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EVALUATING SKIN QUALITY OF SOME RABBIT BREEDS UNDER EGYPTIAN CONDITIONS

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Abstract: Histological skin parameters in addition to mechanical and chemical properties of chrome tanned rabbits' furs were determined in this study to evaluate and compare the quality of some rabbit breeds. Seventy-nine male rabbits aged 3 mo of New Zealand White (NZW, n=27), Rex (RX, n=24) and Gabaly (GB, n=28) were used. Results showed that GB skins had the highest values in skin weight ($P<0.01$) and area ($P<0.05$) followed by NZW and RX skins, respectively. Moreover, NZW skins differed in histological structure from the other 2 breeds, as total thickness and thickness of papillary and hypodermis layers in NZW were more than twice those of RX and GB ($P<0.05$). This structure is caused by an increase in fine collagen fibre bundles in papillary layer and a limited increase in larger collagen fibre bundles in the reticular layer. Furthermore, finished tanned furs properties clarify the superiority of GB furs in values of tensile and tearing strengths followed by NZW and RX, respectively. These results point to the possibility of using the chrome tanned furs of the 3 breeds in leather garment manufacturing.

Key Words: rabbit, breed, hair, fur, tanning.

INTRODUCTION

Rabbits are considered one of the most important livestock animals in the world. The domestic rabbit is characterised by early sexual maturity, high prolificacy, relatively short gestation length, short generation interval, high productive potential, rapid growth, more efficient feed conversion, and its profitability for small-scale production systems compared with other livestock animals (Lebas *et al.,* 1997), particularly in arid and tropical regions of the developing world (Rogers *et al.,* 2006).

Egypt is predominantly desert, containing arid and semi-arid rangelands. Due to the geographical position, it is one of the hottest and sunniest countries in the world, with very low humidity. Temperatures in Egypt range from 9 to 17°C in winter and from 23 to 32°C in summer (El-Nahrawy, 2011).

There are about 7.6 million head of rabbits in Egypt (FAO, 2013). New Zealand White (NZW), Gabali (GB) and Rex (RX) are considered the major rabbit breeds in Egypt (Galal and Khalil, 1994). Although rabbit meat consumption in Egypt is still quite low, there is increasing interest in promoting rabbit meat properties in healthy nutrition (El-Sheikh *et al.,* 2011).

Worldwide, meat is definitely the main goal of rabbit production. Three by-products are usually also recovered from the skins; the fur, the pelt and the shorn hair, with no particular production constraint. Those that are used fall into three categories: fur pelts for dressing, pelts for shorn hair (hair removed from skin) and skins for use as fertiliser (Lebas *et al.,* 1997).

To date, research on coat traits in rabbits under Egyptian conditions is lacking. Rabbit skins are not suitable for manufacturing purposes due to: i) Skinning rabbit skins by the wrong method, tearing the skin into 2 pieces; ii) limited

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numbers of tanneries in Cairo only are tanning rabbit skins to produce furs, making it difficult to collect and transport rabbit skins from other Egyptian provinces; and iii) rabbit fur manufacturing is still limited.

The present work was undertaken to study the histological characteristics of NZW, GB and RX rabbit breeds and evaluate the properties of tanned rabbit furs for manufacturing purposes suitability.

MATERIALS AND METHODS

A total of 79 male rabbits aged 3 mo, and belonging to Maryout Research Station, Desert Research Center, 35 km west of Alexandria were used. The rabbits comprised 3 different breeds: NZW (n=27), GB (n=28) and RX (n=24). The experiment was performed during summer (June, July and August). The average low temperatures varied from 20 to 23°C and the average high temperatures were 27-30°C. All animals were individually housed in commercial wire cages and maintained under the same management programme. The rabbits were fed a commercial diet for growing rabbits (15.8% crude protein, 19.3% acid detergent fibre, 9.8 MJ digestible energy/kg as-fed basis) during the entire experiment. No antibiotic was added to feed or water.

All rabbits were weighed and recorded before slaughtering. After slaughter, skinning was carried out in a manner that ensures the largest possible skin surface. The first cut is usually an incision at the hind feet, passing from one thigh to the other, then the skin is pulled off in one piece.

After skinning, skins were directly weighed and recorded, then cut by making an abdomen incision from head to tail direction. Thus, the skin was opened up and the skin specimen with all skin layers was taken from the right flank region by a curved scissor for histological determinations. The skin specimen was fixed on foam to flatten it, then fixation was done in calcium formol for about 24 h (Barker, 1958).

Histological parameters

Fixed skins specimen were washed after 24 h of fixation and left for 24 h in distilled water before being immersed in 70% ethanol (Barker, 1958). Skin specimens were then dehydrated in an ascending series of ethanol (30 min in each of 70, 80 and 90% of ethanol and finally 2 changes each for 15 min in absolute ethanol). The specimens were cleared in benzene for about 30 min, infiltrated in paraffin wax of a melting point of 60°C (4 changes, 20 min each) and then embedded in the same paraffin to prepare the blocks. For general histological observations of the hair follicles and their appendages, skin sections were haematoxylin and eosin stained (Drury and Wallington, 1980). The stained sections were used to measure the dermis thickness. The follicle groups were counted and the secondary to primary follicles ratio (S/P ratio) was estimated in ten follicle groups for each skin sample taken from the experimental animals.

Fur tanning

Fur tanning was started within 5 min after skinning to avoid the action of enzymes in the derma which attack the hair root and causes hair fall. The tanning steps were as explained in Table 1. According to Lebas *et al.* (1997), visual assessments were done by 5 panellists on finished fur to determine its surface colour. According to ISO (11646), finished fur areas were determined and recorded using a mechanical pin-wheel area measurement machine.

Fur evaluation

After finishing the rabbit furs, samples for various mechanical and chemical tests were obtained as per ASTM methods. Specimens were conditioned at 20±2°C and 65±4% relative humidity over a period of 48 h. Mechanical properties such as tensile strength, elongation percentage at break and split tear strength were measured as per standard procedures. Each value reported is an average of 2 samples (2 values along the backbone and 2 values across the backbone). Chemical properties such as moisture, total ash content, chromic oxide and pH were analysed according to standard procedures.

Table 1: Executed recipe for tanning rabbit furs.

Step	Description		Time (min)	Note
	%[1]	Added		
Fleshing	--	--	--	Manually to remove pellicle membrane and other fatty matter
Washing	100	Water	5	To remove dirt, blood spots and fatty substances
	2	Soap		
Pickling	100	Water	10	To adjust Baumé scale 8
	X	Salt		
	X	Formic	15	To adjust pH=3.5-3.8
Tanning	8	Chrome (33% basicity)	90	
Fixation	1	Sodium bicarbonate	60 then overnight	To adjust pH=4-4.2
Washing	200	Water	10	Out and hours up for 3 d
	1	Soap		
Greasing	--	Fish oil	--	Added manually by nourishing the flesh side
Finishing	--	--	--	Drying in shaded place then combing hair

[1]Percentages were calculated from pelts weight.

Statistical analysis

Data were analysed using GLM procedure from SAS to evaluate the differences among rabbit breeds. Significant differences were detected using the Duncan Multiple Range Test.

The fixed effect model used was $Y_{ij} = \mu + T_i + e_{ij}$, where Y_{ij} is the observation taken on skin (j), μ is an overall mean, T_i is a fixed effect of the (i) breed (NZW, RX, or GB) and e_{ij} is a random error assumed to be normally distributed with mean=0 and variance=$\sigma^2 e$.

RESULTS AND DISCUSSION

Fur colour

Comparing fur colour of the studied breeds, NZW logically has white fur, while all RX rabbits in this study had black fur colour. Previous investigations reported the black colour of RX fur (Galal and Khalil, 1994; Lebas *et al.,* 1997; Khalil *et al.,* 1998; El-Sheikh *et al.,* 2011), while TAO (1994) reported that RX rabbits have many different skin colours; red and blue, which were not observed in the current research. On the other hand, GB furs contained different hair colours of brown, grey and black hairs in the same animal. The different colours were homogenously distributed all over the cover. So, the main colour for GB is Grey-Brownish. Few research works have been carried out on GB rabbits, but Galal and Khalil (1994) stated that GB is coloured mainly with grey. Moreover, Lebas *et al.* (1997) mentioned that white colour can be dyed with different colours and black colour is considered one of the most solicited colours in fashion. Therefore, the superiority in fur colour was for NZW, followed by RX and GB.

Finished fur area

Among breeds, the trend was similar for all three traits; GB had significantly higher values than other breeds in body weight ($P<0.01$), skin weight ($P<0.01$) and finished fur area ($P<0.05$).

Between NZW and RX, the differences were insignificant but NZW tends to be higher in values than RX (Table 2); a similar result was previously reported by TAO (1994). In coincidence, Lebas *et al.* (1997) reported an increase in fur size with increased body weight.

The superiority for GB breed might be due to their higher adaptation to desert and high ambient conditions in Egypt than other breeds, as mentioned by Khalil *et al.* (1998).

Table 2: Least square means (±SEM) of body weight, skin weight and finished fur area for studied breeds.

Item	GB	NZW	RX	SEM	Significance
n	28	27	24		
Body Weight (gm)	1757.14^{b}	1677.78^{ab}	1625.00^{a}	17.38	**
Skin Weight (gm)	163.50^{b}	150.44^{a}	140.46^{a}	2.50	**
Finished fur Area (cm^2)	1021.93^{b}	930.89^{a}	923.46^{a}	17.21	*

GB: Gabaly; NZW: New Zealand White; RX: Rex; SEM: standard error of mean.
^{a,b}Means in the same row having different superscripts are significantly different (P<0.05).
Significance: *P<0.05, **P<0.01.

Histological parameters

Figure 1 shows that the vertical sections of skin samples from the studied breeds contain the different layers of the skin. The skins consist of epidermis, dermis, hypodermis and pellicle layers. The first 3 layers are similar to those found in other mammals, while pellicle layer is found in rabbits (Lebas *et al.,* 1997). It is a subcutaneous skeletal muscle, which should be removed mechanically when fleshing skins before tanning rabbit furs or skins, as it is impervious to curing products (Lebas *et al.,* 1997).

Table 3 presents the thickness values of different skin layers. All differences among studied breeds were significant (P<0.05). Total skin thickness in NZW breed (3438.54 µm) was obviously higher than those found in GB (1479.48 µm) and RX (1249.48 µm), which were comparable in thickness values.

In rabbits, resembling those of other species, epidermis is the outer layer of the raw skin that represents the barrier between the animal and its environment, while hypodermis is the layer of skin closest to flesh of the animal. Both these layers are superfluous to leather forming layer or true skin, the dermis. Their removal is not essential if hair is to be kept on tanned furs (Heidemann, 1993 and Covington, 2009), so in this study the epidermis was not removed, in order to keep the fur hair. Although differences in epidermis and hypodermis layers' thicknesses (P<0.05) were found, they were ignored due to their poor effect on fur quality.

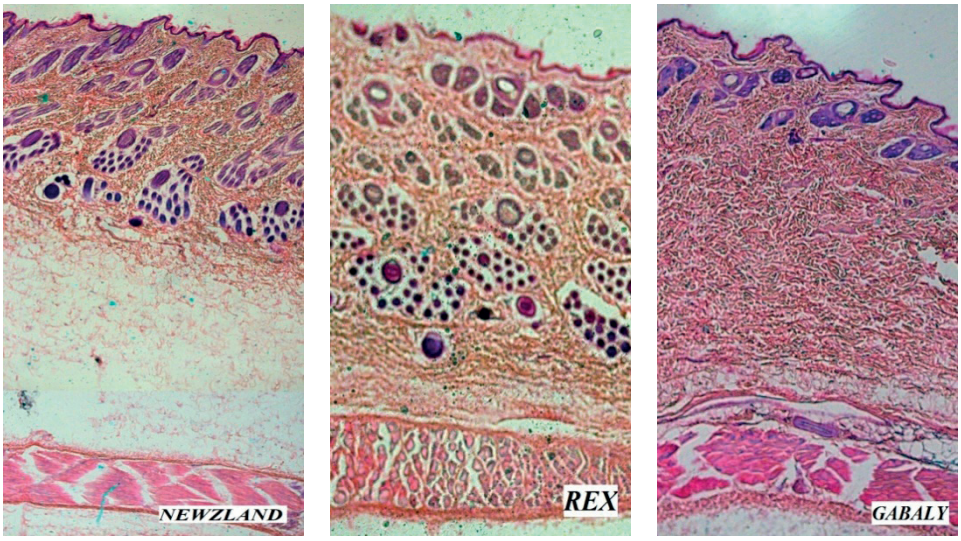

Figure 1: Vertical sections of studied breeds.

Table 3: Least square means (±SEM) of skin layer thickness (µm) for studied breeds.

Layer	Epidermis	Papillary	Reticular	Hypodermis	Total Thickness
NZW	26.08[b]	1577.05[c]	358.97[b]	1476.43[c]	3438.53[c]
GB	14.48[a]	438.50[a]	584.75[c]	456.23[b]	1493.96[b]
RX	18.05[a]	892.29[b]	185.37[a]	153.77[a]	1249.48[a]
SEM	1.29	41.71	17.6	14.28	118.68
Significance	*	*	*	*	*

NZW: New Zealand White; GB: Gabaly; RX: Rex; SEM: standard error of mean.
[a,b]Means in the same column having different superscripts are significantly different ($P<0.05$).
Significance: *$P<0.05$.

The dermis layer contains 2 sub-layers; reticular and papillary. The reticular layer is considered the most important in skin and contains the larger collagen fibres, which makes skins and furs strong and able to resist stresses placed on it, identified as strength (Covington, 2009).

Generally, NZW had the highest thickness values of all skin layers except reticular layer. Differences in reticular thicknesses among studied breeds were significant ($P<0.05$) and GB had the highest value (584.75 µm), followed by NZW (358.97 µm) and RX (185.37 µm), respectively.

Papillary layer contains hair papillae, sweat glands, fat glands, and fine collagen fibres. These fine collagen fibres interact poorly and form weak bundles (Covington, 2009). So, increasing papillary layer ratio of total dermis thickness produces weaker skins such as those of NZW and RX, which was roughly 80% in the 2 breeds compared to 40% in GB.

Table 4 presents the data for histological parameters; external, internal, fibre diameters, wall thickness of primary and secondary follicles and S/P ratio values for studied breeds. Wall thickness is the distance between external and internal diameter. Figure 2 shows that there are 2 main types of hair follicles: primary and secondary follicles. The primary follicles are usually the largest and the secondary follicles are more numerous, lying to one side of the primary follicles (Oznurlu *et al.,* 2009).

Table 4: Least square means (±SEM) of external diameter, internal diameter, wall thickness and fibre diameter of the primary and secondary follicles.

Item	GB	NZW	RX	Significance
Primary Follicles				
n	60	48	60	
External Diameter	86.86±4.63[a]	121.30±5.18[b]	135.56±4.63[c]	**
Internal Diameter	44.75±2.74[a]	65.55±3.06[b]	73.85±2.74[c]	**
Wall Thickness	42.11± 2.39[a]	55.74±2.67[b]	61.71±2.39[b]	**
Fibre Diameter	35.12±2.29[a]	48.22±2.56[b]	56.35±2.29[c]	**
Secondary Follicles				
n	47	62	52	
External Diameter	26.73±1.01[a]	33.17±0.88[b]	32.13±0.96[b]	**
Internal Diameter	13.16±0.59[a]	16.46±0.51[b]	19.36±0.56[c]	**
Wall Thickness	13.58±0.61[a]	16.71±0.53[b]	12.77±0.58[a]	**
Fibre Diameter	8.42±0.92[a]	14.32±0.80[b]	13.19±0.87[b]	**
Secondary/Primary follicles Ratio				
n	32	18	38	
Ratio	20.25±0.94[b]	19.33±1.25[b]	13.31±0.086[a]	**

GB: Gabaly; NZW: New Zealand White; RX: Rex; SEM: standard error of mean.
Means in the same row having different superscripts are significantly different ($P<0.05$).
Significance: **$P<0.01$.

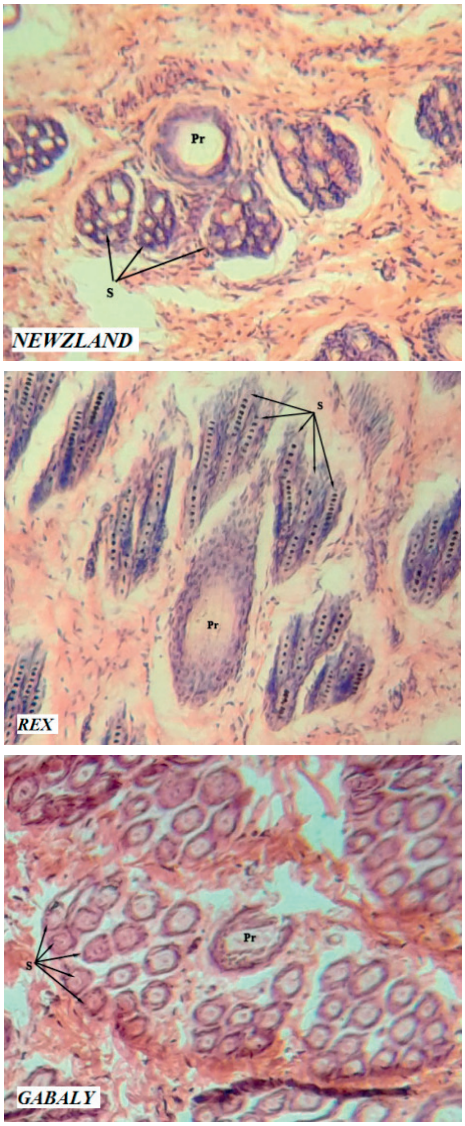

Figure 2: Transverse sections of studied breeds.

From data in Table 4, all differences among studied breeds were significant ($P<0.01$). The most important characteristic that should be taken into consideration is cover smoothness, which depends on fibre diameter. Naylor *et al.* (1992) reported that coarse fibres may cause irritation to humans when worn next to the skin. Thus, increasing fibre diameter is considered among undesirable characteristics in rabbit furs to be used in lining or garments. In addition, the smoothness of the product to the consumer is important for its general acceptance and use.

The lowest fibre diameters were found in GB furs (35.12 µm) and (8.42 µm) while the highest values were in RX furs (56.35 µm) and (13.19 µm) for both primary and secondary follicles, respectively. TAO (1994) found that the diameter of RX rabbit hair fibre is larger than that of NZW rabbits.

Moreover, external and internal diameters and wall thickness values in primary follicles were the lowest in GB furs, followed by NZW and RX furs. The same trend was also found in secondary follicles except wall thickness values, which were higher in NZW (16.71 µm) than GB (13.58 µm) and RX (12.77 µm) furs.

On the other hand, the effect of primary and secondary follicles on histological structure is complex. Oznurlu *et al.* (2009) reported that the primary follicles were distinguished by their large diameter and their roots reaching the dermis, whereas secondary follicles were smaller and the roots located superficially. This means that increasing S/P ratio will increase the quality of hair fibres in cover as reported by Atlee *et al.* (1997), but weakens the strength of collagen fibres in skins, as explained by Abdelsalam *et al.* (1998). In this study, S/P ratio values were comparable in GB (20.25) and NZW skins (19.33), while the lowest value was found in RX skins (13.31).

Tanned fur properties

Chemical properties of finished tanned furs for studied breeds are presented in Table 5. No significant differences were found among studied breeds in chemical properties. This was expected and in agreement with Nasr *et al.* (2013), due to similarity in tanning steps and processes done on skins of all studied breeds. Moreover, the chemical properties values were within an acceptable range for the fur of rabbits from the studied breeds to be used in different manufacturing processes (BASF, 2007).

Mechanical properties, illustrated in Table 5, show significant differences ($P<0.01$) among breeds in fur thicknesses. NZW furs recorded higher values compared to GB and RX. Tearing strength was higher in NZW furs ($P<0.05$) than in RX, but no significant differences were found between NZW and GB or GB and RX furs (Table 5). No significant differences were found among studied breeds in either tensile strength or elongation, and values were comparable.

Table 5: Means (±SEM) of mechanical and chemical properties for different rabbit breed furs.

Item	GB	NZW	RX	SEM	Significance
n	5	5	5		
Mechanical properties					
Thickness (mm)	0.960[a]	1.178[b]	0.820[a]	0.054	**
Tensile strength (kg/cm^2)	139.812	132.716	126.210	6.099	NS
Elongation (%)	43.600	49.600	50.400	2.133	NS
Tearing strength (kg/cm)	20.049[ab]	21.179[b]	16.105[a]	1.009	*
Chemical Properties					
Moisture (%)	14.100	13.820	13.920	0.103	NS
Ash (%)	3.904	3.892	3.858	0.031	NS
Cr (%)	3.110	3.050	3.026	0.041	NS
pH	3.760	3.784	3.810	0.041	NS

GB: Gabaly; NZW: New Zealand White; RX: Rex; SEM: standard error of means. Means in the same row having different superscripts are significantly different ($P<0.05$).
Significance: NS: Not significant, *$P<0.05$, **$P<0.01$.

Several investigations have indicated a negative relation between leather thickness and strengths such as tensile and/or tearing (Kotb, 1987 in cattle; Abdelsalam *et al.,* 1998 in camel and Nasr, *et al.,* 2013 in sheep). However, this relation was not found in this study. This might be due to other reasons related with histological structure, such as reticular and papillary thickness, as explained previously.

In terms of mechanical properties, both GB and NZW furs were comparable and higher quality than RX furs. This result was expected and in agreement with histological data, due to the following constraints:

I. The thinner reticular and thicker papillary layers in the dermis of RX pelts led to decreased collagen bundles in skin sections and, in consequence, decreased the strength of furs and increased elongation.

II. GB pelts had the highest reticular thickness and lowest papillary thickness in dermis layer, which caused an increase in strengths and a decrease in elongation values.

III. NZW pelts were more than twice in total thickness, papillary and hypodermis layers than other breeds. However, reticular layer thickness was higher than RX and lower than GB. This structure is caused by an increase in fine collagen fibre bundles in papillary layer and a limited increase in larger collagen fibre bundles in reticular layer. Therefore, strength values tended to be similar to corresponding values in GB pelts and elongation value tended to be similar to those of RX pelts.

CONCLUSIONS

All 3 rabbit breeds are suitable for use in the manufacture of different leather items, such as garments and linings. The quality of finished rabbit furs can be arranged in descending order to be GB then NZW followed by RX furs. NZW furs are more suitable for fashion garment manufacturers due to their white colour. Despite the non-homogenous colour of GB furs, they seem to be promising raw material in tanning manufacture due to their superior finished fur area, fine fibres and tensile strength, especially for the production of finished items in natural colour. RX furs were the weakest, presenting the lowest tensile and tearing strengths. Moreover, they had the lowest finished fur areas and coarser fur fibres when compared with GB and NZW rabbits. However, they are characterised by a uniform black fur colour. Last but not least, increasing the awareness of manufacturing purposes for rabbit furs in Egypt will highlight their economic value. In addition, it will increase the attention to rabbit skinning, preserving and tanning to maximise the benefits instead of the current situation, where they go to waste.

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