Physical Properties of Chrome-Tanned Nile Perch (*Lates niloticus*) Fish Leather

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Abstract

The aim of this study was to utilise the Nile perch fish skins which are usually a waste from fish filleting companies to make leather and then to determine its physical properties. The skins were processed into leather using chromium(III) sulphate. The physical properties of leathers were determined using standard IUP methods which include: Tensile strength, Tear strength, Flexing endurance, Shrinkage temperature, Grain crack and Grain burst tests.

The results demonstrated that the tensile, tear strength and elongation of the leather varied depending on the direction and location of the collagen fibres. The properties of the Nile perch leather were satisfying enough for the material to be used in the manufacture of high grade leather products. The study showed that the fish skins can supplement sources of raw materials in the leather industry and reduce the environmental pollution caused by disposing of the skins to the environment.

1 INTRODUCTION

With the increase of the fish processing industries in Kisumu along the shores of Lake Victoria in East Africa fish processing activities have increased. Nile perch fish, which is a fast-growing species, is the most abundant in Lake Victoria. The fish processing residues include head, fins, scales, viscera and fish skins. The level of waste is dependent on the species.[1] The waste processing is potentially polluting due to the high amounts of organic matter discharged to the environment.[2] The fish skin which contains collagen as the main constituent can be used as an alternative raw material in leather processing to produce an exotic leather.[3-5] This not only helps in the reduction of pollution but also adds value to the skins. The amount of amino acids, especially hydroxyproline, depends on the environmental temperature in which the fish lives and it affects the thermal stability of the collagens. Nile perch is said to contain more amino acid than most fish species since itís a warm water species.[6]

The processing of fish skins into leather has gained interests among the tanners and customers due to their unique natural and attractive grain structure making it valuable in the market.[7] Nile perch fish skin has scales which differ from those of sturgeon,[4] stingray fish contains denticles[8] – different species have different natural characteristics. The skins have to be processed without losing the natural characteristics.

We determined the physical properties of the skins to help predict their possible applications. Chrome tanning was used due to the good strength that is offered by the chromium salt.

2 MATERIALS AND METHOD

2.1 Raw materials

The raw materials were obtained from Obunga market in Kisumu. The fleshed raw skins were cured with salt before transportation to the tannery for processing to avoid deterioration. The chemicals used in all stages of the leather processing were of commercial grade and were purchased locally.

2.2 Procedure

See Table I on Page 315.

2.3 Sampling and sample preparation

The leather sample was divided into three parts; towards the head (upper part), middle and towards the tail (lower part). The samples from the three different parts of the fish leather were cut in triplicates for both parallel and perpendicular directions. The samples were conditioned at 25 ± 2°C and relative humidity of 65 ± 4% for 48 hours in accordance with IUP 3. The tensile strength, tear strength, ball burst extension, flex endurance and shrinkage temperatures were determined as per IUP 6, IUP 8, IUP 9, IUP 20 and IUP 16 respectively.

2.4 Data analysis

The results obtained were analyzed using SPSS statistical packages version 25. The data was subjected to one-way analysis of valiance and Tukey test to check for the significant differences ($p< 0.05$) of the physical properties of the different areas in fish leather.

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TABLE I

Tannage for Nile perch (*Lates niloticus*) fish leather

Process	Chemical	%	Run time (min)	Remarks
Weighing skins				Weigh
Soaking	Water	300		
	Anionic surfactant	1		
	Bactericide	1	Over night	Drain
Liming	Water	150		
	Lime powder	4		Check swelling
	Sodium sulphide	2	Over night	Drain
Reliming	Water	150		Check swelling
	Lime powder	1		
	Sodium hydrogen sulphide	1	120	Drain, wash and drain
Fleshing				
Weigh the pelt				
Deliming	Water	100		pH7.5-8.0
	Ammonium sulphate	2	60	Drain, wash and drain
Bating	Micro bate	1	60	Drain, wash and drain
Degreasing	Water	100		
	Degreasing agent	1	60	Drain, wash and drain
Pickling	Water	100		
	Salt	10	10	
	Formic acid	0.2	20	In 1:10 dilution with water
	Sulphuric acid	0.8	90	In 1:10 dilution with water. Offer in 3 feeds for every 10 min, pH set to 3 and additional 60 min runtime.
Tanning	Pickle bath			
	Chromium powder 33% basic	4	60	Check penetration
	Chromium powder 33% basic	4	90	pH2.8- 3.0
Basification	Sodium formate	1	30	
	Sodium bicarbonate	1	60	In 1:10 dilution with water. Offer in 3 feeds for every 10 min, and additional 30 min runtime. pH4.8-5.0 Drain, wash and drain
Aging overnight				
Weigh the wet-blue				
Neutralization	Water	100		
	Sodium formate	0.5		
	Sodium bicarbonate	0.5	60	pH6, Drain, wash and drain
Retanning	Water	100		
	Mimosa powder	2	90	
	Universal Syntan (LUNATAN NSP)	2	60	
Dyeing	Brown dye	3	60	Check colour penetration. Drain, wash and drain
Fatliquoring	Warm water	100	120	
	Synthetic Fatliqour	5		
Fixation	Formic acid	1	60	Check pH3.5
Drain, wash and drain				
Horse up overnight				
Toggle dry				

TABLE II
Physical properties of Nile perch fish leather

Physical properties			Towards head	Middle	Towards tail	P values
Tensile strength (N/mm²)		↑	27.60 ± 0.64^{b}	26.67 ± 0.31a^{b}	25.30 ± 0.55a	0.013
		→	22.72 ± 0.77^{a}	21.64 ± 0.32^{a}	21.56 ± 0.74^{a}	0.213
Elongation at break (%)		↑	39.05 ± 1.95^{b}	36.25 ± 0.37a^{b}	35.12 ± 0.93^{a}	0.054
		→	32.72 ± 1.12^{a}	32.67 ± 0.49^{a}	32.92 ± 1.28^{a}	0.960
Tear strength (N)		↑	53.38 ± 0.32^{b}	49.53 ± 0.25^{a}	49.39 ± 0.61^{a}	0.000
		→	50.17 ± 0.31^{b}	48.71 ± 0.42^{a}	48.24 ± 0.28^{a}	0.003
Ball burst extension (mm)	Grain crack		6.47 ± 0.35^{b}	6.27 ± 0.25^{b}	5.17 ± 0.25^{a}	0.009
	Grain burst		8.08 ± 0.35^{b}	7.24 ± 0.24^{a}	6.69 ± 0.54^{a}	0.010
Flexing endurance			No damage @ 50000 flexes			
Shrinkage temperature (°C)	Before tanning		53.33 ± 0.94			
	After tanning		98.67 ± 0.47			

The values are means ± standard deviation of triplicates with a and b indicating significant differences between towards the head, middle and towards the tail ($p<0.05$).

3. RESULTS AND DISCUSSION

The physical properties of Nile perch fish leather were determined so as to predict possible use in the leather industry, enable the manufacturers to predict the performance characteristics and product diversification. The properties are affected by factors such as species, age, weight, sex, skin orientation, source of the material and mainly tanning process.[4] The physical properties of Nile perch crust leather are given in Table II above.

Tensile strength

There was a significant difference ($p<0.05$) in tensile strength (longitudinally) between directions towards the head and towards the tail. There was no significant difference ($p>0.05$) between the middle and towards the tail and also between the middle and towards the head. Towards the head having the highest values of 27.60 ± 0.64N/mm² while the middle and towards the tail having 26.67 ± 0.31N/mm², 25.30 ± 0.55N/mm² respectively. There was no significant difference ($p>0.05$) in tensile strength (transversely) from the three areas. The results in Table II show that there is a difference between the longitudinal and transverse directions for the parameters of tensile strength with longitudinal direction having a higher tensile strength compared to the transverse direction. This shows an anisotropic arrangement of collagen fibres in the leather matrix. The leather is more extensible in the longitudinal direction. In the literature Pessoa da Silva *et al.*,[3] reported the same behaviour with the Amazon catfish leather. Nile perch fish leather also reported higher values of tensile strength than Nile tilapia of 12.18N/mm² as reported by Souza *et al.*,[9] sturgeon of 19.60N/mm² as reported by Taotao *et al.*,[4] and also carp of 18.33N/mm², sturgeon of 14.23N/mm² and conger of 9.78 N/mm² as reported by Zengin *et al.*[10]

Tear strength

This property was measured to understand the materialís resistance to break if it develops any cuts. There was a significant difference ($p<0.05$) in tear strength (longitudinally) between the area towards the head and area towards the tail. Tear strength indicated no significant difference ($p>0.05$) between the middle and the area towards the tail and also between the middle and the area towards the head. There was a significant difference ($p<0.05$) in tear strength (transversely) between towards the head and both the middle and towards the tail. Table II shows that the longitudinal tear strength was higher than the transverse tear strength. Both values for longitudinal and transverse were above the minimum required values as reported in the literature[11] for a variety of uses. The tear strength was higher than that of carp 46.8N and conger 43.97N but lower than sturgeon fish 83.83N as reported by Zengin *et al.*[10]

Burst strength

Burst strength indicates the resistance to cracking during top lasting of a shoe upper. There was a significant difference ($p<0.05$) between towards the head and towards the tail with towards the head having a higher value of 8.08 ± 0.35mm. The average value of ball burst met the minimum recommended value of grain crack of 7.00mm for grain burst.[11] The value for Nile perch leather grain burst was lower than that of sturgeon 8.07mm, conger 8.31mm and carp 13.18mm as reported by Zengin *et al.*[10] but it was higher than stingray 5.2mm as reported by Karthikeyan *et al.*[8]

Flex test

The leather was subjected to 50000 flexes and passed the test as there was no damage to the leather at the end of these flexes.[11] The leather endured more flexes than sturgeon leather studied by Taotao *et al.*,[4] who reported endurance of 36000 flexes.

Shrinkage temperature

Shrinkage temperature of the raw pelt was measured and found to be 53.33 ± 0.94°C which was within the range reported in the literature.[11] After tanning the shrinkage temperature of the wet-blue was 98.67 ± 0.94°C. This temperature was slightly lower than the one reported in the literature for chrome tanned leather 100°C by Covington.[12] This fish species gave higher shrinkage temperature compared to others found in the literature sturgeon 63°C, conger 78°C and carp 90°C Zengin *et al.*[10]

4 CONCLUSION

This study shows that Nile perch fish skins can be processed into leather, supplementing the available sources of raw materials such as bovine, sheep and goat. The processing of Nile perch fish skin needs to be done with care since the skin is delicate and if subjected to high drum speeds the material can be destroyed. Descaling using a knife destroys the pockets of the skin and thus removal using sodium sulphide is recommended. In all the physical properties tested there was a significance difference ($p<0.05$) noted between towards the head and towards the tail. The part towards the head has more strength than the other parts of the leather, it is anisotropic with the longitudinal having more strength than the transverse direction of the leather. The Nile perch leather showed adequate strength for use in the manufacture of high grade leather products.

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