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Effect of adding *Moringa oleifera* residues to rations on some wool, skin and leather properties of growing Barki sheep

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ABSTRACT

The aim of this work was to study the effect of using biological treated Moringa stalks in feeding sheep on wool, skin and leather properties. Twenty-four male Barki lambs divided into three groups were used. All animals fed 2% of animal body weight on concentrate feed mixture, while the roughages fed *ad libitum*, thus the difference among groups was in roughage material. The control group fed Berssem hay, second group fed Moringa stalks treated with fungus (*Trichoderma reesei*) and third group fed Moringa stalks treated with yeast (*Saccharomyces cervisiae*). All skins and leathers were evaluated chemically and physically, in addition wool characteristics were determined for wool samples. The results indicated that majority of physical and chemical properties of skins, leathers and wool were not significantly differed among groups. Therefore, using Moringa stalks as roughage in rations not affected the quality of wool, skins or leathers, which are considered acceptable in different industrial purposes such as carpets, upper shoe, garment and lining.

***Keywords*:** chemical, physical, leather quality, organoleptic, wool characteristics.

INTRODUCTION

Animal production in Egypt is an important component of the agricultural sector, accounting 24.5% of the agricultural gross domestic product **(El-Nahrawy, 2011)**. Animals produce meat and milk as main products while wool, skins and hides are considered as by-product of animal **(Alao *et al.*, 2017)**. On the other hand, the agriculture policy in Egypt recently directed to increase the cultivated area with *Moringa oleifera* due to its economic importance and use for industrial and medicinal applications **(Mahmood *et al.*, 2010; Razis *et al.*, 2014)**. Therefore, cultivated area with *M. oleifera* in Egypt, especially in arid region, produce great amounts of Moringa stalks. It is estimated by about 17 tons/Feddan/year without beneficial usage as almost consider as wastes **(Zaki, 2016)**.

Lately, the nutritionists are interesting to improve the nutritive value of lignocelluloses fibrous using biological treatments **(Mahesh and Mohini, 2013)**. Using biological treated Moringa stalks in feeding sheep was evaluated in a previous work by **Zaki (2016)**. The nutritional impact was determined through meat production, while the effects on wool, skin and leathers were not included in that study. Other past researches revealed that skin structure, wool and leather properties were affected by different environmental factors, such as feeding, which is considered the most important factor **(Azzam and Abdelsalam, 2004; Younis *et al.*, 2012; Tadesse *et al.*, 2016)**.

Consequently, this work is a complementary study to evaluate the effect of using biological treated Moringa stalks on wool, skin and leather characteristics when fed to sheep. Also, it aimed to evaluate the quality of wool and finished leather and the acceptability of using it in different industrial purposes.

MATERIALS AND METHODS

The experiment was conducted at the farm of Maryout Research Station, Alexandria, Desert Research Center, Egypt, which located at 35km South West of Alexandria (Latitude 31.02°N, Longitude 29.80°C).

A total of 24 male Barki lambs with average body weight 20.7±0.17 kg and about 3 months old were used. The experiment was performed during summer (from May until

August) and extended for 140 days. The low temperatures were 20-23°C and the high temperatures were 28-32°C. Lambs were divided randomly into three experimental groups, 8 lambs each. The groups housed separately in shaded pens with concrete floor and fed by separate feed troughs for concentrates and roughages. All animals fed concentrate feed mixture at rate 2% of body weight, while roughages were fed *ad libitum*. The same concentrate feed mixture was fed to the three groups, which consisted of 47% wheat bran, 29 % cottonseed meal, 15% yellow corn, 3% rice bran, 3% limestone, 2% molasses, 1% salt. With respect to the roughages portion, Berseem hay was fed to control group (C), Moringa stalks treated with fungus (*Trichoderma reesei*) was fed to second group (T_1) and Moringa stalks treated with yeast (*Saccharomyces cervisiae*) was fed to third group (T_2). Furthermore, fresh water was available to animals all the day.

Before slaughtering, wool samples were taken from each animal as close as possible to the skin surface, using fine scissor. Each sample was taken from area about 10 cm^2 at left mid-side of animals.

After slaughtering and skinning, skins were directly weighed and salt preserved to avoid any bacterial damage or deterioration till transported into tannery. All skins were chrome tanned at El-Shafei' Sons Tannery, Alexandria, Egypt. Skins from the three groups were marked and tanned with the same recipe, which explained in Table (1).

Table (1): Tanning steps recipe for studied leathers.

Step	Description		Time (min)	Notes
	%*	Added		
Soaking	300	Water		Overnight
Liming and Unhairing	X	Water	180	Paste was applied on the flesh side and skins were piled in pairs flesh to flesh.
	5	Lime		
	3	Sodium sulphide		
Reliming	400	Water	120	Low drum speed
	10	Lime		
	4	Sodium sulphide		
Washing	300	Water	30	Drain float
Deliming and Bating	150	Water	60	pH= 8
	1.5	$(NH_4)_2SO_4$		
	0.25	pancreatic enzyme		
Washing	200	Water	30	Drain float
Pickling	150	Water	90	pH = 3.5 – 4
	10	Salt		Bé = 7 – 8
	0.5	H_2SO_4		
	0.5	HCOOH		
Tanning	8	Chrome sulphate	90	Chrome 33% basicity
Fixation	1	$NaHCO_3$	60	Overnight
Washing	100	Water	60	Drain float
	2	Soap		
Naturilzation	100	Water	60	pH= 5.5
	2	$NaHCO_3$		Drain float
Dyeing and Fatliquoring	150	Water	90	Water temperature 40 ºC
	3	Black dye		
	6	Fishoil		
Fixation	0.5	HCOOH	30	Overnight
	0.5	HCOOH	30	
Washing	100	Water	10	Horse up, samming and then dry hanging

** Percentages were calculated based on the skin weight of the previous step.*

Leather properties

All leathers were assessed for qualitative and operational properties according to indices of physical investigation **(ASTM, 2014)**. A testing machine (Benchtop Tinius Olsen 5KN Tester) was used to determine tensile strength, elongation and split tear strength. Flex resistance test was done by flex tester machine with rotate speed 100 cycles/min. The specimen size is 45 x 90 mm and the test was done up to 20000 cycles. Water absorption (WAb) was done using Kubelka apparatus, while water vapor permeability to (WVP) was done using Herfeld apparatus. Chemical properties such as % moisture, % Ash, % chromic oxide, % oils, % Fats and pH were carried out for all leathers according to standard procedures **(ASTM, 2014)**.

Organoleptic properties were assessed for softness, grain smoothness, grain tightness, fullness, and general appearance by standard tangible evaluation technique **(Kasmudjiastuti and Murti, 2017)**. Five experienced tanners rated the leathers in a scale of 1-10 points for each functional property (higher points indicate a superior property). The average judge of the five tanners was recorded for each sample. In addition, the morphological characteristics of leathers were analyzed using JEOL JSM-5300LV Scanning Electron Microscopy (SEM). Samples were cuted from official sampling position according to ASTM- D2813 **(ASTM, 2014)**. The specimens were cuted with uniform thickness without any pre-treatment. The micrograph for the cross section and surface was obtained by operating the SEM.

Wool characteristics

Wool qualitative parameters were determined for wool samples. Ten staples were taken randomly from each wool sample to measure staple length, to the nearest 0.5 cm, using a ruler. Length measured from the bottom until the dense part of the staple end according to **Chapman (1960)**. Five hundred fibers, from each sample, were used to estimate the average fiber diameter and medullated fiber percentage using Carl-Zeiss Micro Imaging device with optical fiber diameter image analyzer software, Zen (Blue edition), with lens 10/0.847 according to ASTM-D2130 **(ASTM, 2014)**. 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, representing the increase in staple length as proportion of 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. Wool fibers contained very coarse fibers with medulla occupying more than 70% of the medullated fiber are classified as kemp and fibers contained medulla classified as coarse fiber, whereas other non-medullated fibers classified as fine or non-medullated fibers. Fiber type ratios were also calculated according to **Guirgis (1973)**. Crimp frequency (CF) is calculated as the average number of crimps per one centimeter of un-stretched fibers.

On the other hand, wool quantitative traits were determined in this study. Wool production was measured by greasy wool weight in $10cm^2$ area. Clean scoured yield was calculated using the method suggested by **Chapman (1960)**. In addition, cotting score was determined as subjective estimates. According to **El-Gabbas (1993)**, subjective graduation measurement was used to record a cotting trait of wool, which means the matting of different fibers in the fleece together. Cotting score was determined in a scale of 1-4 points for each sample (higher points indicate a superior cotting). The average cotting scores were recorded for each sample.

Statistical analysis

Data were analyzed using GLM procedure of **SAS (2008)** to study the effect of feeding on wool, skin and leather properties. The fixed effect model was $Y_{ij} = \mu + T_i + e_{ij}$, where Y_{ij} is the observation taken on wool, skin or leather (j), μ is an overall mean, T_i is a fixed effect of adding Moringa stalks (1= control, 2= Moringa stalks treated with fungus and 3= Moringa stalks treated with yeast) and e_{ij} is a random error assumed to be normally distributed with mean=0 and variance=$\sigma^2 e$.

RESULTS AND DISCUSSION

Chemical composition of the three experimental rations is shown in Table (2). Berseem hay, traditionally used in Egypt as roughage feeding material, has some simple differences in chemical composition compared to treated Moringa stalks. Furthermore, the values of chemical composition of the three experimental rations, which calculated based on amounts fed to each group, also tended to be similar.

Table (2): Chemical composition (%) of the experimental rations.

Parameters	Berseem Hay	MSF[1]	MSY[2]	Concentrate Feed Mixture	Experimental rations		
					C	T_1	T_2
Dry Matter	87.19	88.47	89.38	90.95	87.06	90.23	90.58
Crud Protein	11.84	10.95	14.34	13.8	12.36	13.03	14.19
Crude Fiber	26.44	34.45	35.57	20.63	25.75	23.89	23.47
Ether Extract	1.94	2.96	2.39	2.13	1.71	2.38	2.21
Nitrogen-free extract	45.52	41.78	39.47	50.03	47.05	48.11	48.07
Ash	14.26	9.86	8.23	13.41	13.13	12.60	12.07

[1]MSF: Moringa stalks treated with fungus,
[2]MSY: Moringa stalks treated with yeast,
C:ration for control group, T_1: ration for group fed on Moringa stalks treated with fungus, T_2: ration for group fed on Moringa stalks treated with yeast.

Table (3): Effect of experimental diets on skin properties.

Parameters	ASTM	Experimental groups			Mean	±*SEM*	*P*
		C	T_1	T_2			
Skin (%)*	--	7.57	7.03	7.42	7.34	*0.27*	*0.721*
Physical properties							
Thickness (mm)	D1813	1.13	1.14	1.19	1.15	*0.02*	0.245
Elongation (%)	D2211	57.63^{ab}	64.42^{a}	53.99^{b}	58.68	*1.71*	0.041
Tensile strength (kg/cm^2)	D2209	106.84^{a}	91.77^{ab}	74.30^{b}	91.97	*5.03*	0.032
Tear strength (kg/cm)	D4704	14.41	15.04	12.45	13.97	*0.94*	0.115
Chemical Properties							
Moisture (%)	D6403	62.80	62.83	62.82	62.82	*0.22*	0.999
Fat (%)	D3495	24.43	24.45	24.52	24.47	*0.08*	0.917
Ash (%)	D2617	4.97	5.07	5.08	5.04	*0.05*	0.611
pH	D2810	5.57	5.58	5.54	5.56	*0.04*	0.920

[a,b] Means in the same row having different superscripts are significantly different ($P<0.05$),
** Percentage calculated based on body weight.*
C: control group, T_1: group fed on Moringa stalks treated with fungus, T_2: group fed on Moringa stalks treated with yeast.

Skin properties

The effect of experimental diets on skin properties presented in Table (3). Elongation and tensile strength were differed significantly ($P<0.05$). Skins of T_2 group had the highest elongation percentage (64.42%), while skins of T_1 group had the highest tensile strength value (106.84 kg/cm^2). The reason of these differences is unknown but the values of all physical properties were in accordance with pervious obtained ranges for properties of Barki sheep skins **(Kotb, 1987; Abdelsalam and Haider, 1993)**. On the other hand, other results of skin properties indicate that using Moringa stalks in feeding did not affect the majority of skin properties. **Zaki (2016)** found the same effect of Moringa stalks on chemical compositions of longissimus muscle, which were not differed significantly. Perhaps the similarity in chemical composition of

Table (4): Organoleptic properties values of different leather types.

Parameters	**Experimental groups**		
	C	**T_1**	**T_2**
Fullness	8	8	7
Grain tightness	1	2	1
Grain smoothness	8	7	7
Softness	9	9	9
General appearance	8	8	8

C: control group, T_1: group fed on Moringa stalks treated with fungus, T_2: group fed on Moringa stalks treated with yeast.

Table (5): Effect of experimental diets on leather properties.

Parameters	**ASTM**	**Experimental groups**			**Mean**	**±*SEM***	***P***
		C	**T_1**	**T_2**			
Physical Properties							
Thickness (mm)	D1813	1.33	1.34	1.39	1.35	*0.02*	*0.245*
Elongation (%)	D2211	64.03^{ab}	71.58^{a}	59.99^{b}	65.20	*1.90*	*0.041*
Tensile strength (kg/cm^2)	D2209	181.33^{a}	156.14^{ab}	126.32^{b}	156.60	*8.54*	*0.033*
Tear strength (kg/cm)	D4704	22.62	23.78	19.72	22.04	*0.80*	*0.177*
W Abs (%)	D6015	173.02	186.51	164.99	174.84	*5.01*	*0.221*
WVP (mg/cm^2/h)	D5052	5.48	5.80	5.41	5.56	*0.12*	*0.408*
Colorfastness	D5053	Good	Good	Good	--	--	--
Flex resistance	D6182	No damage	No damage	No damage	--	--	--
Chemical Properties							
Moisture (%)	D6403	13.58	13.63	13.61	13.60	*0.05*	*0.936*
Fat (%)	D3495	8.37	8.32	8.25	8.31	*0.06*	*0.783*
Ash (%)	D2617	8.55	8.58	8.62	8.58	*0.03*	*0.787*
pH	D2810	4.82	4.87	4.88	4.86	*0.04*	*0.833*

^{a,b} Means in the same row having different superscripts are significantly different ($P<0.05$),
C: control group, T_1: group fed on Moringa stalks treated with fungus, T_2: group fed on Moringa stalks treated with yeast.

experimental rations led to insignificant differences among chemical composition of animal skins and skin percentage of animal weight.

Leather properties

Table (4) shows the organoleptic properties of all leathers, which tended to be nearly similar for all organoleptic properties and thus the general appearance property of the three experimental groups were similar. Moreover, Table (5) shows the effect of experimental diets on different physical and chemical properties of tanned leathers. Although results of both colorfastness and flex resistance properties were not determined as values, they were similar. Also, other obtained results indicated that the same trends of skins properties were found with finished leathers. The majority of leather properties not affected by feeding animals Moringa stalks.

All values of chemical properties were not differed due to participation of all experimental leathers the same tanning steps. Otherwise, all physical properties of finished leathers, except elongation and tensile strength, not affected by experimental diets. This trend was similar to that previously obtained with sheep skins before tanning. Leathers of group T_1 had the highest elongation percentage (71.58%) followed by leathers of group C (64.03%) then group T_2 (59.99%), respectively. Although the results concerning elongation percentages were different ($P<0.05$), their values showed a narrow range and were in accordance with previous records for Barki sheep which ranged from 57% to 74% **(Kotb, 1987; Abdelsalam**

and Haider, 1993; Nasr *et al*., 2013). Regarding tensile strength values, the difference was significant ($P < 0.05$) only between leathers of groups C and T_2. Tensile strength of groups C (181.33 kg/cm^2) and T_1 (156.14 kg/cm^2) tended to be within average tensile strength of chrome tanned leather of Barki sheep **(Kotb,1987 ; Nasr *et al*., 2013)**, while tensile strength of group T_2 (126.32 kg/cm^2) was lower than these averages. The reason for this difference was unknown but the elucidation might found in micrographs (Fig. 1, 2 and 3) scanned by electron microscope. The micrographs of outer surfaces of dermis were nearly similar in surface shape, holes' numbers of wool fiber and their diameters among the three leathers groups, which led to the similarity of water vapor permeability values **(Kanagy and Vickers, 1950)**.

Although the cross section micrographs tended to be similar in total thickness, the shape of leather layers and fiber bundles were differed in their thickness, separation, diameters and alignment. Leathers of group C had the highest compactness, lowest distances among fiber bundles, and highest fibril alignment, while leathers of group T_1 had the finest fiber bundles diameters, highest separation and medium fibril alignment. Otherwise, leather of group T_2 had the longest distances among fiber bundles and lowest fibril alignment. Therefore, the shape of layers and collagen fiber bundles in groups C and T_1 is nearly identical, while group T_2 tended to be the weakest. These changes enhance the significant differences in elongation and tensile strength values. **Wells *et al*. (2017)** illustrated that fibril orientation significantly affected tensile strength of leather. The leathers with highest fibril alignment were the highest in strength for that direction.

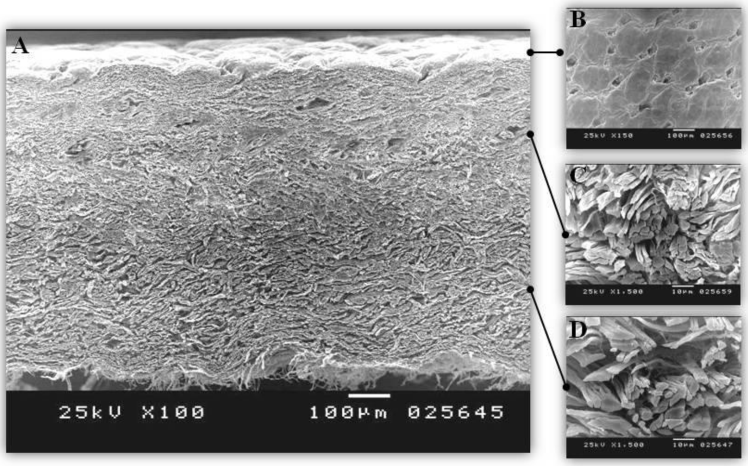

Fig. (1): Scanning electron micrographs of leather of control group.
A=cross section (100X), B=outer dermis surface (150X), C=papillary layer (1500X), D=reticular layer (1500X)

Therefore, the results of leather properties indicated that feeding animals on Moringa stalks as a roughage material did not affect manufacturing properties of leathers due to the similarity among studied leather groups in organoleptic, physical and chemical properties. By comparing physical and chemical properties with introduced limitation ranges by **UNIDO (1994) and BASF (2007)**, it can be concluded that all studied leather were acceptable to use for different manufacturing uses such as shoe upper, garment and lining.

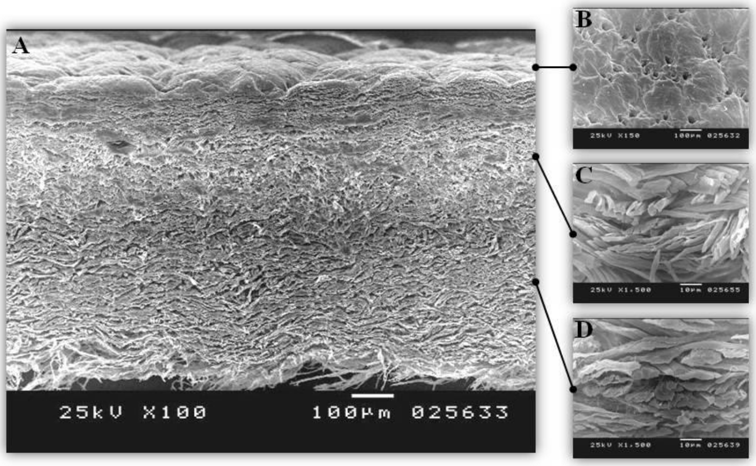

Fig (2): Scanning electron micrographs of leather for Moringa stalks group treated with fungus.

A=cross section (100X), B=outer dermis surface (150X), C=papillary layer (1500X), D=reticular layer (1500X)

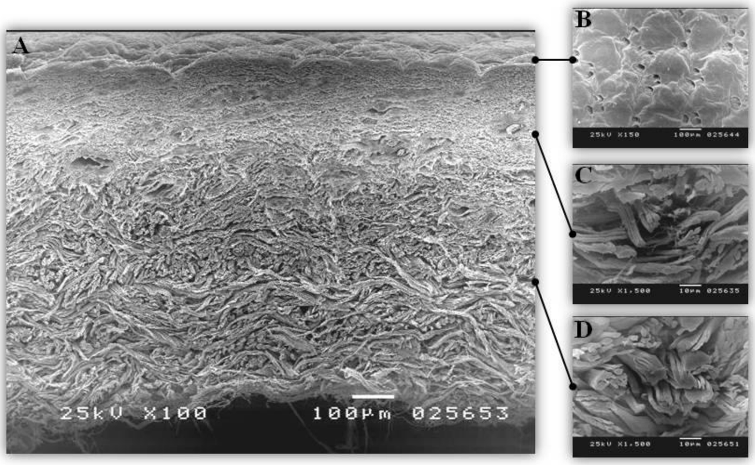

Fig. (3): Scanning electron micrographs of leather for Moringa stalks group treated with yeast.

A=cross section (100X), B=outer dermis surface (150X), C=papillary layer (1500X), D=reticular layer (1500X)

Effect of tanning process on leather quality

Figure (4) shows mean values of physical and chemical properties of skins and finished leathers. Corresponding values of chemical properties explained that the values of moisture, fats and pH tended to be lower in leathers than sheep skins (P<0.01), while the opposite relation was found with ash percentage (P<0.01). These trends were expected due to the exposure of skins to different mechanical and chemical treatments during tanning steps. In beamhouse, skin treated with strong alkalis, which increase pH to 13 and caused saponification of skins' fats and thus facilitates removing fats when washing skins in other steps **(Covington, 2009)**. On the other side, mechanical effect in fleshing step removes high amount of fleshes and fats, which found with residual meats in flesh sides after skinning **(BASF, 2007)**.

With respect to decreasing moisture and increasing ash values in finished leathers, they were a result of reacting chromium sulphate with collagen fiber in tanning step. This interaction prevents the cross-links among water and collagen fibers, which preserve leathers from microbial deterioration **(Dutta, 2008; Covington, 2009)**. Because of chrome tanning, chromium slats remain in finished leather and thus increases ash percentage **(Nasr *et al.*, 2013)**. The other trend was decrease pH in leathers than skins. The reason might due to adding formic acid in last fixation step (Table 1), as well as the effect of chrome tanning on changing the isoelectric point of collagen fiber **(BASF, 2007)**.

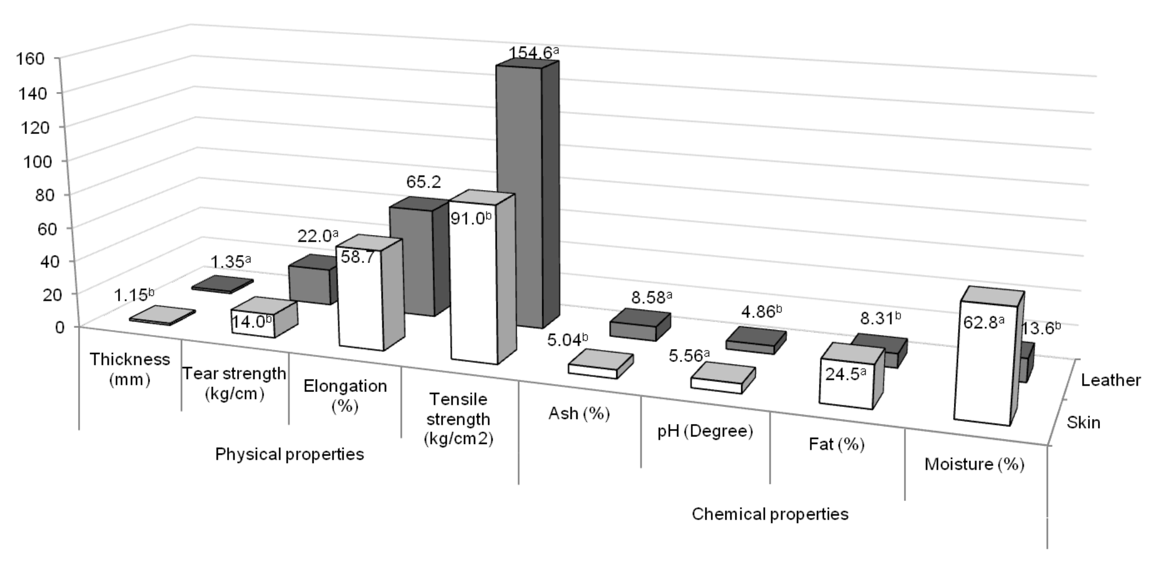

Fig. (4): Effect of tanning process on leather quality.

Concerning physical properties, the finished leathers had higher values for thickness ($P<0.01$), elongation ($P<0.05$), tensile ($P<0.01$) and tear ($P<0.01$) strengths than corresponding values of sheep skins. The previous investigations on this trend were inconsistent. **Abdelsalam and Haider (1993)** found a decrease in physical properties values after tanning camel hides, while **Kotb (1987)** found the opposite after tanning cow, buffalo, goat and sheep leathers which in accordance with the obtained results of this study. The illustration of this trend is due to the effect of tanning interaction, which increase the cross-links among collagenous fibers and thus increase their durability **(BASF, 2007; Covington, 2009)**. Although leather thickness decreases mechanically during fleshing and shaving steps, the finished leathers had higher thickness than skins thickness. **Kotb (1987)** explained that by increasing skin thickness in some tanning steps such as unhairing and tanning.

Wool characteristics

Table (6) shows the effect of experimental diets on different qualitative and quantitative traits and subjective estimates of wool. Although feeding of treated Moringa stalks had no significant effect on all qualitative and quantitative traits of experimental groups, however, most traits of control group showed the higher estimates followed by T_1 group then T_2 group. The explanation of these similarities among studied groups might due to similarity of chemical composition of Moringa stalks treated with fungi or yeast and Berseem hay.

On the other hand, feeding animals on Moringa stalks led to a significant increase in cotting score ($P<0.05$). This result can explained due to the negative relation between cotting score and both of fiber diameter and the ratio between fine and coarse fibers **(Guirgis *et al.*, 2001)**.

Table (6): Effect of experimental diets on wool characteristics.

Parameters	Experimental groups			Mean	±*SEM*	*P*
	Control	T1	T2			
Qualitative traits						
Fiber diameter, µm	32.84	31.68	31.72	32.08	*0.75*	*0.790*
Staple length, cm	7.51	7.39	7.02	7.31	*0.49*	*0.921*
Staple strength, N/Ktex	28.80	27.20	24.78	26.93	*1.18*	*0.389*
Staple elongation%	51.43	48.95	48.33	49.57	*1.52*	*0.697*
Point of break%	48.29	47.63	46.86	47.59	*0.80*	*0.783*
Crimp frequency/cm	2.56	2.06	2.15	2.26	*0.12*	*0.234*
Coarse fibers %	18.98	22.34	24.33	21.88	*1.32*	*0.254*
Kemp fibers %	6.49	6.04	4.90	5.81	*0.48*	*0.397*
Fine fibers %	74.53	71.62	70.77	72.30	*1.09*	*0.350*
Quantitative traits						
Wool production, g	8.00	7.71	6.96	7.56	*0.27*	*0.267*
Clean scoured yield %	59.33	58.31	55.95	57.86	*2.64*	*0.876*
Subjective estimates						
Cotting score	1.88^b	2.38^a	2.63^a	2.29	*0.11*	*0.013*

^{a,b} *Means in the same row having different superscripts are significantly different (P<0.05)*

CONCLUSION

It concluded that use of treated Moringa stalks with fungus or yeast as cheaper feed sources than Berseem hay is encouraging and not causing negative impacts on wool characteristics and skins quality and thus the final properties of finished leathers Therefore, all obtained leathers were acceptable in industrial uses such as footwear and garments. Also, wool can be used in carpets manufacturing.

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تأثير إضافة مخلفات المورينجا اوليفيرا للعلائق علي بعض خصائص الصوف والجلد للاغنام البرقي النامية

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يهدف هذا العمل الي دراسة تأثير إستخدام حطب المورينجا المعامل بيولوجيا في تغذية الاغنام علي خصائص الجلد والصوف. أربعة وعشرون من ذكور حملان البرقي تم استخدامها حيث قسمت إلي ثلاثة مجاميع. تم تغذية جميع الحيوانات علي مواد مركزة بنسبة 2% من وزن الجسم بينما قدمت المادة المالئة حتي الشبع. الاختلاف بين المجاميع كان في المادة المالئة المقدمة. المجموعة الاولي المقارنة تم تغذيتها علي دريس البرسيم والمجموعة الثانية تم تغذيتها علي حطب المورينجا المعامل بالفطر (*Trichoderma reesei*) والمجموعة الثالثة تم تغذيتها علي حطب المورينجا المعامل بالخميرة (*Saccharomyces cervisiae*). جميع الجلود الخام والمشطبة تم تقييم خواصها الطبيعية والكيميائية بالإضافة الي تقييم صفات الصوف في عينات الصوف. أظهرت النتائج أن معظم خواص الجلود والصوف لم تتأثر معنويا بإختلاف نوع الغذاء. وهكذا فإن إستخدام حطب المورينجا كمادة مالئة لم تؤثر علي جودة الصوف والجلود الخام وكذا الجلود المشطبة والتي كانت خواصها مناسبة للاغراض الصناعية المختلفة كالسجاد والاحذية والملابس وجلود البطانة.