Characteristics Of Virgin And Pulled Wool Fibres Used In Tunisian Handmade Carpets

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Abstract: Many factors such as production methods, fibre quality and structural parameters have distinctive influence on the quality and performance of a hand woven carpet. Because the most common fiber used for producing handmade carpet is wool, this experiment was aimed to identify virgin and pulled wool characteristics of Tunisian sheep breeds. A total of 84 sheep and 15 samples of commercial pulled wool were used in this study. Samples of fiber were analyzed using standard objective measurements for staple length (SL), mean fiber diameter (MFD), coefficient of variation of fiber diameter (FDCV), fine fiber contain (FC), Breaking strength and Elongation. Results showed that Tunisian wool can be considered as medium wool. By conducting well-planned sorting, “Fine Queue of west” sheep breed can supply the wool needed for textile industries. The wool of other sheep breeds can be used in handmade carpets. Also, staple strength as one of the important wool characteristic affected significantly by alkali treatment during chemical unhairing process compared with wool collected by shearing process. Great attention must be paid to know the real characteristics of pulled wool before using it in handmade carpet industry.

Index Terms: Fibre, wool, pulled wool, fibre diameter, fibre length, tenacity, handmade carpet

1 INTRODUCTION

Carpets and rugs are classified basically in two main classes such as hand-made carpets and machine carpets. Handmade carpets are defined as piled weavings having piles at the same height or at different heights and constructed by knotting a pile yarn on warp yarns in different ways by passing weft yarns inside these yarns. The loops in machine carpets are not as knots like in the handmade carpets but are yarns in U or V shaped tightened between weft yarns. In case that the ends of loops during tightening are not cut, curled carpets are produced. Meanwhile, in present, various machine carpets are available produced with needling and bonding techniques [1].

The production of machine carpets can be classified mainly into four groups such as woven carpets (including wilton typed carpets), needle punched carpets (tufting, raschel, non-woven), bonded carpets, flock carpets [1]. Hand-made carpet, which is among the most essential cultural products in Tunisia, is the important branch and it is the vital activity of the handicraft sector. It has shown during all these years the main source of income for many craftsmen and involved up to 70% of the labor total work of the sector. Hand-made carpet is a traditional craft that has been practiced in Tunisia since ancient times, and is still found in almost all regions today. Actually, in rural areas, many families still derive significant income from carpet-making. However, this branch knows, for over decade, a most important and continuous regression for both quantitatively and qualitatively production. Generally, the major factors affecting the quality and the marketability of a carpet are the materials used to make it, the workmanship and the design. Tunisian carpets lost its reputation in the international market and it is considered as the most expensive on the rapport quality / price. Among the factors that affect the appearance and usage life of the carpets, along with the production method, the fiber type also plays an important role. The most common fiber used for producing pile yarn is wool. It is clear that, fiber used in the making of a carpet has a significant influence on the carpet properties [2], [3]. Nowadays, pulled wool is mixed with virgin wool and used as pile yarn. Based on the effect of wool on the quality of a carpet, researches restrict using of pulled wool because of the lower quality of the wool due to the damage caused by the chemical treatment, during tanning process [4], [5], [6]. Researches show that, using pulled wool in the carpet leads to more reduction in pile height after applying compressive load and poor elastic recovery after removing the load [5], [7]. Formerly, virgin wool fiber have been used in handmade carpet production, however with the usage of pulled wool as pile materials, the knowledge of how the fibers treat in different conditions has gained importance in determining user’s performance. Normally, wool fiber can be used as pile yarn when its resiliency, length, number of crimp, percentage of vegetable trash, tenacity, elongation and fineness are suitable [7]. However, until now, no technical data is available on Tunisian wool characteristics. To keep the Tunisian hand-made carpet culture alive and to transfer it to the future generations, and to ensure the sustainability of Tunisian hand-made carpet-making, it will be necessary to synthesize the knowledge and experience of the past through systematic studies. The aim of this study is to give much attention to the quality of different wool used in making handmade carpet in Tunisia.

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2 MATERIALS AND METHOD

Analyzed virgin wool samples are taken from sheep located in the governorates of Zaghouan, Beja and Kef. Selected sheep are of different ages and various breeds (Barbary, fine Queue of West and Black of Thibar). A total of 84 sheep (5 males and 79 females) as virgin wool and 15 samples of commercial polled wool were used in this study. All wool samples were sent for analyzes to an Australian Laboratory "Southern Tablelands Fibre Testing" where staple length (SL), mean fiber diameter (MFD), coefficient of variation of fiber diameter (FDCV) and fine fiber contain (FC) were measured using OFDA 2000. The mechanical properties of simple fibres were controlled by using a Shirley dynamometer with constant gradient rate of 20 mm/min and 25-mm test length in accordance with the standard NF G 07 002.Data were analyzed using Minitab in a one-way ANOVA design with breed, sex and age as main effects. Tukey’s test was used to separate differences in the means.

3 RESULTS AND DISCUSSION

3.1. Virgin wool

3.1.1. Wool diameter

The fineness is the most important characteristic of wool, since largely determines its commercial value. The wool fineness is, generally, expressed in terms of average fibre diameter and the unit of measurement is the micrometer (µm). Table 1 presents the results of wool diameter measurements of different sheep breeds. The average Tunisian wool diameter is 28.99µm with a FDCV% of 26.15%. The mean FD of Tunisian breeds was 30.1, 32.3, 24.9 and 32.5% for Barbary, Barbary black face, fine Queue of West and Black of Thibar respectively. Overall fiber diameter of wool in this study is lower than Middle Eastern carpet wool sheep breeds, 36.0 µm for Awassi [8], 35.4 µm for Ossimi [9], 38.4 µm for Barbary [10] and 39.1-40.2 µm for Karakaya [11]. The average percentage of fine fibers (diameter less than 30 µm) in the end product (FC) is 63.75%. This probably explains the increase in the average fineness of the Tunisian wool. According to the systems of wool grading [12], the Tunisian wool is considered as medium wool. In this grading wool there are four grades; Fine (diameter lower than 22 µm), Medium (diameter ranged from 22 to 31 µm), Coarser (diameter ranged from 31 to 36 µm) and very coarser (diameter more than 36 µm). The average wool diameters of sheep breed "Fine Queue of West" that is 24.96 µm, is lowest when compared to the mean wool diameters from other breeds, the difference between means was highly significant ($p < 0.01$). Also, the data analysis (one-way ANOVA) shows a highly significant effect of the factor 'breed' (table 2). Even though not significant, males had slightly lower fiber diameter than females. Two years old sheep had lower fiber diameter than older sheep. Factors 'age' and 'sex' contribute to the variation in the average wool diameters without they have a significant effect. Karakus et al. [13] and Civi [14] had not observed a difference between Karakas and Norduz lamb for wool diameter. Effect of sex is not important on wool diameter of Akkaraman sheep [15]. Furthermore, Tabbaa et al. [8] noted that wool diameter have not importance differences among Awassi sheep at different sex and ages. The wool samples have an average diameter ranging from 21.1 µm to 39.3 µm and the FDCV ranges from 24.05% to 28.33%. This shows a large dispersion of the wool diameter which confirming that the standard uniformity [12] of the Tunisian wool goes from average to poor. Also, we noted that the percentage of fine fibers (FC) has a highly significant effect ($p < 0.001$) on the average diameter and FDCV%. Therefore, a decrease in the percentage of coarse fibers (> 30 µm) causes a decrease in the average wool diameter and FDCV%. This shows the importance of selection against coarse fibres.

3.1.2. Wool length

The fiber length affects how wool can be used. Very short fibers are used in felting process. In spinning, depending on fiber length, there are three processes: worsted, semi-worsted and carded. The length of the wool fiber has a direct influence on the spinning speed, the yarn title and the yarn quality. Average wool staple length was 71.7 mm (Table 1) with an individual sheep range of 64.6-81 mm. Males had longer staple length than females and two years old sheep had longer length than older sheep. There was no significant (p value < 0.2) difference in the staple length of different breeds. The breed of fine Queue of West, with an average of 64,6 mm, had the shortest staple length. The staple length of Tunisian sheep breeds of the present study is lower than that of Afshari, Zandi, Mehrabani, Lori, and Baluchi sheep in Iran [16], Awassi sheep in Jordan 140 mm [8] and Barbary sheep in Libya 120.2 mm [10]. According to the Canadian Sheep Federation [17], for wool fineness of 26µm to 30.1 µm the suggested length is between 75 and 90 mm. So the Tunisian wool has an average length relatively lower promoted value.

3.1.3. Wool mechanical proprieties

Fibre strength is very important in the spinning step, because in this procedure wool fibres should be combed and spun to produce yarn. Thus, fibres should have enough strength to withstand against various mechanical and physical tensions. Staple strength is second in importance to diameter in determining the price of greasy wool in Australia [18], [19], [20]. In the present study, the mean of fiber tenacity and breaking strength were evaluated to 16,2 cN/tex and 14,4 cN respectively (table 1) which are very higher than the required thresholds of the spinning process. In the textile industry, wool fibres should have at least 6 cN/tex of tenacity to withstand against physical and mechanical tensions and breaking [21]. So, it be concluded that Tunisian wool fibres have a desirable tenacity and breaking strength for using in textile industry. Also, Tunisian wool have better tenacity than of same Iranian and Turkish wool, which had a tenacity estimated to 12,2 cN/tex [22] and 9,5 cN/tex [13] respectively. But, t is lower than the average staple strength of Australian

TABLE 1: WOOL FLEECE CHARACTERISTICS OF TUNISIAN SHEEP BREEDS.

		N	MFD (µm)		FDCV (%)		FC (%)		SL (mm)		Breaking strength		Elongation %		Tenacity
			Mean	CV %	Mean	CV %	Mean	CV %	Mean	CV %	Mean	CV %	Mean	CV %	cN/tex
Breeds	Barbary	42	30,19	11,57	26,69	14,10	58,16	27,69	75,48	24,52	24,15	36,52	43,97	33,05	22,46
	Barbary Blackface	11	32,34	11,97	28,33	11,56	49,62	29,89	73,64	37,98	14,48	36,13	32,97	38,91	15,44
	Fine Queue of west	26	24,96	8,65	24,05	11,47	81,73	11,31	64,62	24,65	9,42	36,10	29,13	36,89	14,52
	Black of Thibar	5	32,54	11,40	27,78	17,92	48,28	32,09	73	28,60	17,42	42,26	36,80	33,93	15,99

Sex	F	79	28,86	14,64	25,99	14,75	64,16	29,40	71,20	26,49	13,6	36,95	32,67	37,45	16,35
	M	5	31,08	14,59	28,74	8,67	57,22	30,42	80,00	40,50	26,7	29,92	45,69	33,64	27,18
Age	2	11	27,12	21,04	25,98	13,63	71,70	31,80	80,91	21,86	14,43	38,81	35,34	32,62	19,08
	3	16	29,59	13,26	26,94	17,23	60,09	29,72	68,44	32,75	13,80	33,37	32,33	35,89	15,33
	4	12	29,42	18,74	25,80	14,95	63,13	38,21	66,67	39,73	18,28	36,85	36,85	35,50	20,54
	5	20	29,75	11,33	25,62	13,65	59,71	26,35	73,25	24,45	13,00	37,07	31,16	43,79	14,28
	6	6	28,52	12,89	27,05	10,81	67,28	22,08	73,33	16,07	14,69	38,43	37,61	32,15	17,56
	7	7	29,50	14,26	25,93	9,76	60,86	32,25	75,00	23,37	14,69	34,59	36,31	34,83	16,41
	8	4	28,38	27,82	26,70	28,15	66,23	29,97	61,25	37,33	13,38	44,07	31,02	39,90	16,15
	9	8	28,08	8,82	25,96	17,84	69,83	16,23	70,63	22,79	12,79	34,42	29,31	36,94	15,77
	Total	84	28,99	14,75	26,15	14,61	63,75	29,57	71,73	27,94	14,4	36,53	33,45	37,23	16,18

STAPLE LENGT² (SL), MEAN FIBER DIAMETER (MFD), COEFFICIENT OF VARIATION OF FIBER DIAMETER (FDCV), FINE FIBER CONTAIN (FC).

TABLE 2: ANOVA RESULTS FOR WOOL CHARACTERISTICS.

Traits	Breed				Age				Sex			
	DF	F	P_{value}	Effect	DF	F	P_{value}	Effect	DF	F	P_{value}	Effect
Fibre diameter	3	20,56	0	XX	7	0,51	0,821	0	1	1,25	0,266	0
Fiber length	3	1,64	0,187	0	7	0,68	0,687	0	1	0,89	0,347	0
Breaking strength	3	17,67	0	XX	7	0,67	0,7	0	1	18,89	0	XX
Elongation at break	3	19,25	0	XX	7	1,89	0,083	0	1	19,1	0	XX

FD = free degree; F = Fisher coefficient; Pvalue = significant threshold; XX = high significance; X = significance; and 0 = no significance.

wool which is around 35 cN/tex [20] and that of New Zealand wool which is 41 cN/tex [23]. The mean of elongation of Tunisian wool was estimated to 36,5% (table 1) which is very higher than of same Iranian and Turkish wool, which had a tenacity estimated to 29% [22] and 27,2% [13] respectively. Because the desirable elongation at break for wool fibres is between 40-50% [21], it seems that wool fibres of Tunisian sheep breeds (except the "Barbary" breed) have an adequate but not desirable grade in this mechanical point of view. The Barbary breed has an average of fiber tenacity, breaking strength and elongation equal to 22,5 cN/tex, 24 cN and 44% respectively (table 1). This indicates good mechanical proprieties like that found for Australian merino wool [20]. The results of the analyses of variances for mechanicals proprieties of Tunisian wool are presented in table 2. The factors “breed” and “sex” had a very significant effect on breaking strength and elongation parameters ($p<0,01$). Nevertheless, “Age” factor was not significant on the cited parameters ($p>0,05$).

3.2. Pulled wool

Pulled Wool is identified as wool collected from undressed hide or wool removed from the skins of slaughter animals. Tanning steps generally started with soaking, unhairing, liming,

fleshing, lime removal, bating, fat Removal, picking, tanning, Shaving, neutralization, oiling and dyeing, drying and tempering, skating and finally finishing stages [24]. The results of the pulled wool sample analysis are given in table 3, which shows a comparison of the textile properties between virgin and pulled wool. The major differences are recorded at the length and tenacity parameters. The average values of the tenacity are 16 and 9 cN/tex, respectively for virgin and pulled wool. Lowest pulled wool strength could be explained by the degradation happened especially in the disulfide bond which leads to decrease in wool staple strength. Mildred and Rachel [25] reported that wool was strength decreased when wool treated by alkali. Dusenbury et al. [26] illustrated that treated wool with alkali tended to decrease some physical properties of wool fiber because of its effect on orthocortex and paracortex. The average values of the length are 72 and 45 mm, respectively for virgin and pulled wool. The lower average length of pulled wool may be due to the effects of mechanical actions during the tanning process and also to the short wool growth period before the slaughter animals. Because of using pulled wool in handmade carpet, part of research was focused on the disadvantage of these fibers. Moghassem and Gharehaghaji [27] indicate that an increase in percentage of pulled wool in pile yarn caused an increase in compression and matting percentage and a reduction in elastic recovery of pile yarn. Also, Helal and Mourad [28] mentioned that an increase pulled wool in the blend, the profit tended to increase while yarn strength and yarn regularity tended to decrease. Pulled wool percentage is reasonable at 25%, risky at 50% and not favorable at 75%.

TABLE 3: *CHARACTERISTICS OF PULLED AND VIRGIN WOOL*

	MFD (µm)		FDCV (%)		FC (%)		SL (mm)		Elongation %		Tenacity
	Mean	CV%	Mean	CV%	Mean	CV%	Mean	CV%	Mean	CV%	cN/tex
Pulled wool	28,4	17,57	23,1	14,10	66,8	27,69	45	25,72	32	33,05	9
Virgin wool	28,99	14,75	26,15	14,61	63,75	29,57	71,73	27,94	33,45	37,23	16,18

Staple length (SL), mean fiber diameter (MFD), coefficient of variation of fiber diameter (FDCV), fine fiber contain (FC).

4 CONCLUSION

This research described the results of experiment for improving the wool quality involving of Tunisian sheep and to compare virgin and pulled wool. There are differences between Tunisian sheep breeds in the way the fibers they produce. The factors age, sex and breed have greater or lesser effects on controlled parameters (fiber diameter, staple length, breaking strength, and elongation). Nevertheless, breed is the most important factor. In fact, the breed 'Fine Queue of west' has ability to produce finer fibres with more uniformity. Through selection, wool diameter indicated that there is a good potential for fine wool production. The wool of other sheep breeds can be used in handmade carpets. Moreover, pulled wool presents lower quality than virgin wool. This can limit its utilization in handmade carpet industry. Further study needs to investigate the effect of unhairing process on pulled wool characteristics.

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