Journal of Agriculture and Value Addition
June 2023, Vol. 6(1): 42-50
https://doi.org/10.4038/java.v6i1.68

RESEARCH ARTICLE

Development of leather from the skin of yellowfin tuna (*Thunnus albacares*) and Asian sea bass (*Lates calcarifer*) using an environmentally friendly tanning technique

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Submitted: March 31, 2023; Revised: May 08, 2023; Accepted: May 30, 2023
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ABSTRACT

Yellowfin tuna (Thunnus albacares) and Asian sea bass (Lates calcarifer) are highly demanded export fish species in Sri Lanka. The objective of the present study was to prepare leather from the skin of T. albacares and L. calcarifer using tanning media prepared with black tea (Camellia sinensis) powder and table salt (NaCl). Black tea powder and table salt concentrations were increased by 10 grams (initial weight; 10 gL^{-1}) and 1 gram (initial weight; 1 gL^{-1}), respectively each day for 12 d. Skins were dipped in each concentration for 24 hrs. After additional water was removed, vegetable oil-applied skins were stretched and air-dried at room temperature. The percentage of ash, fat, protein, and tensile strength of the leather prepared from L. calcarifer skin was significantly higher ($P<0.05$) compared to leather prepared from T. albacares skin. The percentage of moisture, average thickness, and tear strength of the leather prepared from the T. albacares skin were significantly higher ($P<0.05$) than the leather prepared from L. calcarifer skin. According to the ΔL^*, Δa^*, and Δb^* values, leather prepared from T. albacares skin has lighter, greener, bluer and L. calcarifer skin has darker, greener, yellower colours respectively. There are no significant colour differences between prepared leathers ($P>0.05$). Sensory evaluation results indicated that, finishing, appearance, handling, and overall acceptability, of leather wallet prepared from T. albacares has higher consumer acceptance. The study demonstrated the effectiveness of this novel method for preparation of leather from T. albacares and L. calcarifer skin. In conclusion, T. albacares skin is more suitable for fish leather preparation using the above described tanning method.

Keywords: *Fish leather, Thunnus albacares, Lates calcarifer, Non-Chromium salt tannin, Value added product*

INTRODUCTION

Processing of fish results more than 60% of waste products (e.g., damaged fish, fish trimmings and other wastage including scales, skins, heads, bones, viscera) depending on the processing level (Chalamaiah, *et al*., 2012). However, bulks of these materials are released into the environment resulting in environmental pollution and health-related issues due to the loading of high organic matter content (Sasidharan *et al*., 2020). These wastes are useful raw materials, which can be used to produce other types of value added products such as chitin, oil, peptides, collagen, gelatin, fish bone powder, and enzymes (Coppola, *et al.,* 2021).

The preparation of leather goods from animal skins has a long history. The majority of leather goods available today are made of skin from cattle, pigs, alligators, *etc*. It poses a menace, particularly to snakes and alligators. Some people have religious objections to goods made from cattle. Moreover, there are environmental issues related to the use of some animal skins. Therefore, use of fish skin to produce leather is of great interest today as an alternative solution to protect the endangered animals and for the scarcity of conventional type raw materials (Sasidharan *et al*., 2020). Leather prepared from fish skins is used to prepare handbags, clothing, and shoes. Products manufactured from fish leather are in greater demand in the international market (Palomino, *et al*., 2021).

Yellowfin tuna (*Thunnus albacares*) and Asian sea bass (*Lates calcarifer*) are highly demanded fish species in the export market of Sri Lanka. *T. albacares* is directly harvested from the ocean; nevertheless, *L. calcarifer* is cultured in ponds and cages. Generally, these species undergo preprocessing before they are sent to the export market. These processing activities result in different types of fish byproducts, which are usually discarded by the majority of Sri Lankan fish processing facilities. As such, there is a high potential to utilize the skins of these fish to produce leather and other related value-added items.

The process of turning skin into leather is known as tanning. Conventionally, the basic Chromium Sulfate tannin and vegetable tannin methods are used in the leather production industry. The basic Chromium Sulfate tannin method is still the most popular but, large discharges of Chromium and Sulfate ions are associated with this method (Thanikaivelan, *et al*., 2005). The heavy metal chromium (Cr), which is naturally occurring and frequently utilized in industrial operations, is one of the most toxic heavy metals (Prasad, *et al.,* 2021). Inhaled Cr (IV) form can cause lung cancers in humans (Pinto *et al*., 2019). Gupta, *et al* (2019) stated, even at low concentrations, exposure to Cr (VI) affects fish reproduction, damages their DNA, and shortens their lifespan. In addition, it accumulates on their gills, penetrates their bodies, and has fatal effects on their liver and kidney. Therefore, it is very important to develop an environmental friendly, low cost tannin method for leather preparation. Black tea (*Camellia sinensis*) consist with theaflavins and thearubigins which are responsible for producing orange red and red brown colours respectively (Kumar, *et al.,* 2013). El-Aswad *et al* (2022) have been shown that black tea powder (*C. sinensis*) has high tanning content ($15.7g100g^{-1}$ dry matter). The objective of the current study was to prepare leather from the skin of *T. albacares* and *L. calcarifer* using an environmentally friendly and low-cost tanning procedure.

MATERIALS AND METHODS

Leather preparation

The present study was carried out at the laboratory of the Department of Aquaculture and Aquatic Resources Management, University College of Anuradhapura, Sri Lanka. Skins of the *T. albacares* and *L. calcarifer* were collected from a local seafood processing factory. Skin samples were transported to the laboratory in ice boxes. Once transported, skins were frozen under -18 ºC until used for product development. After cleaning the defrosted skins, leftover flesh and scales were removed. The initial weights of skins were recorded afterwards. Black tea powder (*C. sinensis*) and table salt (NaCl) were used to prepare the tannin media as shown in Table 1. After adding black tea powder and table salt to boiling water, the mixture was cooled to room temperature and filtered. The skin samples were kept submerged for 24 h in each tannin media concentration. Each day, cross section of three samples from each skin was examined using a dissecting microscope to assess the penetration level of the tannin. After the tannin procedure, extra water on the skins was removed using paper towels. Vegetable oil (5-10 ml) was applied on the outer surface of each skin in order to provide lubrication and prevent cracking. Later, skins were stretched by hand, and hung in a dry, shaded place at room temperature for five days.

Table 1: Weights of tea leaves powder and edible salt used to prepare tannin media

Days	1	2	3	4	5	6	7	8	9	10	11	12	13
Weight of tea powder (gL^{-1})	10	20	30	40	50	60	70	80	90	100	110	120	130
Weight of edible salt (gL^{-1})	01	02	04	06	08	10	12	14	16	18	20	22	24

Physicochemical parameters analysis

Moisture, ash, and protein contents of prepared leather samples were analyzed using AOAC (2000) procedure. To estimate the moisture content, samples were dried in an oven (Memmert UF-450; Schwabach, Germany) at 105 ºC for 12-16 h. Macro Kjeldahl analysis was used to determine the Nitrogen percentage (Raypa Distiller DNP-2000; Barcelona, Spain). The ash contents were determined by burning the samples at 550 ºC for 12-16 h in a muffle furnace (Labtech LEF-P Type; Kyonggi-do, South Korea) until a steady weight was reached. The method outlined by Folch *et al* (1957) was used to determine the lipid content. Colour was measured by using colorimeter (Konica Minolta CR-20; Osaka, Japan). Using L^*, a^*, and b^* values, total colour change was measured. The digital veneer caliper (least count; 0.01 mm) was used to measure the thickness of the leather. Tensile strength was measured using tensile strength analyzer (Yaohua C8; Taichung City, Taiwan). The samples of produced leather were evaluated for tear strength using the "ISO 3377-2: 2015 Leather Physical & Chemical test" at the Industrial Technology Institute of Sri Lanka. Tear strength was analyzed using tensile tester (Testometric M250-2.5kN; Rochdale, United Kingdom). Five samples of each leather were used for the tear strength analysis. All the other physicochemical parameters were measured in triplicates.

Fancy leather products development and sensory evaluation

The processed fish skins were used to make gents' wallets (Figures 1A & 1B). According to the selected design, all parts of the wallets were drawn on a piece of card board and those parts were cut using a sharp knife. Leather was bonded on card board designs using a commercial glue and kept for 15 min. Later, leather was cut using a sharp knife and wallets were fabricated using needle and strings. On a five-point Hedonic scale, consumer preference for prepared leather items was evaluated. Fifty individuals were randomly selected from staff members and students of the University College of Anuradhapura, Sri Lanka as the evaluation panel. Based on the product's appearance, handling, finishing, and general acceptability, they were asked to rank their preferences on a scale of 1 to 5 (Highest score 5 and lowest score 1) (Zhi *et al.*, 2016).

Statistical analysis

Data were analyzed using independent sample t-test at 95% confidence level using the SPSS software package version 16.0 (New York, United States of America).

RESULTS AND DISCUSSION

The physicochemical properties of the prepared leathers are presented in the table 2. According to the physicochemical analysis, percentage of ash, fat, protein, and tensile strength of the leather prepared from *L. calcarifer* skin is significantly higher ($P<0.05$) than the leather prepared from *T. albacares* skin. Moisture percentage, average thickness, and tear strength of the leather prepared from the *T. albacares* skin is significantly higher ($P<0.05$) than the leather prepared from *L. calcarifer* skin. According to the ΔL^*, Δa^*, and Δb^* values, leather prepared from *T. albacares* skin has lighter, greener, bluer and *L. calcarifer* skin has darker, greener, yellower colours respectively. ΔE values show that there is no significant colour difference between the leather prepared from *T. albacares* skin and the leather prepared from *L. calcarifer* skin ($P>0.05$).

Table 2: Physicochemical properties of the prepared leathers (Mean ± Standard Deviation)

Fish spp.	Ash (%)	Moisture (%)	Fat (%)	Nitrogen (%)	Average thickness (mm)	Color difference				Tear strength (N)	Tensile strength (kgcm^{-2})
						ΔL^*	Δa^*	Δb^*	ΔE^*		
T. albacares	2.75 ±0.13^{b}	10.06 ±1.04^{a}	12.83 ±1.60^{b}	6.03 ±0.32^{b}	1.57 ±0.15^{a}	5.46 ±1.96^{a}	-4.51 ±0.50^{b}	-1.55 ±0.07^{b}	7.34 ±1.44^{a}	173.08 ±50.96^{a}	29.12 ±7.11^{a}
L. calcarifer	8.51 ±1.23^{a}	6.18 ±0.96^{b}	76.43 ±4.90^{a}	7.80 ±0.24^{a}	1.27 ±0.49^{a}	-8.72 ±0.62^{b}	-2.63 ±0.26^{a}	0.80 ±0.51^{a}	9.15 ±0.62^{a}	93.84 ±30.88^{b}	45.17 ±10.24^{a}

Values with similar superscripts column-wise are not significantly from one another (P>0.05).

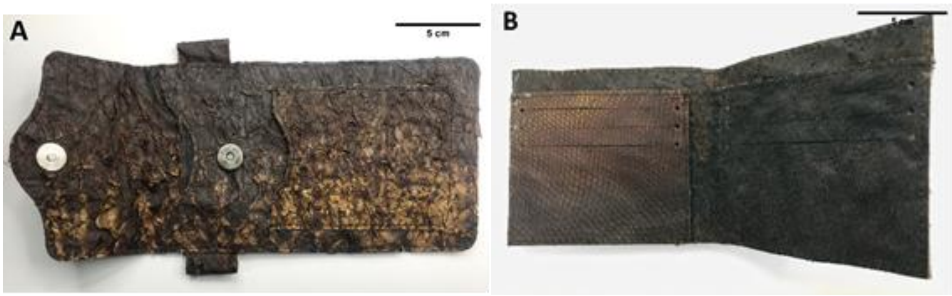

Figure 1: Leather products prepared from (A) *L. calcarifer* and (B) *T. albacares* skin.

Moisture, protein, fat, and ash contents of the raw skin of Basa (*Pangasianodon hypophthalmus*) were 63.29%, 23.2%, 13.07%, and 0.94%, respectively (Sasidharan *et al.*, 2020). Results of the present study show, leather prepared from *T. albacares* skin has lower moisture content (10.06 ± 1.04), lower Nitrogen content (6.03 ± 0.32), lower fat content (12.83 ± 1.60), and higher ash content (2.75 ± 0.13) than the *P. hypophthalmus* skin. Also, the leather prepared from the *L. calcarifer* skin has lower moisture content (6.18 ± 0.96), lower Nitrogen content (7.80 ± 0.24), higher fat content 76.43 ± 4.90, and higher ash content (8.51 ± 1.23) than the *P. hypophthalmus* skin.

Kuria *et al* (2016) used the barks of *Acacia nilotica*, *Acacia xanthophloea*, and *Hagenia abyssinica* as tannin medias for sheep skin. Tear strength/N, of the leather tanned with A. *nilotica, A. xanthophloea*, and *H. abyssinica* were 42.67 ± 7.09, 34.92 ± 4.22, and 31.25 ± 3.94 respectively. Results of the present study show comparatively higher tear strength values (*T. albacares*; 173.08 ± 50.96 and *L. calcarifer* 93.84±30.88) of the leather tanned with *C. sinensis* and table salt mixture compared to the sheep skin tanned with the barks of *A. nilotica*, *A. xanthophloea*, and *H. abyssinica.*

Tannins mainly consist with a mixture of polyphenols. Hydroxyl and carboxyl groups of the tannin compounds make strong complexes with protein and other macromolecules and convert the skin in to a durable material. *C. sinensis* powder has high tanning content (15.7g100g^{-1} dry matter). Table salt reduce the moisture content and prevent the bacterial growth (Kanth *et al.,* 2008). Both *C. sinensis* powder and table salt are common and cheap materials that are abundantly available in the Sri Lankan market.

Results of the sensory evaluation (Figure 2) showed that *T. albacares* skin leather has higher consumer acceptability than the product prepared from *L. calcarifer* skin in terms of finishing, appearance, handling, and overall acceptability.

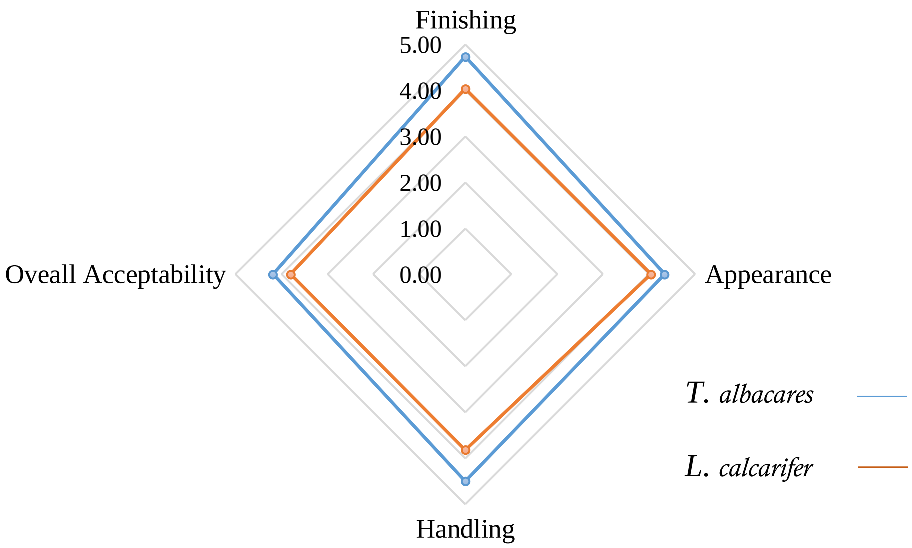

Figure 2: Spider diagram of sensory evaluation based on five -point Hedonic scale

Chromium tannin produce soft, bright-shade, and high wet heat resistance leathers within short time period. Due to these reasons, Chromium tanning is commonly used for the large scale leather productions (Covington, 1997). Eakanayake *et al* (2015) have been shown entire chrome treatment with 18% fat-liquor concentration can be used to convert yellow fin tuna skin into garment type leather. Results of the present study show, tannin media prepared from *C. sinensis* leaves powder and table salt can be used to prepare fish leather from *T. albacares* and *L. calcarifer* skin without using Chromium tannin.

According to the ΔL*, Δa*, and Δb* values, leather prepared from *T. albacares* skin has lighter, greener, bluer and *L. calcarifer* skin has darker, greener, yellower colours respectively. There are no significant color differences between prepared leathers ($P>0.05$). Based on visual observations, *T. albacares* leather was appeared in dark brown color and *L. calcarifer* skin was appeared in golden brown colour. Artificial pigments were not used to enhance the skin color during this study.

The present study proves that *T. albacares* and *L. calcarifer* skins can be converted into leather using an environmentally friendly tannin procedure.

CONCLUSIONS

In conclusion, leather prepared from *T. albacares* and *L. calcarifer* skins can be considered as a high-quality raw material for leather industry. Tannin media prepared from *C. sinensis* leaves powder and table salt can be used to replace commercial tannin media used in the leather production industry. *T. albacares* skin is more suitable for fish leather preparation using the above described tanning method.

ACKNOWLEDGEMENT

The authors would like to thank the Department of Aquaculture and Aquatic Resources Management, University College of Anuradhapura, Sri Lanka for providing facilities to conduct this research.

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