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Pulled Wool as a Recycled Material

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Abstract: Wool used in this study was collected from Falahi sheep after shearing and from Falahi hides after unhairing process by both chemical and enzymatic treatments. The underlying study investigates the possibility of increasing the percent of pulled wool via blending with wool. Unhairing process using enzyme treatment not only considered as environmentally friendly but also gives better pulled wool compared with chemical one. As much as we 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%. Yarns from pulled wool is preferable to use in hand made fabric, which needs 100 % wool and low yarn quality compared with mechanical textile. Chemical unhairing treatment significantly decrease the wool content of amino acids, sulfur content as sulfur ion and as sulfur amino acid (Methionine), as well as some physical properties like staple and yarn strength, yarn elongation and yarn regularity expressed by increasing number of fine and thick places as well as number of nodes.

Key words: Pulled wool · Textile · Yarn regularity · Strength and elongation

INTRODUCTION

Animal hairs consist of aggregates of dead cells filled with keratin protein [1].Keratin is protein, long chains (polymers) of amino acids. General formula is (C72 H112 N18 O12 S) and has many types of chemical bonds, peptide, disulfide, salt and hydrogen bonds. Chemically, wool contains approximately 50% carbon, 22 % to 25 % oxygen, 16% to 17% nitrogen, 7% hydrogen and 3% to 4% sulfur [2]. In Egypt huge number of camel, sheep and goat were slaughtered every year which reached more than two millions head [3]. 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 [4]. Unhairing process of hids and skins is used to remove the hair and epidermis layer as well as the opening up of the hide. Unhairing process could be done by many methods like clipping process, scalding process, chemical process, sweating process and enzymatic process. It's important to announce that unhairing using chemical treatment is one of the most polluting operations in the tannery. The widely used method in Egyptian tanneries is to paste the flesh side of the skin with 20% sodium sulfide, 80% lime. Thus the cells around hair follicles are destroyed and the hairs, becoming free and can be easily removed from the skin. Using lime and sodium sulfide in chemical method especially in high concentration creates an extremely alkaline environment resulting in the pulping of hair and its subsequent removal [5]. The second method of unhairing process is enzymatic process which used enzyme to digest the basal cells of malphigian layer. This is followed by loosening of hair with an attack on the outermost sheath and subsequent swelling and breakdown of the inner root sheath and parts of the hair that are not keratinized [6]. Moreover, enzymatic method of unhairing is suggested as an environmentally friendly alternative to the conventional chemical process [7].

For many years pulled wool is considered as a waste in Egyptian tanneries, while in England, waste hair has been used since 1995 in the production of biologically degradable flower pots. A Dutch company uses waste hair from a German tannery as an ingredient in the animal feed, as well as wool waste used as soil fertilizer [8]. Nowadays the pulled wool and hair from the hides were used as a recycled material in some small factories. The profits of using pulled wool or hair is very high because of the low price of this wool (less than quarter of normal wool price collected by shearing). The aim of this study is

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to give much attention to the quality of pulled wool from different unhairing processes (chemical and enzymatic process). Moreover, the effect of unhairing process on the tensile wool strength, which is considered as one of the most important characteristic during wool processing, which also directed wool towards woolen or worsted process was studied. One of the main purposes of this study is to assume the best percentage of pulled wool used in the blends with sheared wool from the same type (Falahy wool) and gives a reasonable yarn characteristics.

MATERIALS AND METHODS

Two types of Falahi pulled wool collected from two different Egyptian tanneries using the previous unhairing methods, Enzymatic pulled wool (EPW) which coming from enzymatic treatment using Pancreozymin (proteolytic enzyme) and Chemical pulled wool (CPW) which coming from chemical treatment of unhairing process were used. Falahi wool collected after shearing is used as control (SW). Different combinations of 100% CPW, 50% of both SW and CPW, 75% of SW with 25% of CPW, 100% EPW, 50% of both SW and EPW, 75% of SW with 25% of EPW and 100% of SW were blended.

Representative samples from EPW, CPW and SW were kept in plastic bags for further analysis. Fiber diameter (FD) was measured using Image analyzer (LEICA Q 500 MC) with lens 4/0.12. A section of 0.2 mm in length was cut by a Hand-Microtom at a level of 2cm from the base of the staples of each sample. About five hundred fibers were taken at random and measured from each sample. Ten scoured staples were randomly taken from each greasy sample to estimate scoured staple strength (SS sc). The staple was trimmed by cutting its tip. Each staple was subjected to the Agritest staple breaker (Agritest Pty. Ltd).Staple strength (SS) was calculated and recorded for each sample in terms of Newton/Kilotex [9]. Random samples of yarns coming from each category after woolen process were tested as follows:

- Yarn count (metric)=yarns length(m)/yarns weight(g).
- Yarn twisting (yarns from each grade was played at nominal level of 170 turn per meter (TPM) on Z direction).
- Yarn strength and elongation: Uster Tensorapid 3 (Zellweger Uster) was used to measure yarn strength (RKM = count-related force at break), tenacity and elongation.
- Yarn evenness and hairiness, this test to measure the regularity of the yarn by the following abbreviations:
- Thin places (-50%): number of mass reduction of 50% or more in a yarn with respect to the mean value.
- Thick places (+50%): number of mass increase of 50% or more in a yarn with respect to the mean value.
- Neps (+200%): number of mass increase of 200% or more in a yarn with respect to the mean value and reference length of 1cm, these short thick places in a yarn may be the result of vegetable matter or fiber collections pushed together.
- Yarn friction: yarn samples were used in this test to examine the friction for standard length of yarns (Revs).

Amino acids determine as follow: 0.2 gm of air dried wool was dissolved in 5ml of 6N HCl in a sealing tube. The mixture was hydrolyzed at 110°C for 24 hours, then filtered and the hydrolyzed protein amino acids were obtained by evaporation of the hydrolyzate to dryness. The residue was washed with distilled water and then the distilled water was evaporated. The residue was diluted with 2 ml sample dilution buffer. The sample was filtered through 0.2 micropore filter and injected in the Amino Acid Analyzer [10]. Sulfur measured as sulfate and determined by Turbidimetric method according to Rainwater and Thatcher [11] using spectrophotometer after hydrolyzing the wool sample by acid mixture (70%) Nitric acid: (30%) Hydrochloric acid).

Data were analyzed with the general linear model (GLM) of SAS [12]. Source of variation for dependent variable (grades) was tested. Comparisons among means within grades were tested using Duncan's New Multiple Range Test.

RESULTS AND DISCUSSION

Generally SW had the highest amino acids composition compared with both pulled wool types, while EPW had higher amount of amino acids than CPW (Table 1). Some amino acids were found to be affected by chemical treatment more than the others amino acids. Therionine, Isoleucine, Valine and Alanine decreased sharply in CPW, followed by Methionine, Glycine, Aspartic, Tyrosine and Phenylalanine. Amino acids Leucine and Histidine were the lowest amino acids affected by alkali treatment during unhairing process. Similar result was found by Norton and Nicholls [13] who reported that amino acids Cystine, Tryptophan, Threonine, Arginine and Lysine are modified and some main chain breakdown also occurs when wool exposed to alkali. Carr [14] has found that alkali tends to hydrolysis

Table 1: Composition of amino acids (g/100g) among different wool types.

Amino acids	CPW	EPW	SW	± SE
Aspartic	1.323[a]	1.660[b]	2.203[c]	0.0043
Therionine	1.210[a]	1.960[b]	2.540[c]	0.0058
Serine	2.610[a]	3.577[b]	3.527[c]	0.0064
Glutamic	4.130[a]	5.530[b]	5.543[b]	0.0051
Proline	5.450[a]	7.883[b]	5.920[c]	0.0061
Glycine	2.070[a]	3.223[b]	3.647[c]	0.0305
Alanine	1.260[a]	3.260[b]	3.517[c]	0.0510
Valine	0.807[a]	1.107[b]	2.130[c]	0.0580
Methionine	0.903[a]	0.910[a]	1.677[b]	0.0205
Isoleucine	0.787[a]	0.813[a]	1.767[b]	0.0269
Leucine	4.087[a]	4.917[b]	5.667[c]	0.0033
Tyrosine	2.340[a]	2.380[b]	3.840[c]	0.0082
Phenylalanine	1.460[a]	1.547[b]	2.443[c]	0.0092
Histidine	2.550[a]	3.023[b]	3.063[b]	0.0155
Lysine	1.710[a]	2.233[b]	2.530[c]	0.0282
Ammonia	1.270[a]	0.797[b]	3.543[c]	0.0262
Argenine	5.557[a]	7.843[b]	7.570[c]	0.0210

CPW (Chemical Pulled wool), EPW (Enzymatic pulled wool), SW (Sheared wool) and SE (Standard error). Within each classification for each trait means not followed by the same letter are differed significantly (P< 0.05).

The peptide bond and leads to gradual dissolution of the fiber as well as eliminate of sulfur as sodium sulfide. Moreover, the degradation effect of alkali on wool sulfur content increased by increasing both temperature and alkali concentration [15, 16]. The previous results mach the results found in Fig. 1 which show that sulfur content increased in SW followed by EPW then reach the minimum record in CPW due to the degradation occurred by alkali in CPW.

Yarn characteristics affected significantly by the variability of fibers characteristics used in the blend [17]. Treated wool with alkali during unhairing process decreases most of yarn characteristics as showed in Table 2. Dusenbury *et al.* [18] illustrated that treated wool with alkali tended to decrease some physical properties of wool fiber because of its effect on orthocortex and paracortex. Yarn tensile strength tended to decrease significantly (P< 0.05) with the increase the percentage of both pulled wool types (CPW and EPW) compared with 100% SW. Blends which had 50% and 25% of EPW had stronger yarns (5.90 and 4.70, respectively) compared with the blends contain 50 and 25% of CPW (4.20 and 3.97, respectively). Lowest yarn strength found in 100% CPW blend could be explained by the degradation happened especially in the disulfide bond which leads to decrease in wool staple strength. Mildred and Rachel [16] reported that wool was strength decreased when wool treated by alkali. Moreover, results in Figures 1,2 and 3 stated that the increase of both sulfur content and Fiber Diameter staple strength tended to increase, that could explain the trend of yarn tenacity among different wool blends. Many authors attribute the increase in yarn strength when staple length increases to the increase in fiber diameter [19-22], as well as Sadek [23] reported that the high strength of the Ossimi wool compared with Merino might arise from their differences in fiber diameters. Staple strength considered as a good indicator for yarn strength which was found to be high in SW and started to decrease slightly in EPW and classified as tender (less than 25 N/Ktex) in CPW wool as reported by many authors [24-26].

Table 2: Some textile measurements in all studied wool blends

		EPW			CPW			
	SW	----------			----------			
Traits	100%	25%	50%	100%	25%	50%	100%	SE
Tex	290.00[a]	290.33[a]	296.00[a]	290.00[a]	291.00[a]	296.33[a]	299.33[a]	0.1230
Hairiness	352.33[b]	309.00[b]	335.67[b]	333.00[b]	312.67[b]	365.67[b]	189.70[a]	30.6933
Fraction	910.77[e]	1118.40[g]	1066.03[c]	734.70[d]	919.00[b]	559.03[f]	527.70[a]	0.4158
Regularity								
• Fine places	561.00[e]	441.00[b]	1521.33[c]	1322.33[d]	2061.33[g]	1881.00[f]	3211.00[a]	0.9512
• Thick places	100.00[e]	261.33[b]	500.00[c]	780.67[d]	460.33[g]	1021.33[f]	1441.67[a]	0.7454
• node	41.67[e]	100.67[b]	262.00[c]	401.67[d]	260.00[c]	501.00[f]	682.00[a]	0.9512
Strength	7.43[e]	5.90[g]	4.70[c]	4.03[d]	4.20[b]	3.97[f]	2.00[a]	0.0218
Elongation	12.50[e]	9.70[g]	8.97[c]	7.67[d]	10.67[b]	8.57[f]	4.40[a]	0.0504

SE = Standard Error, all % taken from CPW and EPW shows the part of the blend used by the previous wool types which used to make a blend with the integral part which is always SW. Within each classification for each trait means not followed by the same letter are differed significantly (P< 0.05)

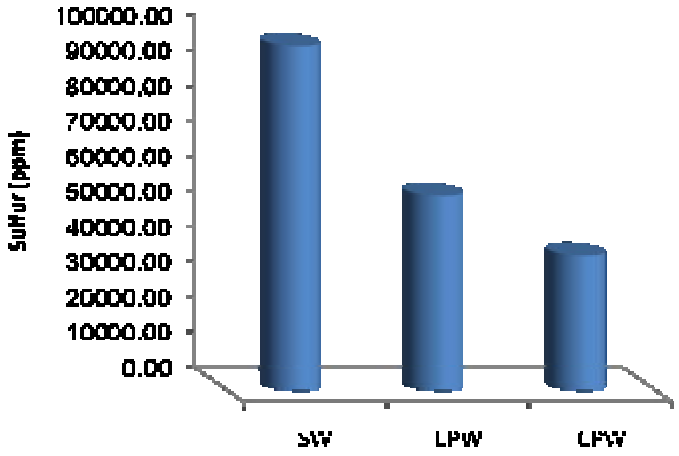

Fig. 1: Sulfur content of different wool types

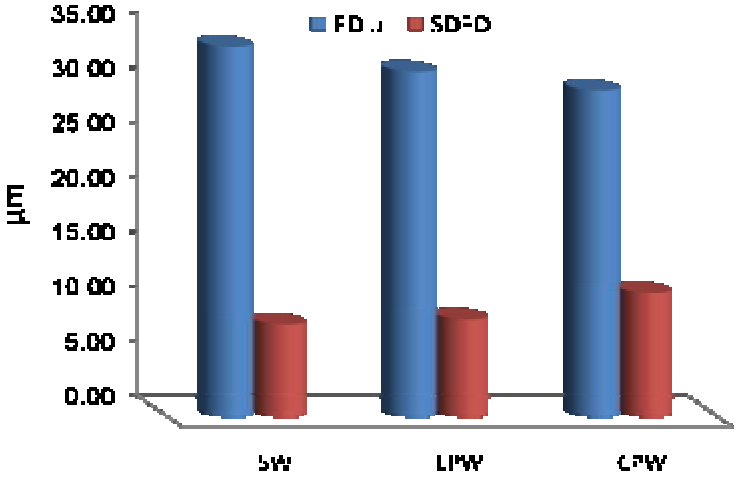

Fig. 2: FD and SDFD of different wool types

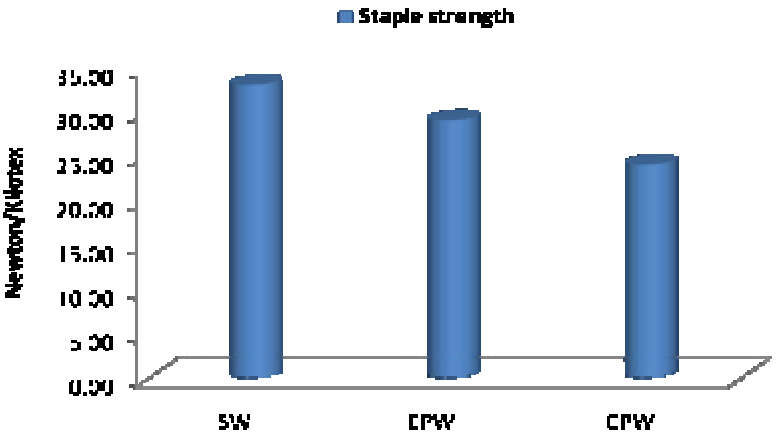

Fig. 3: Staple strength content of different wool types

Yarn elongation followed the same trend of yarn strength, where reached the maximum in SW (12.50) followed by EPW (7.67), while the minimum record was found in CPW (4.40). Helal [27] reported that elongation of wool staples tended to increase with the increase of wool Methionine content. Previous result is in match with the result obtained from Tables 1 and 2 which indicated that yarn elongation increased with increasing Methionine content of wool in SW which was higher than both pulled wool types. Yarn regularity which representative by number of thin, thick places and nods was found to be affected by many reasons, some of them is related to the mechanical process like twisting speed and direction, some other factors related to exist of small parts of vegetable matter [28] or dust and some other factors related to the difference in fiber types and their distribution which have effects on fiber homogeneity in the blend especially when kemp fiber exist [29]. Results in Table 2 reported that SW had the best regular yarn compared with other blends, which is logical because of SW is free from the degradation happened in fiber structure in both pulled wool types. In the same context blends of 25, 50 and 100 EPW are regular than the same sequence blends of CPW percentages. No Significant differences were found among all blends in yarn hairiness except for 100% CPW, which had the lowest record of Hairiness. Yarn fraction had found to be higher in SW and lower in CPW, while EPW record located in an intermediate position. That could be affected by the unhairing process which affected the fibers scales which play a vital role in fiber fraction. Chemical treatment had the worst effect on fiber scales compared with enzyme treatments, which leads to decrease the fraction in 100% CPW compared with 100% EPW blends.

CONCLUSION

Results in this study encourage wool factories to use pulled wool especially for making yarn for handcrafts to increase their profit. Great attention must be paid to know the real quality of pulled wool especially that collected after chemical unhairing process. Quality of pulled wool determines its percentage in the blend. Staple strength as one of the important wool characteristic affected significantly by alkali treatment during unhairing process which leads to rapid reduction in sulfur content compared with wool collected by shearing process. Unhairing process by enzyme treatment not only gives better wool but also eco-friendly compared with chemical one. Further study needs to investigate the effect of storage of pulled wool on its characteristics.

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