An Investigation on Chicken Leg Skin for the Preparation of Fashionable Leather and Leather Products

by

R. Karthikeyan*[1] and N.k. Chandra Babu[2]

[1]*School of Chemical and Bioengineering, Addis Ababa Institute of Technology*
Addis Ababa University, Ethiopia.

[2]*Tannery Division, Council of Scientific and Industrial Research–Central Leather Research Institute,*
Adyar, Chennai- 600 020, India.

Abstract

Chicken leg is available in enormous quantity as a by-product from poultry industry. Due to lack of awareness and technology, most of the chicken legs are wasted by the poultry producers and the skins are not utilized by the tanners. Hence, an attempt has been made in the present study to investigate the feasibility of turning chicken leg skins into leather and products. The raw skin was characterised and converted into finished leather by using suitable tanning methodology and the resultant chicken leg leather with attractive grain pattern has been utilized for the preparation of highly fashionable leather products. Histological examination was carried out on the chicken leg skin at different stages of processing. The leathers were characterized by differential scanning colorimetry and scanning electron microscopic analysis. The strength properties of the crust leathers were also tested and reported in the paper. Visual assessment reveals that vegetable tanning followed by chrome tanning produces fuller and softer leathers with exquisitely raised grain pattern compared to chrome tanning method and the same is corroborated by SEM study.

Introduction

The important byproducts of the meat industry *viz.*, hides and skins from domestic bovine and ovine animals are commonly converted into leather. Similarly, chicken legs are a by-product of poultry processing industry and the skins from chicken legs could also be exploited as a raw material by the leather sector. Poultry industry is the world's second largest source of meat, just after pork and it has been estimated that around 85 million tonnes of chicken meat were produced during the year 2010 worldover.[1] The average area of a skin is around 60 cm^2 (0.065 sq ft) and this means about 6.5 billion sq ft of chicken leg skins can be processed into leathers. This will add to global availability of raw material in a substantial way, especially, when the global leather sector is trying to expand their raw material base. But the commercial exploitation of such rich source of raw material has not happened mostly due to lack of awareness and proper linkage between the tanners and poultry producers on one hand and lack of suitable technology on the other. Generally, chicken leg part is neither consumed by the people nor converted into high value products, most of them goes as a waste and hence there is a scope to use the chicken leg skins as a potential raw material for the leather industry. Table I presents the status of chicken meat production in the world and India's share in the world production during 2010 (Source USDA/FAS)[1]. The availability of chicken leg skin in the world and in India is presented in the Table II.

Treatment and conversion of waste into value added products[2-5] would help not only to strengthen the economy of a country but also to protect the environment from pollution and to improve the socio-economic status of the people by creating employment. Hence, in the present study, an attempt has been made to standardize a suitable process technology for the production of finished leathers.

Experimental Procedure

Materials and Methods

400 pieces of chicken legs were collected from local poultry processing unit at Chennai, India and chemicals used were from reputed Leather chemical companies. The design of experiments carried out in the study is illustrated in Figure 1.

*Corresponding author e-mail address: drkarthi76@gmail.com; Tel.:+251-11-1232417; +251-9401-90909, Fax: +251-11-123-9480.
Manuscript received February 2, 2017, accepted for publication February 28, 2017.

Characterization of Chicken Leg Skin

Determination of Moisture

5 gm of chicken leg skin was taken in a suitable crucible and placed in an oven at 105 ± 2^0C for 6 h, cooled and weighed. The moisture content in the chicken leg sample was determined as shown in the equation (1).

$$\text{The \% moisture} = \frac{A - B}{A} \times 100 \qquad (1)$$

Where A = mass of sample
B = mass of dried sample

Determination of Protein Content

The protein content of the raw chicken leg skin sample was estimated by the Kjeldahl method.[6]

The protein content in percentage = % nitrogen x 6.25

Determination of Fat Content

The fat content of the raw chicken leg skin sample was estimated as per the standard IUC method SLC 4.[7] The sample is continuously extracted with dichloromethane. Solvent is then evaporated from the extract which is then dried at 105^0C.

Tanning Studies

Conversion of Chicken Leg Skins into Leather –Process Details

The body skin of broiler is usually damaged by overheating during scalding process, a method used to remove the feather from the skin which makes the skin unsuitable for leather manufacture. We selected the scaly leg portion which is not covered with feathers. Hence less quantity of sodium sulphide may be required to remove the scales during leather processing. Mechanical fleshing is not possible for chicken leg skins. Hence flesh should be dissolved and removed during the process itself. Addition of NaOH during fibre opening and appropriate degreasing is desirable for chicken leg skins.

Table I
Chicken meat production – World production & India's Share (Source USDA/FAS).

World production in million tons	India's production in million tons	India's share in percentage
85.2	2.65	3.1

Removal of Skin From Chicken Leg

The flaying of skin from chicken leg is a critical task from the point of view of leather making. An easy and effective method for the removal of skin from chicken leg has been standardized on trial and error approach and the same is illustrated in Figure 2.

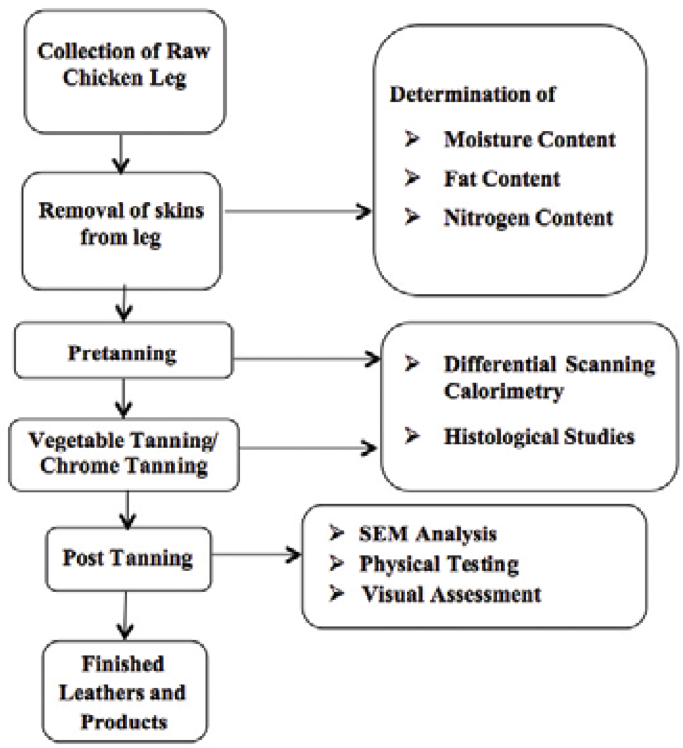

Figure 1. Flow Chart for Plan of Experiments on Chicken Leg.

Table II
Availability of chicken leg skin for making leather (Estimated Calculation).

World Production of Broilers in million numbers	India's Production in million numbers	Average area available per Leg Piece of Chicken	Total area of Chicken Leg Skin Available in the World/ per year (million sq.ft.)	India's Share in million sq.ft.
50,523	1,572	60 cm^2 *or 0.065 Sq.ft.*	6568	204

Tannage

Raw material: Fresh Chicken Leg skins.

Washed with water for 15'.

Descaling & Fibre Opening: (Drum Method)

Water 100%

Sodium sulphide flakes 0.2%

Lime 3.5%

Caustic Soda 0.5%

Initially the drum was run for 60 min (3rpm).

Then for every 1h, it was run for 10min for 8 h. Then left overnight.

Next day, the drum was run for 30 min and drained and skins were washed thoroughly.

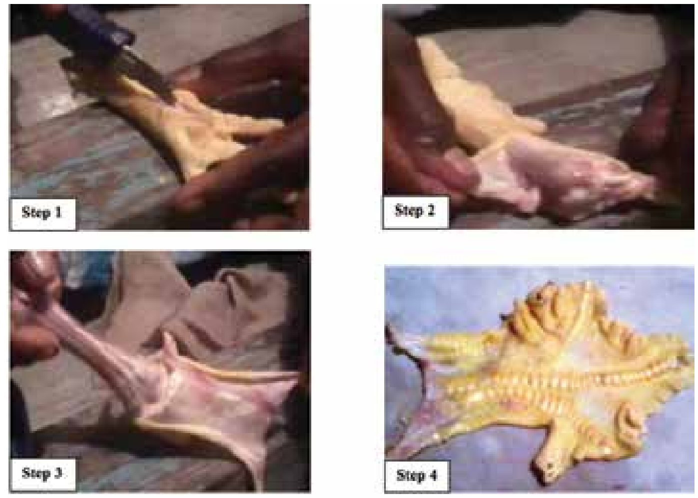

Figure 2 . Flaying of Skin from Chicken Leg.

Table III
Chicken leg tanning trials.

Experiment 1	Experiment 2
Vegetable tanning (% based on pelt weight) Partial pickling Water 50% Salt 5% Formic acid 0.5% 2x10min+30min pH 4.0. Pretanning syntan 3% 30min Wattle 10% Sulphited Veg Oil 1% 1h Wattle 10% Sulphited Veg Oil 1% 1h Myrobalan 5% 45min pH adjusted to 3.0-3.2. Drain, rinsed, piled for 2 days. **Semi Chroming:** Wetting Agent 0.5% 30 min, Drain, Wash. Water 200% Borax 1% 60 min Drain, Wash. Oxalic acid 1% 30min, Drain, Wash Water 50% Chrome syntan 5% BCS 5% 60 min Sodium formate 1%(in 10% water) Sodium bicarbonate 0.5% 2x10min + 45min (in 10% water) pH 4.0 Drain, rinsed and piled overnight.	**Chrome tanning** (% based on pelt weight) Water 80% Salt 8% 10min Sulphuric acid 1% (in 10% water) 3x10min+60min Leave over night. Next day add Sulphuric acid 0.2% (in 5% water) 2x10min+30min pH 2.8-3.0. Drain 50% pickle water. Add BCS powder 8% 90min Water 50% Sodium formate 1%(in 10% water) 30min Sodium bicarbonate 1% 3x10min + 60min (in 10% water) pH 3.8. Drain, rinsed and piled overnight.

Deliming and Bating:
Water 100%

Ammonium chloride 1.0% - Run for 30 min

Microbate 1% - Run for 30 min

Drain /Wash.

Degreasing: Without float

Degreasing Agent 2.5% - Run for 30 min

Water 50% - Run for 30 min. Drain /Wash.

After degreasing, the tanning trials were carried out as listed below.

Experiment 1. Partial pickling + Vegetable tanning + Chrome tanning (Semi chroming)

Experiment 2. H_2SO_4 pickling + Chrome tanning

The process details are given in Table III.

Determination of Thermal Stability by Differential Scanning Calorimetry (DSC)
The thermal stability of vegetable and chrome tanned chicken leather was measured using a DSC Q 200 differential scanning calorimeter (TA Instruments). The DSC method offers a much more objective and comprehensive way of evaluating the thermal shrinkage process of collagen.[8,9] 5-10 mg of samples were sealed in aluminium pan and an empty pan was used as a reference. The heating rate of 5°C per minute and temperature range between 0° to 200°C in N_2 atmosphere were maintained.[10]

Histological Studies with H & E Staining
The histological studies for the soaked, limed, chrome tanned and vegetable tanned chicken leg leathers were carried out. After the completion of the above mentioned processes, the samples were cut and preserved in 10% formalin for 48 h. The fixed samples were dehydrated in a series of solutions of alcohol of different concentrations (50 to 100%) and then cleared in xylene. They were finally embedded in paraffin wax into moulds. The moulds were labeled and stored until use. Thin sections (10μm thick) were cut on a microtome, mounted on glass slides and stained with Hematoxylin and counterstained with Eosine.

Post Tanning
All the tanned leathers were neutralized to pH 5.8-6.0 before dyeing with 2% acid dye followed by fatliquor, retan and drying. The process details are given in Table IV.

Table IV
Post tanning procedure for chicken leg leather.

Process	Chemicals	%	Time	Remarks
Neutralization	Water	100		
	Vernatan AKM (Neutralizing syntan)	1.0	20 min	Check
	Sodium formate	0.75	3x10+30min	pH 5.8 -6.0
	Sodium bicarbanate	0.75		Wash/drain
Retanning	Water	100		
	Acrylic Resin	4	40 min	
Dyeing and Fatliquoring	Acid Dye 2%	2	30 min	Check penetration
	Vernaminol ASN (synthetic fatliquor)	3	15 min	
	Basyntan DI (Phenolic syntan)	4		
	Basyntan FB 6 (Resin Syntan)	4	40 min	
	Balmol SXE (synthetic fatliquor)	3		
	Balmol BL II (semi synthetic)	3		
	Lipsol LQ (synthetic fatliquor)	4		
	Lipsol BSFR (synthetic fatliquor)	5	60 min	
	GS Powder	5	30 min	
Fixing	Formic acid	1.5	3x10+30min	
Drain, wash and pile overnight. Next day, dry, stake by hand and trim				

SEM Study on Chicken Leg Leather

In order to study the effect of the tanning on the structural characteristics of the leathers produced, scanning electron microphotographs of chrome tanned and semi-chrome tanned crust were compared. The samples measuring 5mm x 2mm were cut from the crust leathers using fresh stainless steel blades. The samples were mounted both vertically and horizontally on aluminum stubs using an adhesive. These were then coated with gold using an Edwards E-306 sputter coater. The stubs were introduced into the specimen chamber of a FEI-Quanta 200 scanning electron microscope. The stubs mounted on the stage could be tilted, rotated and moved to the desired position and orientation. The micrographs for the cross-section were obtained by operating the microscope at 10 kV.

Physical Testing and Assessment of Leathers

The samples for physical testing were cut from the chrome and semi-chrome tanned crust leathers. The samples were conditioned at 80±4°F and 65±4% R.H. for 48 h. The tensile strength and % elongation were measured as per the IULTCS method.[11] Experienced technologists assessed the organoleptic properties such as fullness, feel and general appearance. The leathers were rated on a scale of 1-10 points for each functional property, where higher points indicate better property.

Results and Discussion

Characterization of Chicken Leg Skin

Analytical values of moisture, total protein and fat contents of chicken leg skin are presented in Table V. It is evident from the data that the chicken leg skin contains high amount of natural fat which should be taken into account while standardizing the process technology.

Histological Studies on Chicken Leg Skins with H & E Staining

The optical microphotographs taken for the soaked, limed, chrome tanned and vegetable tanned chicken leg skins are set out in Figure 3. In general, the structure of chicken leg skin seems to be porous and uniformly structured across the cross section. The opening up of fibre bundles during liming stage is clearly presented in the photograph. In the case of chrome tanning, the fibre bundles seem to be compressed (dense) compared to vegetable tanned leather.

DSC Profile for Tanned Chicken Leather

The denaturation temperature of vegetable and chrome tanned chicken leather recorded by DSC is presented in Figure 4. Denaturation temperature of vegetable tanned chicken leg leather shows a value of 73.4^{0}C where as for chrome tanned leather it is 109.3^{0}C. It was reported that chicken skin contains approximately 75% type I and 15% type III collagens.[12] The denaturation temperature of tanned chicken leather was found to be close to that of conventional hides and skins.

Effect of Tanning System on the Fibre Structure of Chicken Leg Leather

SEM cross-sections of chrome and semi-chrome tanned chicken leg leathers at magnifications of 100x and 500x are given in Figure 5. From the pictures, it is evident that the fibre bundles are well separated in semi-chrome tanned leather whereas in the case of chrome tanned leathers, the fibres bundles are compact and compressed. This is probably due to the colloidal nature of vegetable tannins. The inference from the SEM study is that the semi-chroming can lead to softer and fuller leather compared to chrome tanned and this has been corroborated by the visual assessment data as will be discussed in the next section. The SEM image of the surface of chrome tanned chicken leg leather

Table V

Chemical characteristics of chicken leg skin.

Characteristics	Value in % w/w
Moisture Content	63.5 ± 0.3
Nitrogen Content	4.2 ± 0.05
Protein Content	26.2± 0.1
Fat Content	8.7±0.1

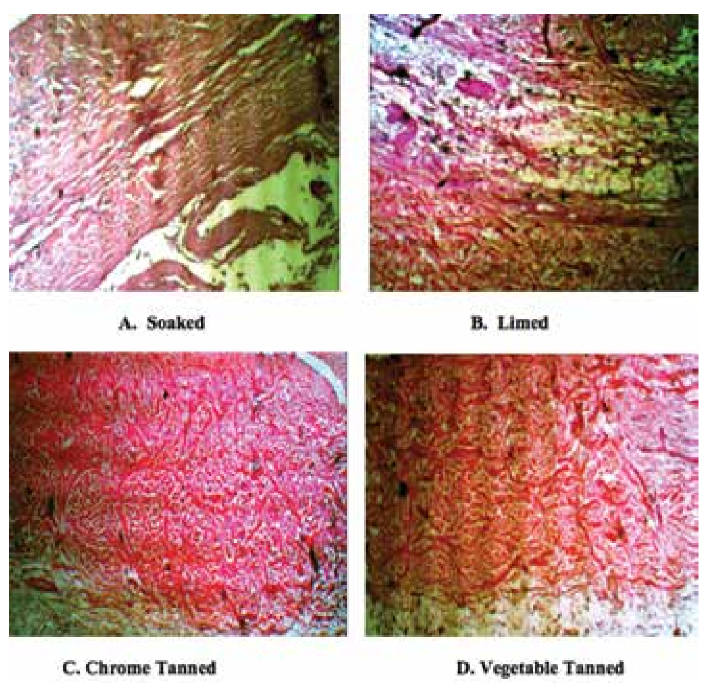

Figure 3 Optical microphotograph of chicken leg skin soaked (A), Limed (B), Chrome Tanned (C), Vegetable Tanned (D)

at a magnification of 30x is also presented in Figure 5 and this reveals that chicken leg leather does not contain follicles.

Physical Testing and Visual Assessment Data

The strength properties of chicken leg crust leathers are given in Table VI. 20 pieces of crust leathers (both chrome and semi-chrome) were subjected to tensile strength analysis. The mean of twenty values is given in the table. The tensile strength is similar for both chrome tanned and semi-chrome crust leathers. The percentage elongation for chicken leg leather is less compared to other conventional species used for leather making. But the property would be considered as an advantage, where the leathers for making goods need a minimum value of percentage elongation. Visual assessment data of crust leathers presented in Table VII reveals that fullness, grain pattern and feel are better for semi-chrome leathers compared to chrome tanned leathers. The mimosa vegetable tanning produces more exquisitely raised grain pattern in chicken leg skin, which is absent in the case of chrome tanned leather.

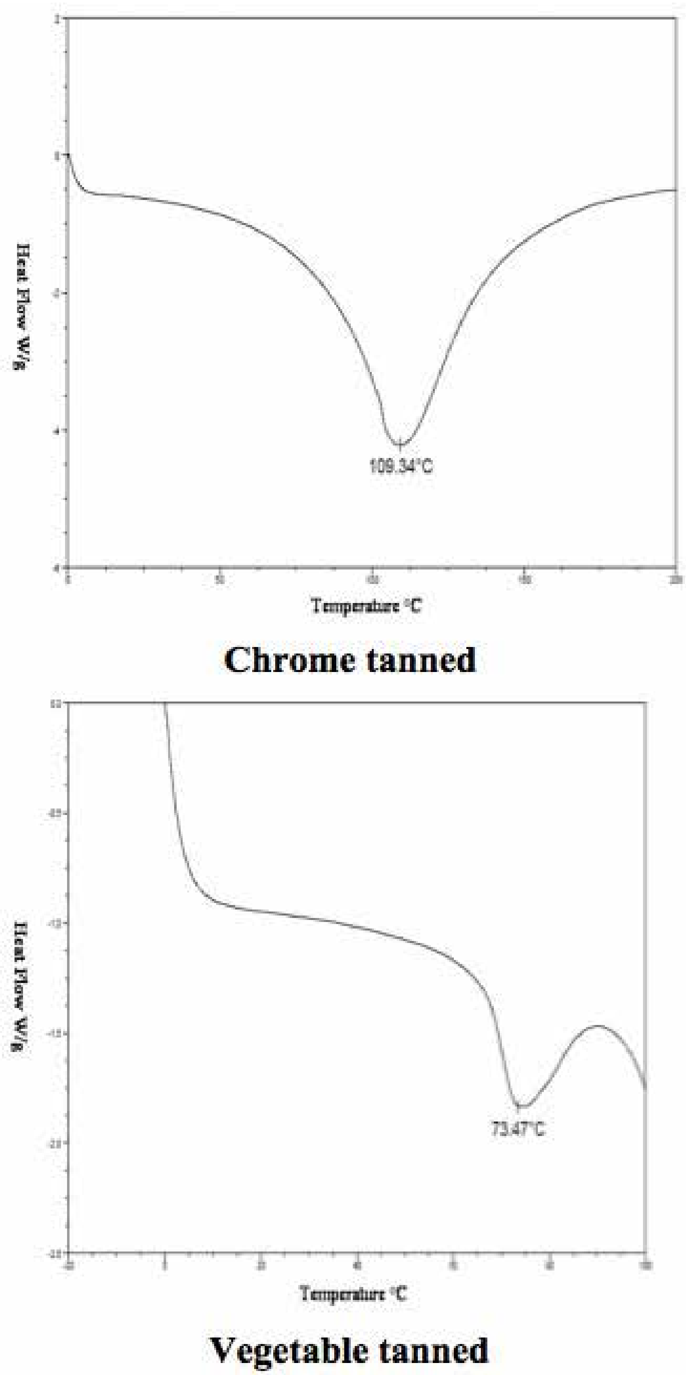

Figure 4. Optical microphotograph of chicken leg skin soaked (A), Limed (B), Chrome Tanned (C), Vegetable Tanned (D).

Table VI
Physical testing data.

Parameter	Chrome Tanned	Semi-chrome
Tensile Strength Kg/cm^2	98 ± 3	96 ± 2.5
% Elongation	21 ± 1.5	16.5 ± 1

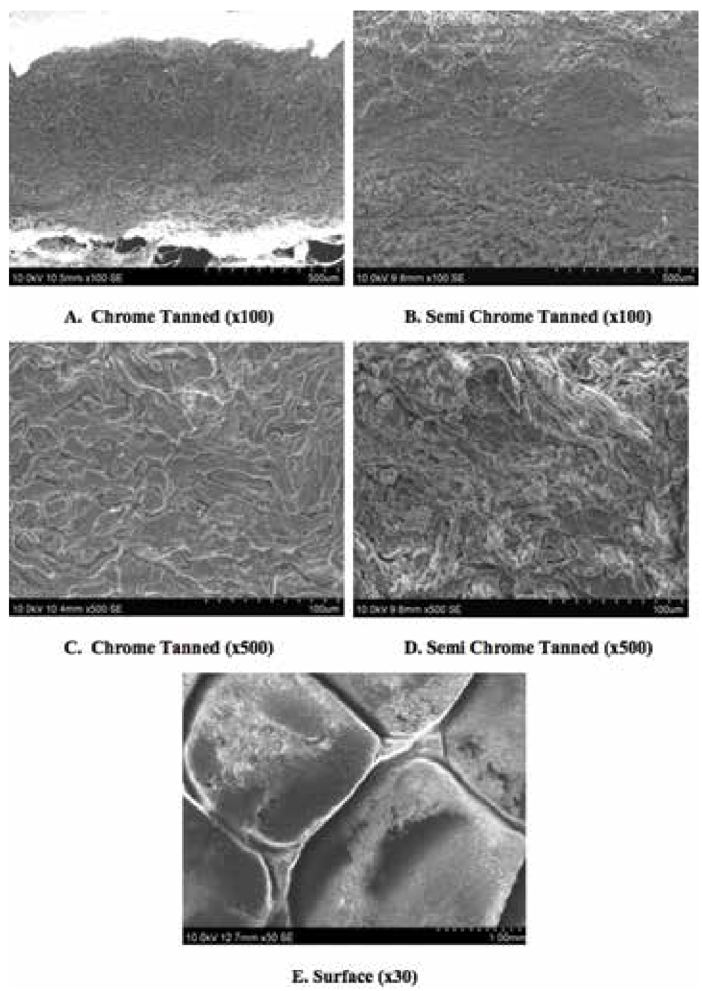

Figure 5. Scanning electron microphotographs of chicken leg leather A. Chrome Tanned (x100), B. Semi chrome Tanned (x 100), C. Chrome Tanned (x500), D. Semi chrome Tanned (x 500), E. Surface (x30).

Table VII
Visual assessment data (scale 1-10).

Properties	Chrome Tanned	Semi-chrome
Fullness	6	8
Grain Pattern	6	9
Uniformity of Colour	8	8
Feel	6	8
General Appearance	7	9

Table VIII
Physical characteristics of chicken leg leather.

Properties	Chicken Leg Leather
Length	13-15 cm
Width	3.5-4.5 cm
Thickness	0.8 -1.2 mm

Figure 6. Photographic picture of finished chicken leg leather.

Figure 7. Products made from chicken leg leather.

General Features of Chicken Leg Skin Leather
The thickness, length and width of the raw leg skin ranges from 0.8 to 1.2mm, 13 to 15cm and 3.5 to 4.5cm respectively. The unique and uniform surface pattern or "grain" is a major attractive feature of the leather, making it more valuable, even though the area is very less. The leather with beautiful grain structure (similar to reptiles) can be used for the production of decorative ornamental goods. The photographic picture of finished leathers and the goods made from chicken leg leather is presented in Figures 6 and 7 respectively. The general physical characteristics of chicken leg leather are presented in Table VIII.

Conclusion

A process technology for the production of chicken leg leather has been standardized in the present investigation. The process involves the use of sodium hydroxide in liming and good degreasing to remove high amount of natural fat present in the skin. Vegetable tanning followed by chrome tanning was found to be the ideal tanning system as it produces fuller and softer leather with exquisitely raised pattern compared to chrome tanning. On the whole, the present study can open up a new avenue for global leather in the form of a new source of raw material, which hitherto has been mostly neglected and wasted.

References

1. USDA/FAS. (2010). National Agricultural Statistical Board, United State Department of Agriculture, Foreign Agriculture Service, Washington, DC.

2. Karthikeyan, R., Chandra Babu, N.K., Mandal, A.B. and Sehgal, P.K.; Soft leathers from *Himantura* stingray skins. *J. Soc. Leather Technol. Chem*. **93**, 108-113, 2009.
3. Karthikeyan, R., Chandra Babu, N.K., Mandal, A.B. and Sehgal, P.K.; A new depigmentation and fibre opening method for the conversion of stingray skins into leathers. *JALCA* **105**, 25-32, 2011.
4. Karthikeyan, R., Chandra Babu, N.K., Mandal, A.B. and Sehgal, P.K.; Keratin-Silica Matrix – A New protein filler from chicken feathers for retanning. *JALCA* **105,** 59-67, 2011.
5. Karthikeyan, R., Chandra Babu, N.K., Sehgal, P.K. and Mandal, A.B.; Chromium-Keratin Tanning Compound – Preparation, Characterization and Application in Tanning Process. *JALCA* **107**, 149-158, 2012.
6. SLC 7: Determination of Total Nitrogen and Hide Substance, In: Official methods of analysis, *The Society of Leather Technologists and Chemists,* Northampton, 1996.
7. SLC4: Determination of substances (fats and other solubles) soluble in dichloromethane In: Official methods of analysis, *The Society of Leather Technologists and Chemists,* Northampton, 1996.
8. Covington, A.D.; An explanation of an hydrothermal stability anomaly in some chrome tanned leathers. *J. Soc. Leather Technol. Chem*. **72**, 30-31, 1988.
9. Covington, A.D.; The effects of processing conditions on the hydrothermal stability of chrome leather – part I. constant tanning conditions then ageing'. *JALCA* **86**, 376 – 405, 1991.
10. Naghski, J., Wisnewski, A., Harris, E.H. and Witnauer, L.P.; Correlation of differential thermal analysis data with the shrinkage temperature of collagen and leather. *JALCA* **61**, 64-74, 1966.
11. IUP 6: Measurement of tensile strength and percentage elongation. *J. Soc. Leather Technol. Chem*. **84**, 317-321, 2000.
12. Abedin, M.Z. and Riemschneider, R.; Chicken skin collagen-molecular diversity and susceptibility to neutral proteinases. *Pharm. Ind*. **46**, 532–535, 1984.