ruler without damaging the natural shape of 50 randomly selected locks for each wool sample, and the actual fibre length was measured in cm by holding each of the 50 randomly selected hairs from each sample at both ends with the help of a pair of forceps without stretching them too much, only removing the curls. The length was measured with the help of a yellow ruler with mm graduations on it, which prevented the wool hair from slipping, within a rectangular wooden frame of approximately 30 × 40 cm, covered with plain black broadcloth [11].

The following mathematical model was used in the least squares analysis of variance for wool yield and traits:

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

Y_{ijkl} : Wool yield and traits (wool yield, ringlet length, fibre length, efficiency, fineness, elasticity, and strength) of the i -th sheep of the k -th sex in the j -th live weight group, from the i -th age.

μ : Overall mean;

a_i : Effect of the i -th sheep's age ($i = 2, 3, 4$);

b_j : Effect of the j -th live weight [1. (39–64 kg), 2. (64.10–100 kg)];

c_k : Effect of the k -th sex, $k = 1, 2$ (Male, Female);

e_{ijkl} : Error effect.

The normality hypothesis was tested using the Shapiro–Wilk test. Homogeneity of variance for each trait was tested using the Levene's test. Descriptive statistics for traits are presented as mean $\pm$ standard error. The GLM multivariate analysis method was used to determine wool traits of sheep according to age, sex, and live weight. Significant differences were detected between groups at a threshold of $p \leq 0.05$. The Duncan test was used to test the significance of differences between groups. Statistical analyses were performed using IBM SPSS Statistics Premium Concurrent User V 30.

Results. Findings regarding the wool yield characteristics of the sheep, based on their sex, age, and live weight, are presented in Table 1. In Akkaraman sheep, wool yield was 3.17 kg, ringlet length was 10 cm, fibre length was 15.48 cm, efficiency was 57.33%, fineness was 27.20 microns, elasticity was 24.87%, and strength was 19.95 Cn/Tex. Wool yield, ringlet length, and fibre length were significantly affected by sex ($p < 0.001$; $p < 0.01$), but there was no sex effect on other traits. This suggests that these wool traits vary depending on sex, and males and females may have different yield levels in this respect. Males, in particular, generally have higher live weights, larger body surface areas, and more active endocrine activity, which can directly affect wool development. Therefore, higher wool yield, longer fibre length, and more developed tress structure can be expected in male sheep. These differences may be due to sex-related differences in nutritional status, hormonal structure (especially the effect of testosterone), and metabolic rate. Furthermore, this finding demonstrates the importance of considering sex in selection or breeding programmes.

T a b l e 1

Means and standard errors of wool characteristics in sheep at different ages, sexes, and live weights

		Wool yield (kg)	Ringlet length (cm)	Fibre length (cm)	Efficiency (%)	Fineness (microns)	Elasticity (%)	Strength (Cn/Tex)
	<i>n</i>							
Overall	60	3.17±0.06	10.00±0.10	15.48±0.16	57.33±0.98	27.20±0.38	24.87±1.06	19.95±0.60
Sex	p	0.000	0.005	0.002	0.139	0.187	0.948	0.062
Female	51	2.83±0.07 ^a	9.73±0.10 ^a	14.98±0.16 ^a	56.17±0.98	27.66±0.38	24.85±1.07	18.84±0.60
Male	9	3.87±0.15 ^b	10.55±0.23 ^b	16.45±0.36 ^b	59.64±2.18	26.27±0.85	24.92±2.38	22.16±1.34
Age (year)	<i>p</i>	0.449	0.001	0.000	0.277	0.720	0.805	0.695
2	20	3.06±0.12	9.34±0.19 ^a	14.28±0.29 ^a	58.19±1.77	26.97±0.69	25.26±1.93	19.56±1.09
3	20	3.24±0.11	10.32±0.17 ^b	16.05±0.27 ^b	57.63±1.66	27.53±0.64	25.58±1.80	19.72±1.02
4	20	3.22±0.11	10.34±0.17 ^b	16.09±0.27 ^b	56.16±1.66	27.10±0.64	23.77±1.80	20.57±1.02

Different letters (a, b, c) in the same column are statistically different.

Male and female animals should be evaluated separately, particularly when conducting breeding studies focused on wool yield.

The research findings indicate that age has a statistically significant effect on ringlet length and fibre length ($p < 0.001$), demonstrating that these two wool characteristics change significantly with the animal's age. This suggests that wool development is influenced by the animal's physiological maturity and age-related changes in metabolic activity. The study determined that 2 age sheep had shorter ringlet lengths and fibre lengths than 3 and 4 age sheep. Generally, while younger sheep tend to have shorter and thinner wool, with age, fibre lengthening (increased fibre length), development of ringlet structure (increased ringlet length), and consequently, an increase in wool mass can be observed. This result suggests that age should be considered in wool production and that comparing fibre characteristics of different age groups, particularly in breeding studies and evaluation analyses, would be appropriate. However, problems such as decreased fibre quality, brittleness, and irregular growth can also be observed in very old individuals. The significant effect of age on tresses and fibre length demonstrates that fibre development is a temporal process, that physiological maturity contributes to fibre elongation, and that age-based classification should be considered in wool evaluations. While incomplete fibre development in young individuals can result in shorter and thinner fibres, it has been observed that with age, the fibres acquire a more developed form in terms of both length and structural integrity. This demonstrates that age is a factor that should be considered for wool productivity and quality. Furthermore, these results demonstrate that age should not be neglected in selection programs and that analyzing age groups separately, particularly in wool length assessments, will contribute to more accurate and objective results.

In sheep, live weight significantly affected only wool yield ($p < 0.001$), but it did not significantly affect other parameters. While wool yield was 2.62 kg for sheep weighing between 39 and 64 kg, it was 3.45 kg for sheep weighing between 64.10 and 100 kg. Sheep with higher live weights are generally larger in size. This means they have a larger body surface area. A larger surface area means a greater amount of skin surface area that produces more wool. Therefore, wool yield may naturally be higher in these animals.

The value of wool is primarily determined by the fineness, length, curl, and cleanliness of the fibre. Fine, long, curled, clean, and homogeneous fibres are the most valuable in commercial wool. As seen in Table 2, the correlation coefficient between fibre length and ringlet length was $r = 0.819$, and this result was found to be statistically highly significant ($p < 0.01$). The correlation is significant and positive. This suggests that as ringlet length increases, fibre length also increases; thus, ringlet length can be used as an effective indicator of fibre length. This finding provides a significant advantage in the rapid and practical assessment of wool quality. Directly measuring fibre length, especially under pasture conditions, can be laborious and time-consuming, so using ringlet length as a representative

T a b l e 2

Correlation values between wool characteristics in sheep

	Wool yield	Ringlet length	Fibre length	Efficiency	Fineness	Elasticity	Strength
Wool yield		0.210	0.241	0.095	−0.122	0.015	0.173
Ringlet length			0.819**	−0.007	−0.052	0.042	0.244
Fibre length				−0.020	−0.249	−0.160	0.094
Efficiency					0.003	−0.092	−0.092
Fineness						0.207	0.208
Elasticity							0.327
Strength							

** – $p < 0.01$

measure for this purpose is important for both producers and researchers. Furthermore, this high correlation level suggests that these fibre traits respond similarly to genetic and environmental factors and can be manipulated together. In this respect, direct measurement of ringlet length in selection programmes can indirectly contribute to improving fibre length.

Discussion. Wool quality is influenced by animal nutrition, genetics, breeding, and management strategies [12]. Differences in fibre properties between body regions are of limited economic importance. In this study, wool was collected from the side rib region, which represents the dominant wool-producing region of sheep. The wool yield, fibre length, and elasticity values obtained in the study were higher than those reported for Akkaraman sheep [13], Polish sheep [14], and Hu sheep [15]. These differences are thought to be due to changes in environmental conditions and management and feeding practices. The findings obtained for fineness and strength traits in the study are similar to those reported by KÜCÜK [13] for Akkaraman sheep.

In this study, it was determined that the live weight of sheep had a statistically significant effect on wool yield ($p < 0.001$). This finding suggests a direct and positive relationship between body mass and wool production. Similarly, the literature has reported that individuals with higher live weights produce more wool due to increased skin surface area [16, 17]. The generally better nutritional status and overall body condition of animals with higher live weights may lead to higher follicle activity and therefore more intensive wool production. Furthermore, the larger wool production area on the body of larger animals directly increases the total amount of wool produced at shearing. However, it should be noted that this relationship should not be evaluated independently of other factors such as genetics, age, sex, and nutrition. Increased live weight does not always trans-

late to higher-quality wool production; in some cases, fibre quality may decrease. Therefore, selection studies should focus not only on wool quantity but also on quality parameters.

Fibre length and fineness directly affect yarn structure and processing technology and are among the main determinants in evaluating wool quality [7, 15]. The study determined that fibre length varies by sex. Similar findings in the literature indicate that fibre length is affected by sex [18]. The effect of sex on fibre length may be due to various biological factors, particularly hormonal and physiological differences.

Fibre properties obtained from sheep wool vary depending on various factors, such as the animal's breed, age, environmental grazing conditions, and local market demands [7]. The finding that fibre length is higher in 3 and 4 age sheep compared to younger sheep is consistent with the results reported in the literature [13, 16]. The higher fibre length found in 3 and 4 age sheep compared to younger sheep may be related to the fact that wool development reaches a certain maturity with age. Young sheep (e.g., 1–2 age) may not yet have reached full physical maturity, thus limiting their wool production capacity and fibre development. In contrast, 3 and 4 age sheep have reached optimal levels of both hormonal balance and body development, which may support increased fibre length.

The wool strength values obtained in the study are similar to those reported by SUN et al. [15] for Hu sheep. On the other hand, when compared to the ringlet length (11.34 cm), fibre length (134.58 mm), and average wool yield (661.76 g) reported in the study on Changthangi sheep by MALIK et al. [19], the findings obtained in this study appear to be lower. These differences are thought to be due to genetic makeup, environmental conditions, and management and feeding practices. Monitoring live weight and ensuring optimal body condition can be considered a strategy to increase wool yield in breeding practices aimed at increasing wool production. Future studies will examine this relationship across different breeds and age groups, enabling more comprehensive assessments.

Conclusion. This study revealed that live weight has a significant impact on wool yield. The results indicate that wool yield is higher in individuals with higher live weight, indicating that live weight is an important selection criterion for wool yield. The positive relationship between live weight and wool yield indicates that both traits should be considered together in herd selection. However, to better understand the reasons for this relationship, other factors such as age, sex, feeding level, and genetic differences should also be considered. Age and sex influence wool yield and quality traits. Ringlet length can be used to assess fibre length. Further studies are needed on wool yield, quality, and areas of use.

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