# Industrial Characteristics of Wool Produced From Sheep Fed on Salt Tolerant Fodder Crops

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**Abstract:** The present trial was lasted for 14 weeks and used twenty four males of Barki lambs (18.8 Kg average body weight and 6 months of age) to investigate the effect of feeding salt tolerant plants on the industrial characteristics of raw and yarns of wool. Animals fed on different salt tolerant plant mixture (47% Kochia and 53% Pearl millet grass) as hay (G2) or haylage (G3), while control group (G1) fed on Berseem hay as a basal diet. Concentrate feed mixture (CFM) was given to all animals to cover 100% of maintenance. Haylage group had significant differences in fiber diameter, staple strength, staple elongation and medullated fibers compared with hay group. The prickle factor found to be 49.2 (G1), 37.2 (G2) and 46.6 (G3) with significant differences ($P< 0.05$) between both (G1) and (G3) compared with (G2). Staple strength found to be higher ($P< 0.05$) in G1 (35.9N/Ktex) and G3 (35.7N/Ktex) compared with G2 (29.1N/Ktex). Yarn strength increased significantly ($P< 0.05$) in haylage group (7.2 kg) compared with hay one (5.8 kg). Yarn elongation reached the maximum in G1 (12.6%) followed by haylage group (10.3%) and finally hay group (9.2%). Yarn irregularity representative in number of thin and thick places as well as number of nodes, found to be higher significantly ($P<0.05$) in both G2 and G3 compared with G1. It was concluded that haylage group had better characteristics than hay one while both treatments with salt tolerant plants had lower characteristics compared with control group. Correlation among both yarn and raw wool characteristics were also discussed.

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## 1. Introduction

Approximately 400 million/hectare of land is affected by salinity **(Al-Sadi et al., 2010).** Moreover, **Rhoades and Loveday (1990)** illustrated that about 20% of the world cultivated lands as well as half of the irrigated lands are affected by salinity. That could be due to the degradation of the irrigation system, addition of waste salts to our environment as well as increasing contamination of underground water sources **(Ashraf, 1999).** In Egypt the salt-affected area found to be 9.1 M ha as estimated by **Anon, (2006). Ashraf et. al., (2006)** reported that Halophytes could be classified as excluders versus includers on the basis of internal salt contents of the plant. Excretive halophytes, which is capable of excreting the excess salt out of plant body. In such types of halophytes, the salt crystals may remain visible on the plant leaf surface; they have glandular cells that help to remove excess salt from the plant body **(Marschner, 1995)**. Succulents are types of halophytes that have a salt bladder on their leaf surface. Succulents store large amount of water within their body to minimize salt toxicity **(Weber, 2008)**. Almost all halophytes found in deserts belong to this category. Most halophytes problems could be summarized in its content of salt and anti-nutritional factors. Ash reflects the presence of certain salts such as sodium chloride and percentages of secondary metabolites such as nitrates, tannins, alkaloids, saponins, which considered as anti-nutritional factors **(El Shaer and Attia-Ismail, 2002)**. Kochia Indica and Pennisetum Americanum as a salt tolerant plants showed great palatability as animal fodders, and used it in hay or silages form be more efficiently rather than in fresh state because of these processing tended to improve their nutritive values **(El Shaer et al., 2005; Fahmy and Ibrahim, 2005; Anon., 2009 and Youssef et al., 2009).**

In most Bedouins communities animals are the main source of income and considered as a social prestige among local inhabitants. Using halophytic plants help the indigenous population to settle down and decrease the migration from one place to another looking for green vegetation for their animals. In the same time, utilization of halophytes supports the fragile systems especially in desert area **(El-Hadary and Nasr, 2002)**.Thus, the present study was carried out to investigate the effect of feeding KochiaIndica and Pennisetum Americanum to Barki lambs on the characteristics of both wool as a raw material and industrial characteristics of wool yarns.

## 2. Materials and methods

The present trial was lasted for 14 weeks and contains twenty four males of Barki lambs which divided randomly into three groups (eight animals / each). Animals had 18.8 Kg average body weight and 6 months of age. Animal raised in South Sinai

Research Station which belongs to Desert Research Center, Egypt. The present study done under the patronage of the project entitled "salt-tolerant forage production systems to salt-affected lands in Sinai Peninsula in Egypt" which supported by ICBA (International center for Biosaline agriculture). Concentrate feed mixture (CFM) was given to all animals to cover 100% of maintenance requirement according to **Kearl (1982)**. The CFM consisted of 25% cotton seed cake, 30% corn, 35% wheat bran, 3% rice bran, 3% molasses, 1% urea, 2% limestone, 1% common salt. Large quantity of chopped air-dried of Kochia (KochiaIndica) and Pearl millet grass (Pennisetum Americanum) mixed together at a ratio of 47: 53%, respectively. The total amount of mixture was divided into two equal parts: the first part was kept as hay to be fed for the second group (G2), while the other part was mixed with 5% molasses to make haylage for the third group (G3). Both of these salt tolerant mixtures (STM) were given to sheep as basal diets in comparison with the Berseem hay (*Trifolium Alexandrinum*, 4$^{th}$ cut) fed to the first group (G1) as a control group.

Wool growth of 10 $cm^2$ patch from left mid-side position was taken from each animal as close as possible to the skin surface using fine scissors. Five hundred fibers from each sample were used to calculate the average fiber diameter as well as medullated fiber percentage using optical fiber diameter image analyzer (LEICAQ 500 MC) with lens 4/0.12. Three greasy staples of each sample were used to measure staple strength using Agritest Staple Breaker with the procedure displayed by **El-Gabbas et al. (1999)**. Elongation, the increase in staple length in proportion to the original length was measured. Point of break by weight and by length (the weight and length of top in proportion to the weight and length of both top and base) were calculated at the time of measuring staple strength. Sub samples "not less than 300 fibers" were classified into kemp, medullated and fine fiber categories; according to its coarseness and the percentage of medulla. kemp; very coarse fibers with medulla occupying more than 70% of the medullated fiber, coarse fiber; fibers containing medulla and fine or non-medullated fibers; fibers with no medulla. Fiber type ratio were also calculated **(Guirgis, 1973)**. Prickle factor (PF) was estimated from the fiber diameter distribution in each sample as the percentage of fibers had diameters more than 30µm from the total fibers number **(El-Gabbas, 1998)**.

Random samples of yarns coming from each category after woolen process were tested as follows:

Yarn count (Tex) = yarns weight (g) for 1000 m of yarn length

Yarn twisting (yarns from each grade was played at nominal level of 170 turn per meter (TPM) on Z direction).

Yarn strength and elongation: The maximum breaking force was expressed in kilogram force (Kg). Uster Testers 3 (Zellwegeruster) was used to measure yarn strength 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).

Data were statistically analyzed using one way analysis of variance using General Linear model (GLM) of **SAS (2000)** and differences between means were tested using Duncan's multiple range test **(Duncan, 1955)**.

## 3. Results and Discussion

Figure (1) showed that G3 (Haylage group) had higher crude protein compared with G2 (Hay group). That could be related to the effect of Haylage process which slightly increased the crude protein (CP) and cellulose values as a result of biological treatment as reported by **Singh and Mudgal (1980) and Youssef, et al. (2009). Sahoo and Soren, (2011)** reported that wool production affected by both level and type of protein compared with energy level. **Masters et al. (1999)** and **Helal (2004)** indicated that feeding protected protein tended to increase wool growth. Result findings in figures (1) and (2) could explain the increase in fiber diameter in G1 (control group) followed by G3 then G2 according to the same pattern of CP expressed in Figure (1).

Prickle factor as a sensation arises from the coarse fiber which doesn't bend readily and be able to provide sufficient distortion of the skin to excite some receptors compared with fine fibers **(Lamb, 1997b).** The percentage of fibers greater than 30 micrometers is a useful predictor of prickle response (**Naylor, 1992).** Harsher wool grade found to be associated with maximum prickle factor **(Abdelaziz and El-Gabbas, 1999 and Al-Betar, 2007)**, Also many authors reported that prickle factor had high correlation with mean fiber diameter **(Whiteley and Thompson, 1985; Dolling et al., 1992 and Hansford, 1992).** In the present study fiber diameter found to be associated with both percentage of medullated fibers and prickle factor. Control group had the highest fiber diameter with significant difference (P<0.05) compared with G2 while G3 had lower value of fiber diameter but insignificantly compared with G1 (Figure 2 and Table1). **El-Gabbas (1998)** estimated the overall average of the prickle factor to be 45.1%, in Barki wool, while in the present study, the percentage of prickle factor found to be 49.2 (G1), 37.2 (G2) and 46.6 (G3) with significant differences (P< 0.05) between both G1and G3 compared with G2.

Staple strength found to be higher (P< 0.05) in G1 and G3 compared with G2 and this result is very important because staple strength is a good indicator for yarn strength **(Ross et al. 1986)** and essential in all manufacture processing to reduce the waste as carding losses or combing noilage **(Rogan, 1988 and Story, 1978).** Wool called tender when staple strength being less than 25 N/ktex **(Hunter et al., 1983; Ralph, 1984 and Rogan, 1988),** so Regardless of the variability in staple strength among all nutritional treatments, no tender wool found because of these treatments. Staple strength is affected by many factors such as fiber diameter **(Mooy et al. 1988).** Variation in fiber diameter along the staple tended to reduce staple strength **(McKinley et al., 1976 and Hansford and Kennedy, 1990)**. Coefficient of variation of fiber diameter had a measurable effect on yarn tenacity **(Phillips et al. 1991 and De Groot, 1995).** Moreover, presence of kemp fibers **(Groff 1983),** irregularity of fiber length **(Ross, 1982),** number of crimps **(Ryder and Stephenson 1968 and Helal, 2000)**, Sulfur in the diet and sulfur amino acids **(Helal, 2004 and 2008)**, Feeding halophytes **(Taha, et al. 2009),** poor nutrition **(Al-Betar, 2000)**, Pregnancy and lactation **(Hansford and Kennedy, 1988)** as well as Breed and strain of sheep and age of ewe **(Stobart and Sumner, 1991)**. **Thompson and Hynd (1998)** found that an increase of 1 µm in fiber diameter was associated with an increase in staple strength of about 5 N/ktex. Within the staple, coarse fibers were stronger than fine fibers (**Sharafeldin and Ghoneim, 1963)**. Same trend found in Table (1), that fiber diameter associated with staple strength. Yarn strength could be affected by other factors like Yarn twisting and fibers evenness **(Lamb, 1997a)** as well as irregularity in the yarn **Lamb (1997b)**. Kemp percentages are almost the same among all groups with slight increase in G2. **Gadallah, (2007), Ince and Ryder (1984) and Tawfik (1983)** found that with increasing fiber diameter, yarn strength tended to increase. In the present study, Yarn strength increased significantly (P< 0.05) in Haylage group (7.2 kg) compared with hay group (5.8 kg). Strength in both yarn and staple followed the same trend as well as elongation which reached maximum in G1 (12.6%) followed by Haylage group (10.3%) and finally Hay group (9.2%).

Tex is defined as a unit of measure yarn count and calculating as the mass in grams per 1000 meters of yarn and results in table (1) shows no significant differences among treatments, while all other studied yarn traits found to be significant (P<0.05) among studied groups, which illustrated that yarn had a great sensitivity towards the changes in average fiber diameter, staple strength, medullated fibers percentage and irregularity of fiber diameter among the staple. Control group had the best quality of yarns followed by G3 and finally G2 which had the worst yarn quality among the studied groups.

**Yarn imperfections:-**

In woolen system, wool web contains fibers coming off in random alignment then the web divides into small strips called pencil roving, which placed on the spinning frame to make yarn for that irregularity in fiber diameter and/or different of diameter along the same fiber as well as presence of small particles of any materials like dust will cause irregularity in yarn diameter and strength along the yarn. **Gadallah (2007)** reported that presence of different fiber types especially kemp leads to increase the irregularity of yarn, while **Emara, (1995)** illustrated that dust or small parts of vegetable matter also increase the yarn irregularity. This Irregularity decrease yarn strength, which means the strength at the weakest point of the yarn. **Helal, et al (2006)** reported that separating camel-hair into fine and coarse make significant differences in yarn characteristics compared with yarn coming from raw camel-hair. For that, to obtain good quality yarns, most of yarn factories add different types of fibers to wool for making a perfect blend according to the type of end product they produce. Yarn irregularity representative in number of thin and thick places as well as number of nodes, found to be higher significantly (P<0.05) in both G2 and G3 compared with G1. Thick places in G2 reached 1.6 times of G1. Haylage group had lower values of thin places (434.4), thick places (193.1) and nodes (69.2) compared with G2 (455.8, 204.1 and 78, respectively). Increase in fiber diameter coefficient of variation leads to increases number of thin places **(De Groot 1992)**. This irregularity in yarns coming from animals fed on salt-tolerant plants could be attributed to the anti-nutritional factors which could affect on the amount and regulation of protein reached the follicles. **El-Shereef (2012)** illustrated that kochia contains different types of anti-nutritional factors like Oxalates, Alkaloids, Tannins, Flavonoids and Saponins when it was in fresh form, while anti-nutritional factors decreased in hay and silage forms and the last one consider the best form which contain the lowest values of anti-nutritional factors with disappearance of Flavonoids. **Gihad et al. (2003)** reported that Ensiling kochia reduces saponins content by 28% than drying (9%) which had negative effects on growth rate and toxicity effects as well as saponins decrease Fe absorption. Moreover, Tannins interfere with proteins and this could affect negatively on the animal productivity as growth rate, feed intake and nutrient digestibility as well as wool growth and reproduction **(Kumar and Vaithiyanathan, 1990; Ben Salem et al., 1999 and El Shaer et al., 2005).**

Friction is a physical character affects on the yarn quality and defined as the resisting force on the fiber body sliding over another under a normal load due to the force needed to lift one surface over the irregularities of the other. The fiber surface geometry of natural fibers is sub-divided into surface roughness, cross-sectional shape and crimp/ convolution. **Scardino and Lyons (1977)** deduced that the roughness has adverse effect while the crimp and cross-sectional shape (toward circular) have positive effect on inter-fiber friction. In the present study friction found to be higher in G1 followed by G3 and the lowest group was G2. It could be concluded that yarn friction increase with increasing fiber diameter (Tables 1 and 2).

**Correlations:-**

Table (3) illustrated that fiber diameter had a significantly positive correlation with staple strength (r = 0.78), staple elongation (r = 0.82) and modulated fiber(r = 0.99). Staple strength had a highly significant positive correlation with Medullated filer percentage (r = 0.83) and significant negative correlation with kemp percentage (r = - 0.74) in Barki wool. yarn irregularity as representative in both thin and thick places as well as number of neps had significantly negative correlation with yarn strength (r = - 0.84, r = - 0.79 and r = - 0.91, respectively) and yarn elongation (r = - 0.97, r = - 0.95 and r = - 0.97, respectively), while had a positive and significant correlation with yarn friction (r = 0.94, r = 0.91 and r = 0.98, respectively). Staple characteristics like staple strength found to be correlated significantly with yarn strength (r = 0.81). **Al-Betar, (2007)** found the same result that with increasing staple strength, yarn strength tended to increase. irregularity of Barki wool along the animal positions, among and within staples and even along the same fiber increase the irregularity happened in yarns so to decrease this disharmony we assume that with increasing yarn thickness of coarse wool, yarn irregularity tended to decrease and that could be attributed to the highly negative correlation found between fiber diameter and both of Thin places (r = - 0.81) and thick places (r = - 0.88).

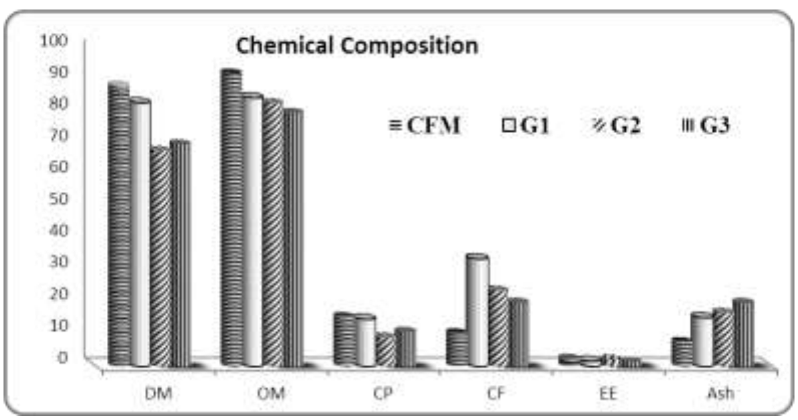


**Figure (1):** Chemical composition of rations used for the same experimental groups as measured by (**Youssef, et al. 2009).**

*DM: Dry matter, OM: Organic matter, CP: Crude protein, CF: Crude fiber, EE: Ether extract, G1: Control group, G2: Hay group, G3: Haylage group*

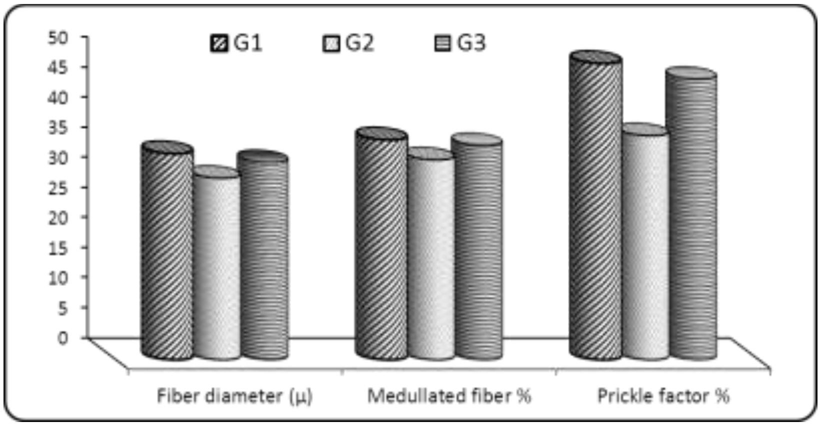


**Figure (2) Fiber diameter and both percentage of modulated fiber and prickle factors among treated groups.**
*G1: Control group, G2: Hay group, G3: Haylage group*

**Table (1).** Least squares means of wool characteristics among experimental groups

| **Items** | **G1** | **G2** | **G3** | **±SE** |
|---|---|---|---|---|
| **Fiber diameter (µm)** | 34.1$^{a}$ | 30.0$^{b}$ | 32.4$^{c}$ | 0.096 |
| **Staple Strength (N/Ktex)** | 35.9$^{a}$ | 29.1$^{b}$ | 35.7$^{a}$ | 1.190 |
| **Staple elongation (%)** | 47.2$^{a}$ | 45.3$^{b}$ | 45.4$^{a}$ | 0.153 |
| **Kemp (%)** | 3.7$^{a}$ | 3.8$^{a}$ | 3.8$^{a}$ | 0.058 |
| **Medullated fibers (%)** | 36.6$^{a}$ | 32.1$^{b}$ | 35.4$^{c}$ | 0.082 |
| **Fine fibers (%)** | 63.2$^{a}$ | 67.9$^{b}$ | 64.2$^{c}$ | 0.115 |

G1: Control group, G2: Hay group, G3: Haylage group
Values with different superscripts within the same row are significantly different ($p<0.05$)

**Table (2).** Least squares means of wool yarn characteristics among experimental groups

| **Items** | **G1** | **G2** | **G3** | **±SE** |
|---|---|---|---|---|
| Tex | 285.3$^{a}$ | 294.4$^{a}$ | 288.1$^{a}$ | 0.84 |
| Friction | 1011.2$^{a}$ | 877.3$^{b}$ | 938.3$^{c}$ | 0.709 |
| Thin-places | 364.5$^{a}$ | 455.8$^{b}$ | 434.4$^{c}$ | 1.297 |
| Thick-places | 131.0$^{a}$ | 204.1$^{b}$ | 193.1$^{c}$ | 1.219 |
| Neps | 55.2$^{a}$ | 78.0$^{b}$ | 69.2$^{c}$ | 0.613 |
| Strength | 7.8$^{a}$ | 5.8$^{b}$ | 7.2$^{c}$ | 0.079 |
| Elongation | 12.6$^{a}$ | 9.2$^{b}$ | 10.3$^{c}$ | 0.205 |

G1: Control group, G2: Hay group, G3: Haylage group
Values with different superscripts within the same row are significantly different ($p<0.05$)

**Table (3).** Simple correlation among yarn and staple characteristics

| | | Yarn characteristics | | | | | Staple characteristics | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Thin | Thick | YN | YS | YEl% | FD | SS | EL% | K% | MF% | FF% |
| Yarn characteristics | YFr | 0.94$^{**}$ | 0.91$^{**}$ | 0.98$^{**}$ | -0.97$^{**}$ | -0.95$^{**}$ | -0.99$^{**}$ | -0.78$^{*}$ | -0.83$^{**}$ | 0.64$^{NS}$ | -0.98$^{**}$ | 0.96$^{**}$ |
| | Thin | | 0.99$^{**}$ | 0.98$^{**}$ | -0.84$^{**}$ | -0.97$^{**}$ | -0.91$^{**}$ | -0.60$^{NS}$ | -0.95$^{**}$ | 0.65$^{NS}$ | -0.84$^{**}$ | 0.81$^{**}$ |
| | Thick | | | 0.96$^{**}$ | -0.79$^{*}$ | -0.95$^{**}$ | -0.88$^{**}$ | -0.55$^{NS}$ | -0.97$^{**}$ | 0.64$^{NS}$ | -0.79$^{*}$ | 0.76$^{*}$ |
| | YN | | | | -0.91$^{**}$ | -0.97$^{**}$ | -0.96$^{**}$ | -0.69$^{*}$ | -0.89$^{**}$ | 0.63$^{NS}$ | -0.91$^{**}$ | 0.89$^{**}$ |
| | YS | | | | | 0.88$^{**}$ | 0.99$^{**}$ | 0.81$^{**}$ | 0.72$^{*}$ | -0.54$^{NS}$ | 0.99$^{**}$ | -0.98$^{**}$ |
| | YEl% | | | | | | 0.93$^{**}$ | 0.60$^{NS}$ | 0.92$^{**}$ | -0.51$^{NS}$ | 0.88$^{**}$ | -0.85$^{**}$ |
| Staple characterist | FD | | | | | | | 0.78$^{*}$ | 0.82$^{**}$ | -0.59$^{NS}$ | 0.99$^{**}$ | -0.97$^{**}$ |
| | SS | | | | | | | | 0.44 | -0.74$^{*}$ | 0.83$^{**}$ | -0.86$^{**}$ |
| | EL% | | | | | | | | | -0.58$^{NS}$ | 0.73$^{*}$ | -0.67$^{*}$ |
| | K | | | | | | | | | | -0.57$^{NS}$ | -0.58$^{NS}$ |
| | MF% | | | | | | | | | | | -0.99$^{**}$ |

Yarn characteristics:-YFr = Yarn Friction, Thin= Yarn thin places, Thick= Yarn thick places, YN= Yarn neps, YS=Yarn strength and YEl = Yarn elongation

Staple characteristics:- FD= Fiber diameter, SS= Staple strength, EL= Elongation, K Kemp, MF%= Medullated fiber percentage and NMF%= Fine fiber percentage.

## 4. Conclusion

Generally haylage group had better characteristics than hay one while both treatments with salt tolerant plants had lower characteristics compared with the control group.

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