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WOOL GRADING AND PROCESSING SYSTEM TO IMPROVE THE UTILITY OF THE EGYPTIAN BARKI WOOL

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SUMMARY

The present study aimed to define those wool traits of significant processing performance to be included in the sheep breeding program. About 1.64 tons of wool was harvested from the flock of Barki sheep at Maryout Research Station belonging to the Desert Research Center. The harvested wool was subjected to a clip preparation technique and subjectively graded for harshness and bulkiness into four lines; L1: coarse wool with high bulk, L2: coarse wool with low bulk, L3: fine wool with high bulk and L4: fine wool with low bulk in addition to another one (L5) as a wool line left without grading for comparison. Representative wool samples were taken from each line to measure fibre diameter (FD), standard deviation of FD (SDfd), medullated fibre percentage (M%), prickle factor (PF%), loose wool bulk (BUL), resilience (RES), staple strength (SS), point of break (POB) and staple elongation (EL) in order to determine the characteristics of each line of the raw wool. The formed wool lines were sent to the manufacture to be processed according to the normal procedures practiced in such mill. Representative wool samples were also taken from each line after carding, after spinning and from the processed blankets. These samples were tested according to the Egyptian Standards for blankets. The same wool traits measured in the raw wool were tested again from those samples taken from each line after carding. Samples collected to represent each processed line after spinning were used to measure yarn count, yarn strength and elongation, coefficient of variability of irregularity of yarn mass and yarn hairiness. Some blanket properties such as weight of blanket/ m^2, heat loss, air permeability, strength and elongation as well as covering factor were also recorded from samples taken from each line of processed blanket.

Results indicated that L1 and L2 had significantly higher FD, SDfd, M% and PF% as well as less SS and EL compared with L3 and L4. L1 and L3 had significantly higher BUL and RES compared with L2 and L4. Blanket weight/ cm^2 was significantly lighter for blankets processed from those lines of more harshness (L1 and L2) and more bulkiness (L1 and L3). Moreover, blankets made from higher BUL wool lines tended to maintain more heat and being less permeable with significantly better covering, while blankets made from finer wool lines tend to be stronger and more extensible. The present study recommend that blanket made from L1 line to be the best since it provides better processing efficiency in terms of yarn count as well as producing blanket with the least blanket weight/ cm^2 and maintaining more heat. Moreover, the manufacturer could save about 20% of the *woolen materials to produce such high quality blankets matching with standards requirements for the Egyptian markets.*

The present study demonstrated the potentiality of the local Barki wool once subjected to the grading system implemented and proved to be beneficial from the processing and economical points of view. It is emphasized that sheep breeders should go for selecting their sheep for higher BUL and coarser wool in order to attain good quality wool satisfying wide range of good quality end products. That would help increasing the utility of the local wool in the industry, hence increasing wool prices which consequently enhance the profitability for sheep farming in general.

Keywords: Wool, grading, breeding, bulk, harshness, processing, blanket, Barki sheep

INTRODUCTION

Wool production in Egypt has often little contribution to the income of sheep farming as in many countries, since wool is usually sold to manufacturers without grading. Considerable amount of the indigenous wool is often processed in local mills producing poor quality carpet, rugs, blankets,…etc. Producers do not get a reasonable price since they are not able to adequately present their wool from the industry's point of view. On the other hand, the manufacturers are reluctant to buy this wool since they cannot determine the quantity and quality of such clip. Therefore, they offer reduced prices and prefer to buy the expensive imported wool.

Recently, the expansion of the Egyptian wool industry has led to increase the demand for more raw wool, hence creating the need to improving the local wool and standardize the manufacturing needs in order to produce woolen textiles satisfying the consumer's taste and decreasing imported wool.

Improving wool could go through introducing a proper grading system and/ or efficient breeding program. It is of crucially importance to grade the wool before marketing to be classified into different types to suite the needs of the textile industry and consequently attain higher prices for their wool. The implementation of a breeding program for better wool necessitates a clear definition of those traits of major contribution to the profitability of sheep farming, which depends on many traits. Defining those wool traits of significant processing performance to be included in the sheep breeding program is the corner stone of the present study. Abdelaziz and El-Gabbas (1999) indicated that carpet manufacturers could attain processing and economic advantages by using high bulk and harsher wools which would help to increase the utility of the local wool once graded in the carpet industry and in turn attain higher return for carpet manufacturers and sheep breeders. The present study displayed some interventions to consider the interaction between these traits to enhance the performance of the blanket as an end product. While few studies investigated the processing of the Egyptian wool into carpet, the processing of blankets was rarely attempted. Thus, the present study was designed to produce information to be included into a package of evaluating the local Barki wool to elucidate its suitability to satisfy widely different end-use requirements. It would also provide the sheep breeder with those wool characters which he should strive to attain to meet the interests of the textile industry and consumers.

MATERIALS AND METHODS

About 1.64 tons of Barki wool was harvested from the shearing season of the flock of Barki sheep at the Maryout Research Station belonging to the Desert Research Center, 35 kilometers west of Alexandria and used in the present study. Shearing is usually practiced once a year in May. The harvested wool was first skirted by removal of belly, shanks and inferior wool from each fleece. The remainder was considered as fleece wool which was then graded based on the subjective assessments of greasy wool for harshness and loose wool bulk according to the grading system of El-Gabbas (1994). The whole lot of wool was visually graded for harshness into two sub-lots; fine and coarse wool. Then each sub-lot was further graded for loose wool bulk into two lines; high bulk and low bulk. Accordingly five lines were set; L1: coarse wool with high bulk, L2: coarse wool with low bulk, L3: fine wool with high bulk, L4: fine wool with low bulk and L5: fleece wool line left without grading for comparison. Ten representative wool samples were taken from each line just before processing to measure fibre diameter (FD), standard deviation for FD (SDfd), medullated fibre percentage (M%), prickle factor (PF), loose wool bulk (BUL), resilience (RES), staple strength (SS), point of break (POB) and staple elongation (EL) in the standard conditions of 65% relative humidity and a temperature of 20^{o}C. FD, SDfd, M% and PF were measured using Image analyzer (LEICA Q 500 MC) with lens 4/0.12 as the methods described by El-Gabbas (1998). Measurements of BUL and RES were done using loose wool WRONZ (Wool Research Organization of New Zealand) bulkometer according to El-Gabbas (1999). Ten staples were taken at random from each line to be prepared for measuring SS (in Newton in kilotex, N/Ktex), POB and EL using the Agritest Staple Breaker (Caffin, 1980) in harmony with the procedure adopted by El-Gabbas *et al.* (1999). These wool traits were tested again from those samples taken from each line after carding.

The studied wool lines were sent to the wool processing plant (Blanket Department at Misr Spinning & Weaving Company of El-Mehalla El-Kubra, El-Gharbia Governorate) to be manufactured according to the same processing system applied in the factory. Wool of each line was processed by traditional woolen carding and spinning system to produce woolen yarns for blankets. Each line was treated and processed separately from the other lines throughout the processing route on the same machines from scouring to blanket finishing by highly experienced wool manufacturers. Representative wool samples were collected at random from each line after carding, after spinning and from the processed blankets. These samples were tested in the mill labs according to the Egyptian standards for blankets (ES: 682, 2001).

The processing route for each line comprised of scouring, carding, spinning and weaving to blanket. The processing of the yarns was adjusted to have approximately the same yarn count of 2.0 metric while the processing of blankets was adjusted to have approximately the same weight/ square meter of 600 gms. The desired wooly finish of the blankets was obtained by teasing the surface and then passed through a cropping machine. These processing stages were described in details elsewhere (Al-Betar, 2008).

Samples collected to represent each processed line after spinning were used to measure yarn count (YC), yarn strength (YS) and elongation (YE), coefficient of variability of irregularity of yarn mass (CVm%) and yarn hairiness (YH). Some blanket properties such as weight of blanket/ m^2, heat loss, air permeability, strength, elongation, number of weft and warp threads/ 5cm and covering factor were also recorded from samples taken from each processed blanket.

YC and fabric weft count were measured in metric count, i.e., length, km / weight, kg (ASTM D 1907-01 (2005)). Uster Testers 3 (Zellweger uster) was used to measure YS, YE and YH. As a maximum breaking force and extension, YS and YE were measured in kilogram force (Kg) on 50 cm length of yarn being extended until the thread breaks. CVm% was measured with a cut length of approximately 1cm along of yarn 1000m length. However, YH was regarded as the average total length of the protruding fibres within the measurement field of 1cm length, calculated over a thread length of 1000 meters.

According to the American standards of testing and materials, ASTM D 5034-95 (2005), the fabric strength (Kg) and elongation (%) were measured in pieces of blankets (20cm length by 5cm width) through its weft threads directions. Air permeability (in $foot^3$ of air / $foot^2$ of fabric/min., ASTM D 737-04 (2005)) was tested on an air permeability apparatus of Ellison draft gage company, Chicago, USA which uses petroleum oil 0.834 sp. The heat loss (calorie/cm^2) was measured by apparatus designed by Mansour (1992) using pieces of blankets with 20cm x 20cm dimensions. Covering factor of weft, warp and blankets were calculated according to Ibrahium (1995).

Statistical procedures

Data were analyzed using the general linear model procedure (Proc GLM) of SAS (1995) to test the sources of variation for the dependent variable (grades). Analysis of variance was performed for YS, CVm% and YH using YC as a covariate. Similarly, blanket weight/m^2 was also analyzed using number of warp/5cm and fabric warp count as well as number of weft/5cm and fabric weft count as covariates. Moreover, heat loss, air permeability, weft strength and elongation as well as warp strength and elongation were also analyzed using blanket weight, number of warp/5cm, fabric warp count, number of weft/5cm and fabric weft count as covariates.

RESULTS AND DISCUSSION

Properties of raw wool

The performance of such line of wool left without grading (L5) was found to lie in between those lines graded for harshness and bulkiness from the raw wool throughout all processing stages (Tables 1 to 6). That might reveal the effectiveness of grading system to separate the wool into distinct lines for given traits in order to elucidate the impact of these lines on the quality of the end products rather than leaving all traits undistinguishable in that wool left without grading. It should be mentioned that each of the formed lines would be looked at as a specific identity of the interaction between bulk and harshness, since the value of wool is generally regarded as a result of the interrelations between many wool traits.

Table 1. Least squares means± standard errors for raw wool characteristics of fibre diameter (FD), standard deviations of fibre diameter (SDfd), percentage of medullated fibres (M%) and prickle factor (PF) obtained from the studied wool grading lines

Traits / Factor	No.	FD (µm)	SDfd (µm)	M (%)	PF (%)
Overall mean	50	32.06 ± 0.41	15.13 ± 0.49	14.96 ± 0.98	42.02 ± 1.3
Grading lines		**	**	**	**
L1	10	34.31 ^{a} ± 0.93	15.43^{ab} ± 1.1	13.16^{ac} ± 2.2	49.24^{a} ± 3.2
L2	10	37.40^{c} ± 0.93	17.44^{a} ± 1.1	25.62^{b} ± 2.2	55.72^{a} ± 3.2
L3	10	28.89^{bd} ± 0.93	12.70^{b} ± 1.1	09.62^{a} ± 2.2	31.70^{b} ± 3.2
L4	10	28.55^{b} ± 0.93	13.01^{b} ± 1.1	07.66^{a} ± 2.2	35.58^{b} ± 3.2
L5	10	31.14^{d} ± 0.93	17.08^{a} ± 1.1	18.76^{c} ± 2.2	37.84^{b} ± 3.2

^{a,b,c,d} Within each column, means followed by the same superscript are not significantly different.

L1= coarse wool and high bulk, L2= coarse wool and low bulk, L3= fine wool and high bulk, L4= fine wool and low bulk and L5= fleece wool line without grading. ** P<0.01.

Table (1) indicated that L1 and L2 had significantly higher fibre diameter (FD; 35.86 µm Vs 28.72 µm), standard deviation of fibre diameter (SDfd; 16.44 µm Vs 12.86 µm), medullated fibre percentage (M%; 19.39% Vs, 8.64%) and prickle factor (PF%; 52.48% Vs 33.64%), as overall averages compared with L3 and L4. Since L1 and L2 were originated from a coarse wool lot, they appeared to be of harsher wool, greater FD with higher variability in addition to more M% and PF% compared with those lines came from a lot of fine wool, L3 and L4. Probably the interaction of bulkiness with harshness when combining these studied lines had no effect on that expected trend for FD, SDfd, M% and PF%.

While the mean FD is one of the key traits affecting the processing performance and quality of the end products, the variability of fibre diameter could be more effective. Fibre diameter distribution analysis is an objective measure of wool quality and is required to be described adequately, in terms of prickle factor, in relation to fabric comfort (El-Gabbas, 1998). The obtained results of PF% (Table 1) agreed with findings of Abdelaziz and El-Gabbas (1999), who reported the maximum PF values in those lines of harsher wool grade while the minimum one was recorded for those lines of fine wool grade. In wool sale lots, it was reported that PF had high correlation with mean FD (Whiteley and Thompson, 1985; Hansford, 1992). Higher level of coarse fibres content was found to be associated with more prickly fabric (cited by Dolling *et al.*, 1992). The fibre ends protruding from the surface of fabric can trigger nerve endings just below the skin surface, providing an irritating sensation. Mahar and O'Keefe (2002) showed that the PF of fibre ends in a top was best predicted by the raw wool PF ($R^2 = 0.93$).

Table (2) indicated that L1 and L3 had significantly higher loose wool bulk (BUL; 30.01 cm^3/g Vs 26.68 cm^3/g) and resilience (RES; 9.64 cm^3/g Vs 7.98 cm^3/g), as overall averages compared with L2 and L4. That is expected since L1 and L3 have been graded initially for higher BUL when formulating these lines compared with L2 and L4 which have been graded for lower BUL. Once again, combining bulkiness with harshness to formulate these studied lines probably did not impair the identity of each line to show those traits from which they were initially graded. However, the effect of bulk seems to be high in the presence of coarseness rather than fineness. That is probably due to that Barki sheep is mainly coarse wool breed. Most studies investigating the compression properties of wool were based on fine wool breeds and explained the variation in loose wool bulk as a function of fibre diameter, crimp frequency with helical rather than planer crimp types (Carnaby and Elliott, 1980; Ince and Ryder,1984). However, little work coming to hand from the coarse wool breeds showed that BUL tended to increase with increasing fiber diameter or medullation. Medullated fibres also contribute positively to increase BUL as a result of the hollow cells and stiffness of these fibres which make them resistant to compression (Chaudri and Whiteley, 1968; Elliott and Carnaby, 1980; Hunter, 1980). The correlation between compressibility and medullation was found to be very high (r = 0.9) when estimated by Ross (1978).

Table 2. Least squares means± standard errors for raw wool characteristics of loose wool bulk (BUL), resilience (RES), staple strength (SS), point of break (POB) and elongation (EL) obtained from the studied wool grading lines

Traits / Factor	No.	BUL (cm^3/g)	RES (cm^3/g)	SS (N/Ktex)	POB (%)	EL (%)
Overall mean	50	28.82 ± 0.1	8.85 ± 0.1	26.56 ± 1.0	45.97 ± 1.5	28.30 ± 1.5
Grading lines		**	**	**	NS	NS
L1	10	30.84^{a}±0.2	09.70^{a}± 0.3	26.79^{a}±2.3	39.92 ± 3.3	27.64 ± 3.4
L2	10	26.78^{b}±0.2	08.12^{b}±0.3	16.82^{b}±2.3	53.71 ± 3.3	23.80 ± 3.4
L3	10	29.18^{c}±0.2	09.58^{a}±0.3	31.28^{a}± 2.3	44.18 ± 3.3	31.20 ± 3.4
L4	10	26.57^{b}±0.2	07.84^{b} ±0.3	32.78^{a}± 2.3	44.03 ± 3.3	34.33 ± 3.4
L5	10	28.03^{d}±0.2	09.02^{a}±0.3	25.15^{a}± 2.3	48.00 ± 3.3	24.56 ± 3.4

[a,b,c,d] Within each column, means followed by the same superscript are not significantly different. L1= coarse wool and high bulk, L2= coarse wool and low bulk, L3= fine wool and high bulk, L4= fine wool and low bulk and L5= fleece wool line without grading. ** P<0.01. NS: not significant.

Results obtained from tables (1 and 2) obviously reveal the effectiveness of the grading system implemented to formulate lines differ significantly in FD, SDfd, M%, PF%, BUL and RES which would definitely be beneficial to clear the differences, if any, in the processing behaviour of these lines towards their end products, blankets. Moreover, these results indicated that objective measurements could successfully verify the subjective assessments of these wool traits on which the grading system are based on.

Although loose wool bulk, BUL, is considered to be of key processing significance for wool likely to be used for carpet, it has not been investigated for blankets. BUL is a desirable property of wool associated with compressibility, springiness as well as filling and covering power which directly affects the appearance and handle of products (Stobart and Sumner, 1991). Processing studies have firmly demonstrated the importance of bulk characteristic of wool which remains throughout all the processing stages (Carnaby *et al.*, 1984). It is specifically associated with resilience which is regarded as the ability to recover after compression (Dunlop *et al.*, 1974). Carpet manufacturers are very conscious of the commercial significance of yarn bulk which influences the cover a yarn will provide in a carpet (Carnaby and Thomas, 1978). It appears that improving bulk in the local wool would be of commercial significance in some products such as hand knitting, carpets, blankets and wool filled quilts, etc.. This could be achieved through either blending with other bulky wool, or improving this character in the Barki and other local sheep.

Results of table (2) indicated that L3 and L4 lines of finer wool had significantly higher staple strength (SS; 32.03 N/Ktex Vs 21.81 N/Ktex), as overall averages than those L1 and L2 lines of coarser wool. Harsh wool often contains kemp and medullated fibres which are susceptible to be broken and are known to be of little strength which probably is the likely explanation. However, the behaviour of finer lines might differ from that of harsher ones particularly when subjected to the tension during the measurement of SS. It seems that fine fibres can better stand for the tension and tend to stretch rather than break. That is probably matched with those results obtained for elongation, El, in which higher values were recorded for L3 and L4 as fine wool lines (32.77% Vs 25.72%), as overall averages compared with those lines of the coarse wool lot (L1 and L2). Results also indicated no significant differences in the point of break, POB, among all lines except for L2 which appeared to be broken much closer to the center of the staple compared with other lines. Wool fibres of L1, L3 and L4 tended to break relatively far from the centre of the staple and maintained most of the staple length which is more convenient for processing.

Tender wools affect the usefulness and the value of such wool as a textile fibre causing a problem in the industry. When the fibres come under tension during processing, particularly during carding, many tender fibres are broken resulting in poorer manufacturing performance as well as a greater loss of fibre. As processing speed continue to increase, soundness becomes of increasing importance (Story, 1978). This can result in a humble processing efficiency as well as increased carding losses and combing noilage (Rogan, 1988) and hence, slower and more costly production. On the other hand, several factors were reported to affect staple strength such as annual variation in wool growth, poor nutrition, lambing in addition to other stress agents (El-Gabbas *et al.*, 1999). Al-Betar (2000) investigated the effect of poor nutrition and fluctuation of feeding levels on the tenderness in Barki wool. He reported that the fluctuated feeding level produced tender wool with higher variability in fibre diameter both along staples and fibres compared with continuous maintenance or productive feeding regime.

Properties of wool after carding

During blending and lubricating stage, the normal procedure practiced by the wool factory is to add 35% polyester fibres in order to provide more strength to the materials used. Polyester fibres blended to the wool grading lines are characterized by much higher SS (135.4 ± 2.86 N/Ktex), less FD (14.75 ± 0.12 µm) less BUL (21.44 ± 0.21 cm^3/g) and RES (07.64 ± 0.14 cm^3/g). Therefore, it is expected that addition of polyester would increase SS while decrease FD and its variability as well as decreasing BUL and RES in the processed grading lines after blending.

Results obtained after carding (Table 3) showed similar trend to that obtained in the raw wool state, with a lower magnitude, where harsher wool lines with higher and lower BUL (L1 & L2) tended to have significantly higher FD (26.81 µm Vs 23.51 µm), SDfd (16.19 µm Vs 13.08 µm), M% (11.85% Vs 8.26%) and PF (27.98% Vs 19.37%), as overall averages compared with L3 and L4. Similarly, lines of higher

BUL with harsher (L1) and finer wool (L3) showed significantly higher BUL (30.55 cm^3/g Vs 27.54 cm^3/g) and RES (9.01 cm^3/g Vs 8.16 cm^3/g), as overall averages compared with L2 and L4. The magnitude of differences in FD, SDfd, M% and PF% between harsher wool lines (L1 and L2) and finer wool lines (L3 and L4) tended to decrease after carding. Similar trend was found regarding the magnitude of differences in BUL and RES between higher (L1 and L3) and lower BUL lines (L2 and L4). It seems that grading system implemented still maintaining its effect from the raw wool state till after carding, lubricating and blending processes.

Table 3. Least squares means ± standard errors for blended fibres characteristics of fibre diameter (FD), standard deviations of fibre diameter (SDfd), medullated fibres percentage (M%) and prickle factor (PF), loose wool bulk (BUL), and resilience (RES) obtained from the studied wool lines after carding stage

Traits Factor	No.	FD (µm)	SDfd (µm)	M (%)	PF (%)	BUL (cm^3/g)	RES (cm^3/g)
Overall mean	50	25.17±0.1	14.39±0.2	09.84 ± 0.2	23.79±0.3	29.01±0.1	08.64±0.1
Grading lines		**	**	**	**	**	**
L1	10	26.61^{a}±0.2	15.80^{a}±3.9	10.42^{a}± 0.5	27.44^{a}±0.7	30.61^{a}±0.2	09.10^{ac}±0.2
L2	10	27.01^{a}±0.2	16.58^{a}± 3.9	13.28^{b}± 0.5	28.52^{a}±0.7	25.80^{b}±0.2	06.72^{b}±0.2
L3	10	23.19^{b}±0.2	12.47^{b}± 3.9	07.52^{c}± 0.5	18.66^{b}±0.7	30.48^{a}±0.2	08.91^{a}±0.2
L4	10	23.83^{b}±0.2	13.69^{c}± 3.9	09.00^{ac}±0.5^{c}	20.08^{b}±0.7	29.28^{c}±0.2	09.59^{c}±0.2
L5	10	25.18^{c}±0.2	13.44^{bc}±3.9	09.00^{ac}±0.5	24.24^{c}±0.7	28.89^{c}±0.2	08.87^{a}±0.2

^{a,b,c} Within each column, means followed by the same superscript are not significantly different. L1= coarse wool and high bulk, L2= coarse wool and low bulk, L3= fine wool and high bulk, L4= fine wool and low bulk and L5= fleece wool line without grading. ** $P<0.01$.

Yarn Properties

After spinning (Table 4), results showed that grading lines differed significantly in yarn count (YC), yarn strength (YS) and elongation (YE) as well as yarn hairiness (YH). Yarns processed from lines of harsher wool with higher and lower BUL (L1 and L2) had significantly higher YC (2.36 metric Vs 2.10 metric), less YS (3.57 Kg Vs 4.49 Kg) and YE (15.87% Vs 18.35%) compared with those yarns made from lines of finer wool with higher and lower BUL (L3 and L4). Similarly, lines of more bulky wool (L1 and L3) tended to produce yarns with significantly higher YC (2.27 metric Vs 2.19 metric) as well as less YS (3.98 Kg Vs 4.07 Kg) and YE (16.59% Vs 17.64%) compared with lower bulky wool (L2 and L4). Wool harshness and bulkiness might have a positive impact on increasing YC. That probably explains the highest YC achieved from L1 line of more harsh and bulky wool compared with the other studied lines. This is an advantage since longer yarns can be processed from the same weight in that line.

Table 4. Least squares means± standard errors for yarn count (YC), yarn strength (YS), and elongation (YE) as well as the coefficient of variation of irregularity of yarn mass (CVm%) and yarn hairiness (YH) obtained from the studied wool lines after spinning stage

Traits Factor	No.	YC (metric)	No.	YS (Kg)	YE (%)	No.	CVm (%)	YH (mm/cm)
Overall mean	225	2.23±0.02	125	4.05±0.06	17.13±0.16	25	16.59±0.41	28.96±0.32
Grading lines		**		**	**		NS	*
L1	45	2.43^{a}±0.04	25	3.49^{a}±0.1	15.50^{a}±0.4	5	17.10 ± 1.0	29.61^{ab}±0.8
L2	45	2.28^{b}±0.04	25	3.64^{a}±0.1	16.24^{ab}±0.4	5	18.28 ± 0.9	29.07^{ab}±0.7
L3	45	2.11^{c}±0.04	25	4.47^{b}±0.1	17.67^{c}±0.4	5	15.10 ± 0.9	30.66^{a}±0.7
L4	45	2.09^{c}±0.04	25	4.50^{b}±0.1	19.03^{d}±0.4	5	16.90 ± 0.9	28.01^{b}±0.7
L5	45	2.24^{b}±0.04	25	4.14^{b}±0.1	17.20^{bc}±0.4	5	15.59 ± 0.9	27.44 ^{b}±0.7
R^2		0.17		0.31	0.32		0.29	0.50
CV%		12.81		15.86	10.39		12.33	5.47

[a,b,c,d] Within each column, means followed by the same superscript are not significantly different. L1= coarse wool and high bulk, L2= coarse wool and low bulk, L3= fine wool and high bulk, L4= fine wool and low bulk and L5= fleece wool line without grading. R^2 = coefficient of determination, CV% = coefficient of variation. ** P<0.01, * P<0.05, NS = not significant.

The same trend was observed for SS and EL in the raw wool state (Table 2) probably still existed after spinning (Table 4) since yarns processed from lines of finer wool (L3 and L4) tend to have higher YS (4.49 Kg Vs 3.57 Kg) and more YE (18.35% Vs 15.87%), as overall averages compared with those yarns processed from lines of harsher wool (L1 and L2). Yarns processed from lines of harsher wool had higher content of medullated fibres in the raw state (Table 1) and after carding (Table 3). These fibres are known to be more susceptible to break with less extensibility and hence, resulted in low YS compared with those yarns made from lines of finer wool. Thus, the higher the SS the higher the YS would be and similarly, the higher the EL the higher the YE would be (Tables 2 and 4). This might indicate that SS and EL as characters of the raw wool are vital parameters affecting the subsequent use of the spun yarns.

Table (4) showed that the interaction between bulkiness and harshness probably magnified the difference in YH, being significantly higher for those yarns originated from higher bulky wool (L1 and L3) than those yarns processed from lines of low BUL wool (30.14 mm/cm Vs 28.54 mm/cm), as overall averages. On the other hand, the irregularity of yarn mass (CVm%) tended to be higher in yarns processed from lines originated from harsher wool (17.69% Vs 16.00%) compared with those yarns processed from lines of finer wool (L3 and L4), although these differences were not significant.

Properties of the processed blanket

Table (5) showed that the weight of the square meter was significantly lighter for blankets processed from lines distinguished for more harshness (570.61 gm/m^{2}Vs 708.48 gm/m^2) and more bulkiness (622.85 gm/m^{2}Vs 656.24 gm/m^2), as overall averages compared to those processed from lines of finer wool (L3 and L4) and less bulkiness (L2 and L4). Blanket processed from that line of harsher and more bulky wool (L1) tended to have significantly the least blanket weight per square meter decreasing by 19.31% compared with the average of the other three processed lines. This is of economically beneficial since the manufacturer could save about 20% of the woolen materials to produce such high quality blanket. The Egyptian standards for blankets (ES: 682/ 2001) states that the lighter the weight of the blanket/m^2 the better the quality. As expected, blankets processed from harsher wool lines (L1 and L2) tended to be of lighter weight as a result of their higher content of hollow medullated fibres compared with those of finer wool lines (L3 and L4). Moreover, the main feature of bulky wool is to have higher volume with relatively less weight. Therefore, the implemented grading system appeared to be more effective to combine the advantages of harshness and bulkiness in the same grading line (L1) to attain an economically good quality blanket.

Table 5. Least squares means± standard errors for blanket weight/ m^2, heat loss, air permeability, weft strength and elongation obtained from blankets processed from the studied wool lines

Traits / Factor	No.	Blanket weight (gm/m^2)	No.	Heat loss (cal/cm^2/hr)	No.	Air permeability (ft^3/ft^2/min)	Weft strength (Kg)	Weft Elongation (%)	No.	Blanket weft count (metric)
Overall mean	20	655.98±6.1	25	27.64±0.2	50	143.70±1.5	60.78±1.3	22.55±0.3	125	1.98±0.03
Grading lines		**		NS		NS	**	NS		**
L1	4	542.22^a±15.0	5	27.48 ± 1.3	10	139.30± 3.5	46.00^{ab}±8.4	20.31±1.8	25	2.09^a±0.06
L2	4	598.99^b±14.6	5	28.72 ± 0.7	10	151.63± 4.0	45.02^a ±5.4	20.81±1.2	25	2.25^b±0.05
L3	4	703.48^c±16.5	5	26.55 ± 0.7	10	143.33± 4.4	65.54^b ±5.3	24.27±1.1	25	1.69^c±0.05
L4	4	713.48^c±16.4	5	27.38 ± 0.8	10	145.75± 3.6	77.53^c ±5.6	23.04±1.2	25	1.83^c±0.05
L5	4	721.71^c±18.4	5	28.05 ± 0.8	10	138.50± 3.6	69.85^{bc}±5.1	24.32±1.1	25	2.04^a±0.05
R^2		0.92		0.51		0.30	0.75	0.56		0.35
CV%		4.14		3.42		7.35	15.53	8.86		13.9

a,b,c Within a column in each classification, means followed by the same superscript are not significantly different. L1= coarse wool and high bulk line, L2= coarse wool and low bulk line, L3= fine wool and high bulk line, L4= fine wool and low bulk line and L5= without grading wool line. R^2 = coefficient of determination, CV% = coefficient of variation. ** P<0.01, NS: not significant.

Table (5) showed that blankets made from higher BUL wool lines (L1 and L3) tend to maintain more heat (27.02 cal/cm^2/hr Vs 28.05 cal/cm^2/hr), as overall averages compared with those blankets made from lower BUL wool (L2 and L4), the difference was not significant. This result gives more advantages to those blankets made from L1 and L3 lines. Using bulky wool in blanket processing might increase the volume occupied with a space full of air inside to provide isolated layer acting to decrease heat loss. In the same context, it is obvious that L1 has the least permeability among other studied lines (Table 5). Moreover, blankets made from higher BUL wool lines (L1 and L3) tended to be less permeable compared with those blankets made from lower BUL wool lines (141.32 $ft^3/ft^2/min$ Vs 148.69 $ft^3/ft^2/min$), as overall averages although differences were not significant. As expected, less permeability is associated with less heat loss which probably being a beneficial character for those higher bulky wool lines.

In the factory, the normal procedure is to make the warp from cotton to provide more strength to the processed blanket. However, the weft is often made from the all or mixed wool to meet the customer preference. Thus, the present study gives more emphasis and deals with the wool weft since the objective is to evaluate the properties of such wool from which the blanket was made. Therefore, blanket strength and elongation in the present material, might be regarded as a function of the weft strength and elongation rather than those of the warp. Table (5) indicated that blankets made from finer wool lines (L3 and L4) had significantly stronger weft than those blankets made from lines of coarser wool (71.54 Kg Vs 45.51 Kg), as overall averages. Similar trend existed for weft elongation as L3 and L4 lines tended to be more extensible than those in L1 and L2 lines (23.66% Vs 20.56%), as overall averages, the differences were not significant. These results agreed with the above mentioned findings for SS and elongation in the raw wool state (Table 2) as well as yarn strength and elongation (Table 4) which means that the impact of wool soundness is obvious from the raw wool throughout all processing stages and consequently affecting the quality of the end product, the blanket. It should be mentioned that, while blankets made from L1 and L2 lines appeared to be of less strength and elongation compared with those made from L3 and L4 lines, results of blanket strength and elongation indicated that blankets made from all studied lines met quality standards accepted in the Egyptian market (ES: 682/ 2001) which states that a good quality blanket should have 40.0 kg weft strength.

Sheep breeders are advised to give more emphases to improve the soundness of their wool which ensures higher processing performance, the quality of the end product and hence attain higher return. Improving wool soundness could be done by feeding animals on an adequate and stable level of feeding to avoid the thinning occurred along the fibre (Al-Betar, 2000).

Tables (4 and 5) indicated that blankets processed from lines of harsher wool (L1 and L2) had significantly higher blanket weft count (2.17 metric Vs 1.76 metric), as overall averages compared with those blankets made from lines of finer wool (L3 and L4). On the other hand, the Egyptian standards for blankets (ES: 682/ 2001) states that a good quality blanket should have 43/1 for the average number of yarns along 5cm of the weft and 50/2 for the average number of yarns along 5cm of the warp to be acceptable in the Egyptian market. For the four studied lines (L1 to L4), the average number of yarns along 5cm of the warp (59.8/2) and the weft (56.56/1) were found to be higher than that level stated to be accepted in the Egyptian market, although the differences among these studied lines were not significant (Table 6). Moreover, blankets made from higher bulky wool lines (L1 and L3) tended to have significantly better covering for the weft (28.80% Vs 26.9%), warp (9.30% Vs 8.63%) and the processed blankets (38.09% Vs 35.52%), as overall averages compared with those blankets made from lower bulky lines, L2 and L4. These results clearly demonstrate that better covering capacity in blankets is probably associated more with bulkiness in wool. Similar findings were reported by Carnaby *et al.* (1984) in carpets.

Table 6. Least squares means ± standard errors for number of weft and warp threads/ 5cm and covering factors (CF) in weft and warp threads as well as blankets processed from the studied wool grading lines after finishing stage

Traits Factor	No.	Number of blanket weft/5cm	Number of blanket warp/5cm	No.	Weft CF (%)	Warp CF (%)	Blanket CF (%)
Overall mean	25	56.56±0.1	59.80±0.02	50	27.35±0.3	8.86±0.1	36.21±0.4
Grading lines		NS	NS		**	**	*
L1	5	57.60±0.2	59.60 ± 0.1	10	27.32^{a}±0.6	8.67^{ac}±0.2	35.98^{ac}±0.8
L2	5	57.00±0.2	60.00 ± 0.1	10	25.39^{b}±0.6	8.18^{a}±0.2	33.56^{b}±0.8
L3	5	56.20±0.2	60.00 ± 0.1	10	30.27^{c}±0.6	9.92^{b}±0.2	40.19^{d}±0.8
L4	5	57.00±0.2	59.40 ± 0.1	10	28.41^{a}±0.6	9.07^{c}±0.2	37.48^{c}±0.8
L5	5	55.00±0.2	60.00 ± 0.1	10	25.36^{b}±0.6	8.47^{a}±0.2	33.83^{ab}±0.8

[a,b,c,d] Within each column, means followed by the same superscript are not significantly different. L1= coarse wool and high bulk, L2= coarse wool and low bulk, L3= fine wool and high bulk, L4= fine wool and low bulk and L5= fleece wool line without grading, ** P<0.01, * P<0.05.

The foregoing results indicated that blankets processed from all studied lines attained the acceptable quality level according to the Egyptian standards for blankets (ES: 682/ 2001). That provide confidence and reliability in the local Barki wool subjected to the grading system implemented in the present study to process good quality blankets meet the standards accepted in the Egyptian market. That grading system was more effective in formulating raw wool lines distinguished for harshness and bulkiness as well as having the advantages of both characters in one line (L1) from which a good quality blanket was made and proved to be beneficial from the processing and economical points of view.

The present study recommend making blankets from L1 line graded initially for harsher and more bulky wool since it provides better processing efficiency in terms of yarn count as well as producing blanket with the least blanket weight/ cm^2 and maintaining more heat. Moreover, the manufacturer could save about 20% of the woolen materials to produce such high quality blankets matching with standards requirements for the Egyptian markets. These advantages attained, could probably compensate for less blanket strength and elongation observed for that line compared with other studied lines, although the levels achieved for both traits are adequately accepted in the Egyptian market (ES: 682/ 2001).

The manufacturers could be benefited from the economic advantages verified in the present study as a result of applying such grading system to ensure higher processing performance and produce good quality products accepted in the Egyptian market. That would also help to reduce their production costs, diminishing the importation of wools from abroad and hence increasing their returns.

The most remarkable outcome obtained from the present study is the importance of harsher and more bulky wool in the processing performance of good quality blankets. Thus, sheep breeders should go for selecting their sheep for higher loose wool bulk and coarser wool in order to attain good quality wool suitable for processing wide range of good quality end products, carpets and blankets. More emphases have to be given to improve the whiteness of the wool and avoid tenderness, vegetable matter and cotting. In turn, that would help increasing the utility of the local wool to be processed, after grading, into good quality woolen products, which lead to enhance the demand for local wools and hence, increasing their prices. Such increase in wool prices would help sheep breeders to enhance the profitability for sheep farming in general and increasing their productivity not only for wool, but also for lambs, meat and milk.

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نظام لتدريج وتصنيع الصوف لتحسين إستخدامات الأصواف البرقى المصرية

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استهدفت الدراسة التعرف على صفات الصوف ذات الأهمية فى الصناعة حتى يمكن إدراجها فى برامج التحسين الوراثى للأغنام، حيث أن الأصواف هى المادة الخام الأساسية فى صناعات السجاد والبطاطين والأقمشة وغيرها. استخدمت الدراسة حوالى 1.64 طن من أصواف الأغنام البرقى الناتجة من محطة بحوث مريوط التابعة لمركز بحوث الصحراء. تم إعداد جزات الصوف وتدريجها بصورة تقديرية لصفتى الخشونة والمقاومة للضغط (البلك) ونتج عن ذلك أربعة خطوط هى:1- صوف خشن عالى البلك،2- صوف خشن منخفض البلك، 3- صوف ناعم عالى البلك ، 4- صوف ناعم منخفض البلك، بالإضافة لخط خامس وهو لصوف لم يتم تدريجه بهدف المقارنة. تم اخذ عينات صوف ممثلة لكل الخطوط السابقة لقياس قطر الليفة، التباين القياسى لقطر الليفة، نسبة الألياف الخشنه، معامل الوخز، البلك والمرونة، قوة شد الخصلة، مكان قطع الخصلة واستطالتها وذلك لتحديد خصائص الصوف الخام لكل من هذه الخطوط. تم ارسال خطوط الصوف المدروسة إلى المصنع وذلك لتصنيعها طبقا للنظام المتبع فى ذلك المصنع. تم اخذ عينات صوف ممثلة من كل الخطوط خلال عمليات التصنيع وخاصة بعد عملية التمشيط والغزل وكذلك من البطاطين المصنعة. تم اختبار هذه العينات على أساس المواصفات القياسية المصرية للبطاطين. تم قياس نفس صفات الصوف التى تم قياسها على الصوف الخام مرة أخرى فى العينات المأخوذة من كل الخطوط بعد عملية التمشيط. تم أخذ عينات صوف ممثلة لكل الخطوط بعد عملية الغزل لقياس نمرة الغزول، قوة شد الغزول واستطالتها وكذلك خشونتها ومعامل اختلاف تجانسها. كما تم تقدير بعض صفات البطاطين مثل وزن المتر المربع، الفقد الحرارى، نفاذية الهواء، قوة الشد والاستطالة ومعامل التغطية فى العينات المأخوذة من البطاطين المصنعة.

أوضحت النتائج أن خطى الصوف الخشن (1، 2) كانا أعلى معنويا فى كل من قطر الليفة، التباين القياسى لقطر الليفة، نسبة الألياف الخشنة، عامل الوخز بينما كانت أقل فى قوة شد واستطالة الخصلة مقارنة بالخطين الثالث والرابع. كما أظهرخطى الصوف العاليين فى المقاومة للضغط (1، 3) ارتفاعا معنويا لصفتى المقاومة للضغط والمرونة مقارنة بالخطين الثانى والرابع. وزن المتر المربع من البطاطين المصنعة كان اخف معنويا فى تلك البطاطين الناتجة من الخطوط الأكثر خشونة (1، 2) والأكثر مقاومة للضغط (1، 3). كما كانت البطاطين المصنعة من خطى الصوف الأكثر مقاومة للضغط (1، 3) أكثر احتفاظا بالحرارة وفى معامل التغطية بالإضافة لقلة نفاذيتها للهواء بينما كانت البطاطين المصنعة من خطى الصوف الأكثر نعومة (3،4) أفضل فى قوة الشد والاستطالة. أوصت الدراسة بأن البطاطين الناتجة من الخط الأول كانت الأفضل حيث أظهرت أعلى كفاءة تصنيعية من حيث نمرة الغزول بالإضافة إلى كونها الأخف وزنا وقدرتها على الاحتفاظ بالحرارة. علاوة على ذلك فإن الصانع قد يوفر حوالى 20% من الصوف المستخدم فى إنتاج مثل هذه البطاطين عالية الجودة والمطابقة للمواصفات القياسية للأسواق المصرية.

أوضحت الدراسة صلاحية الأصواف البرقى المحلية بعد تدريجها وتصنيعها طبقا للنظام المتبع فى هذه الدراسة فى إنتاج بطاطين عالية الجودة وتحقيق مزايا عديدة من الناحية التصنيعية والاقتصادية. وتنصح الدراسة مربى الأغنام بالعمل على الإنتخاب لزيادة خشونة الصوف وكذلك مقاومة الصوف للضغط للحصول على صوف عالى الجودة يمكن استخدامة بكفاءة فى تصنيع منتجات صوفية متعددة عالية الجودة، مما ينعكس على زيادة استخدام الأصوف المحلية فى الصناعة ومن ثم زيادة أسعار الصوف مما يؤدى إلى زيادة ربحية مزارع الأغنام بصفة عامة.