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Organic Chemistry: Current Research

Research Article

Sky Fruit Seed Crush (SFSC): A Potential Source of Less Salt Curing of Raw Goatskin

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ABSTRACT

The curing of raw hides and skins using sodium chloride salt is a widely recognized technique, although it has negative consequences for the environment by elevating water salinity and introducing a significant amount of Total Dissolved Solids (TDS). In order to tackle this issue, goat skin was conserved through the utilization of a mixture consisting of crushed sky fruit seeds and sodium chloride salt. Various ratios of mixtures were applied to raw goat skin to determine an optimal outcome. The most favorable result was achieved by utilizing a blend of 10% seed crush and 10% salt, based on the weight of the raw skin. A control specimen was run with the experimental specimen, and preservation-related variables such as odor, hair loss, shrinkage temperature, moisture level, and bacterial population were evaluated. After preservation, the experimental sample and a control sample were subjected to the standard leather processing technique. The liquor from both samples was analyzed to confirm the impact of the environment on preservation. The experimental trial indicated a 59% decrease in Total Dissolved Solids (TDS) and a 44% reduction in chloride (Cl^-) content. The processed leather samples were assessed for their quality through an analysis of their physical properties. Besides, the fiber structures were assessed using a Scanning Electron Microscope (SEM). The comparative evaluation of the physiochemical properties of the introduced preservation showed superb results with the hope of new preservation possibilities.

Keywords: Sky Fruit Seed Crush (SFSC); Hides and skins; Preservation; Sodium salt; putrefaction; organoleptic properties.

INTRODUCTION

Preservation or curing is the primary stage of leather processing where an appropriate conservation technique is followed within 5-6 h after the death of the animal or flaying the skin to desist putrefaction [1]. Amongst dozens of preservation methods commonly practiced techniques are salting, drying, cooling and chilling [2]. Salting is the most popular leather conservation which includes application of 40-50% common salt (based on the green weight of skin) on fresh hides and skins [3]. Since, approximately 13-17% salt is fixed into the hide and skins, the excess unabsorbed salts are disposed into nearby rivers in form of waste water during de-salting and soaking operations in tanneries [4]. This provides the initial pollutants to the aquatic ecosystem and includes addition excessive amount of chlorides, sulfides and TDS [5]. Consequently, immense degradation of water occurs which severely affects the aquatic life and enters into human food chain [6]. Besides, an adverse effect on crop production appears due to deterioration of soil fertility [7]. In addition to that, there is extreme possibility of blending of chlorides with deeper groundwater which will result in adverse phenomenon for human civilization [8].

Hence, there is a strong appeal among scientific communities to introduce environment friendly leather preservation recipes.

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Received: 13-Nov-2023, Manuscript No. OCCR-23-28046; **Editor assigned:** 16- Nov -2023, PreQC No. OCCR-23-28046 (PQ); **Reviewed:** 01-Dec-2023, QC No. OCCR-23-28046; **Revised:** 08-Dec-2023, Manuscript No. OCCR-23-28046 (R); **Published:** 15-Dec-2023, DOI: 10.35841/2161-0401.23.12.346.

Citation: Razzaq MA, Rahman MM, Rahman MM (2023) Sky Fruit Seed Crush (SFSC): A potential Source of less Salt Curing of Raw Goatskin. Organic Chem Curr Res. 12:346.

Traditional leather conservation techniques were based on physical treatments or application any substance on leather with a view to either destruct bacteria or prevent bacterial action [9]. Phyto-based organic preserving agents are abundantly available and a potential source of diminishing pollution load occurring in leather soaking [10]. A noticeable aptitude of phyto-based techniques to preserve raw hides and skins has been proposed in recent scientific articles. Diverse parts of plant *viz*. leaf paste of *Acalypha indica* [11], dry leaf powder of *Calotropis gigantean* [12], seed oils [13], peels etc. has been being introduced by researchers in this regard.

Swietenia macrophylla, is a locally available timber tree and commonly known as mahogany tree [14]. Although native to the west Indies, it has been expanded in southern Asia (India, Srilanka, Bangladesh) and in the pacific (Malaysia, Philippines, Indonesia and Fiji), and West Africa by plantation [15]. Mahogany roots, barks, seeds etc. have been used for the treatment of hypertension, diabetes, malaria, amoebiasis, coughs, chest pain and tuberculosis, and as an abortifacient, antiseptic, astringent, depurative, and tonic [16]. The synthesis of modified triterpenes known as limonoids Figure 1, which contain a 4,4,8-trimethyl-17-furanyl steroid skeleton, distinguishes the mahogany (Meliaceae) family [17].

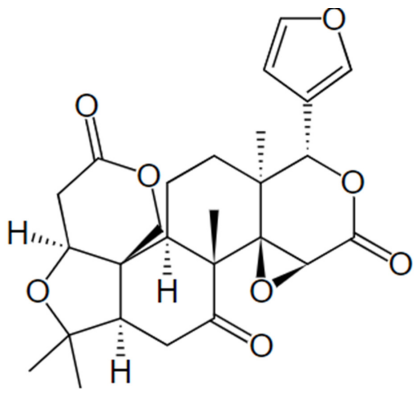


Figure 1: Structure of limonoids produced by plants of Meliaceae family.

Presence of triterpenoids in mahogany family is an important constitutive and defensive substance against microbes [18]. The antimicrobial properties of different parts of Swietenia mahagoni has been reported in many research articles[19,20] Therefore, Mahogany seed oil has got application in agricultural field to control pesticides and leather preservation [17]. In this research, powdered form of the fruit of *Swietenia macrophylla* which is also named as sky fruit has been utilized to preserve raw goat skin with a view to develop a low salt preservation technique. The preserved skin was continuously assessed during the preservation period and allowed to treat by traditional processing technique.

MATERIAL AND METHODS

Collection of skin and chemicals

After purchasing freshly flayed goat skin samples from a local trader, the samples were washed in water to remove impurities such as dirt, filth, blood, and other substances. After that, the skin was hung for a few minutes so that the water could drain off. Tannery Estate in Savar, Dhaka was the source of all of the utilized chemicals and auxiliaries, all of which were of a commercial grade and purchased there. For the determination of the biochemical and pollution index, chemicals of analytical grade were utilized.

Preparation of SFSC

The sky fruits were gathered from the plantation region of the Leather Research Institute, and once the pods were opened, the fruits were found inside. After the seeds had been peeled, they were left out in the sun for two full days to dry. After that, the seeds were grounded into a fine powder with an analytical grinder and stored at room temperature Figure 2.

Figure 2: Sky fruit tree with fruit, peeled seeds and crushed seed powder.

FTIR analysis of skin samples

To find out the functional group of the SFSC a Perkin-Elmer FTIR spectrophotometer with UATR was employed. The obtained absorbance from the FT-IR spectra of the samples was recorded and studied according to the literature [21,22]. The stored powder was directly placed on the additionally outfitted with a ZnSe-diamond crystal of FTIR which enables the acquisition of FTIR spectra directly from a sample without the need for additional sample preparation [23].

Application of SFSC for curing

During our preliminary lab assessment, variable twelve (12) ratios (w/w) of SFSC and salt mixture ware applied on several portions of freshly flayed goat skins as follow to find out the optimum proportion for the preservation during initial trial for about 30 days.

All measurement was taken based on the weight of raw skin. Organoleptic properties *viz*. odor, hair slip, and moisture content of all the samples were assessed periodically. All samples were kept in same environmental condition and temperature. The preservation parameters *viz*. moisture content (%), bacterial count, hair slip, odor, shrinkage temperature and extractable nitrogen were assessed periodically (raw, 1st, 4th, 7th, 15th and 30th days of preservation). Desired combination was identified on the evaluation of preliminarily preserved goat skins. The salt and SFSC utilized during determination of organoleptic properties *viz*. Hair sleep, odor and physical feel have been illustrated for a full observation period of 30 days in the Table 1. Among the twelve preserved samples one sample with supreme performance was selected for final trial. During final assessment, a single section of recently removed goat hide was acquired. One side of the setup was designated for the experimental group, while the other side was designated for the control group.

Moisture content of skin samples: During days of assessment, small pieces (1-2 g) of skin samples were cut and placed on the sample pan to determine moisture content by using a high-performance moisture analyzer model WBA-110M.

Nitrogen content of skin samples: To quantify total extractable nitrogen, 5 g sample from the preserved skins were taken and treated with ten times (w/v) its weight of distilled water into a conical flask. The flask was shaken at 200 rpm for 30 minutes by keeping it on a shaker. Then the liquor was filtered through a filter paper and transferred to the digestion unit of kjeldhal chamber allowing its temperature to 400°C. The sample was then distilled over into a receiving flask containing 50 ml sodium hydroxide solution in the distillation chamber. Finally the nitrogen content was determined following titration method described in the literature [24].

Bacterial count of skin samples: Skin samples of known weight (5 g) were cut and processed through the nitrogen content determination procedure up to filtration at various stages of preservation. 1 ml of the filtrate was taken and diluted with sterile water to make 10 ml. The solution was thoroughly shaken to obtain identical bacteria suspension, and 0.1 ml was placed in a sterile petri plate. The sample was serially diluted up to the required colony formation level. Molten nutrient agar was added and carefully shaken to ensure that bacteria were distributed uniformly. Finally, petri plates were placed in an incubator for 48 hours at 37°C [25]. A bacterial colony counter (Bioevopeak CC-J2) was used to count the bacterial population.

Hydrothermal property: Shrinkage temperature indicates the hydrothermal property of hides and skins. It was determined by using SATRA TD 114 shrinkage temperature tester. Test samples (80 × 10 mm) were cut and hooked in the holder of shrinkage temperature apparatus which was then dipped in a bath containing a glycerin/water solution in the ratio of 70:30. The rate of temperature increment was 3°C/min. The skin's shrinkage temperature was recorded as the temperature at which the shrinkage began.

Leather making: After finishing continuous observation of the preserved skin whose duration was 30 days, both the preserved samples were processed up to crust leather by following conventional leather processing technique.

Analysis of pollution load: The wastewater in soaking operation generated from the control as well as experimental trial was collected and analyzed for Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS) and Chloride (Cl) content. The standard APHA methods were followed in analysis and all the experiments were triplicated [26].

Physical properties analysis: The prepared crust leathers were left about 1 month for aging. Physical strength of the leathers were determined after conditioning at temperature 23 ± 2°C and relative humidity 50 ± 2% for defined hours relevant to method. Then the samples were taken from the specified sampling location. The properties such as the tensile strength, elongation at break, tear strength, and bursting strength were assessed following SATRA TM 43, TM 162, and TM 24 respectively.

SEM analysis of skin samples: Processed wet blue leathers from the experimental and control trials were subjected to an electron microscope (VEGA3 TESCAN, Czech Republic) for evaluating their morphological characteristics. The fiber structures were assessed by enabling cross section of the leather and by accelerating voltage 30.0 kV with magnification 500X.

RESULTS AND DISCUSSIONS

Organoleptic properties

The initial indication of putrefaction comes about during the protein degradation process carried out by bacteria in the hair bulb during the early stages of decomposition [27]. Therefore, it is commonly accepted that odor emission and hair slip are important factors to consider when evaluating the effectiveness of a curing method, as they can serve as indicators of the beginning stages of the putrefaction process Figure 3.

Table 2 describes the properties of preserved leather during the preliminary trial. Sample A was for conventional control trial there was no change in result as estimated. 18% SFSC was applied to preserve the sample B and it was found hard after the preservation duration. Sample C, D, E and F had 10% SFSC and variable amount of salt. There was neither existence of hair slip nor formation of hard skin for these combinations. Sample G, H and I had 5% SFSC and variable amount of salt. The surfaces of these three tests showed signs of fungal growth, worms, and hair loss, as well as a slight putrid odor. J and L showed medium hard skin. Sample K has a combination of 25% salt and 5% SFSC. This combination was sustained in the trial.

Table 1: Percentage of salt and SFSC used for preliminary trial

Sample ID	A	B	C	D	E	F	G	H	I	J	K	L
Salt (%)	50	0	25	20	15	10	5	10	15	20	25	12.5
SFSC (%)	0	18	10	10	10	10	10	5	5	5	5	7.5

Figure 3: Skins Preserved with 10% NaCl+10% SFSC (Experimental trial) and 50% NaCl (Control trial).

Table 2: Organoleptic properties of goat skin preserved in preliminary trial

Sample ID	A	B	C	D	E	F	G	H	I	J	K	L
Odor	No	No	No	No	No	No	No	Yes	No	No	No	No
Hair slip	No	No	No	No	No	No	Yes	Yes	Yes	No	No	No
Physical feel	Soft	Hard	Soft	Soft	Soft	Soft	Soft	Soft	Soft	Medium soft	Soft	Medium hard

Although sample C, D, E, F and K showed brilliancy in preservation, the sample F consists of minimum amount of salt. Hence, considering minimum use of salt, we decided to proceed with the sample F for the final experimental trial holding combination of 10% salt and 10% SFSC.

FTIR analysis

FTIR spectroscopy can identify unknown substances, analyze chemical composition, study molecular structure, monitor chemical reactions, and investigate materials' physical properties. Pharmaceuticals, polymers, forensics, environmental science, and more use it [28]. FTIR peak of the SFSC has been labeled and depicted at the Figure 4. As seen the figure the Fourier Transforms Infrared (FT-IR) spectrum analysis result shows various functional groups. The occurrence of aromatic rings in flavonoids results in absorption peaks at approximately 3009 cm^{-1}, signifies the stretching of C-H bonds within the aromatic rings. Peak at 2923.18 cm^{-1} and 2853.69 cm^{-1} shows the presence of aliphatic groups. The absorption peak at 1742.55 cm^{-1} in the flavonoid structure corresponds to the stretching of the carbonyl group (C=O), specifically indicating C=O stretching. Presence of ester group at the wavelength 1709.92 cm^{-1} is for presence of fatty acid. Hence, it can be concluded that the SFSC could show strong antimicrobial effect on preservation

Moisture content

The durability, pliability, and aesthetic quality of leather goods depend on the leather's ability to withstand and be unaffected by moisture [29]. Fluctuation of moisture content of the experiment has been depicted on the Figure 5 where identical moisture content was observed for the fresh sample. After 1 day preservation duration, the moisture content of the experiment and control sample was found 54% and 57% respectively. The moisture content of the control trial exhibits a gradual decline, ultimately reaching a value of 35%. In contrast, the moisture content of the experimental trial decreases to 30% after a 30-day preservation period.

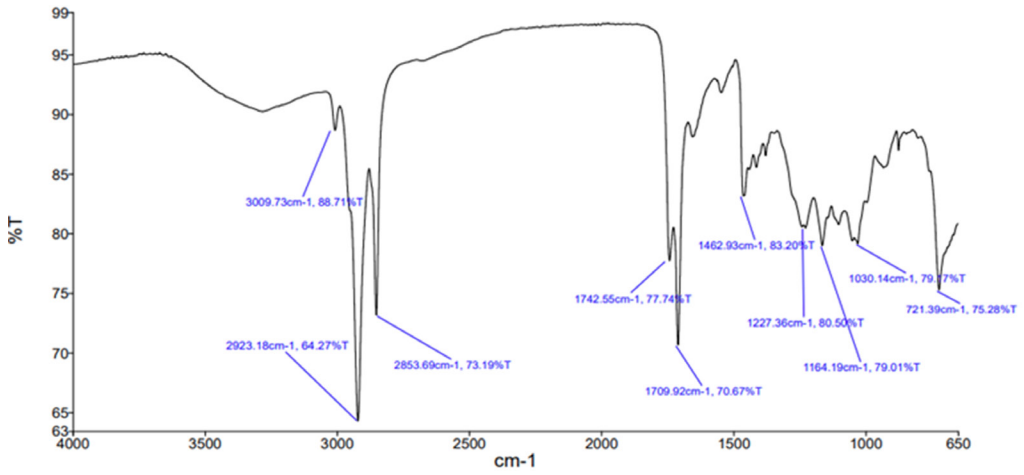


Figure 4: FTIR Spectrum of mahogany seed crush. The absorption peak at 1742.55 cm^{-1} in the flavonoid structure demonstrated the inhibitory effects of flavonoids on the proliferation and maturation of fungal pathogens.

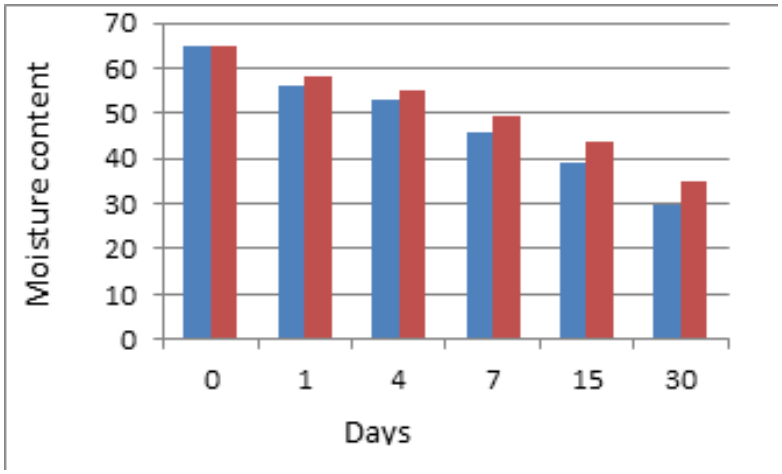


Figure 5: Moisture Content of preserved skins the moisture content of the experimental trial decreases to 30% after a 30-day preservation period which is unfavorable for bacterial growth. **Note:** (■) Experimental trial; (■) Control trial.

It is evident that the experimental trial dehydrates the sample approximately similar to the control trial. Moreover, comparatively lower moisture content of the preserved leather would facilitate minimizing transport cost as well as acceleration of antimicrobial activity [13]. The lower moisture content will also be helpful to inhibit bacterial growth on the preserved skin [12].

Nitrogen content

Bacterial decomposition of hides/skins produces extractable nitrogen [30]. The level of putrefaction caused by microorganisms can be determined by testing the hide or skin for extractable nitrogenous compounds. The total extractable nitrogen content of the experimental and control skins at varying times over a 30-day preservation period has been presented in the Figure 6. From the figure it is evident that the content of extractable nitrogen for the both trial was similar until the 7th day of preservation. This might be due to the harmonious preservation of the skin. At the end of 30 days the experimental sample discharged comparatively less amount of extractable nitrogen. The value of the both trial was very low and comparable with values of many similar preservation techniques. Hence, it can be expressed that the experimental preservative combination is in no risk of putrefaction.

Bacterial count

The deterioration status of hides and skins can be described by the number of bacterial colonies present on it at the time of preservation [13]. Table 3 presents the quantitative data on the bacterial colony count observed in the samples collected for monitoring and study purposes. The samples were obtained from fresh (raw) sources on the fresh, 1st, 4th, 7th, 15th, and 30th day of the experiment. In raw goat skin bacterial population was about 3×10^{8} CFU/g. The results revealed that the quantity of bacteria present in the experimental sample is comparatively lower than the control sample; both during the initial and final stages.

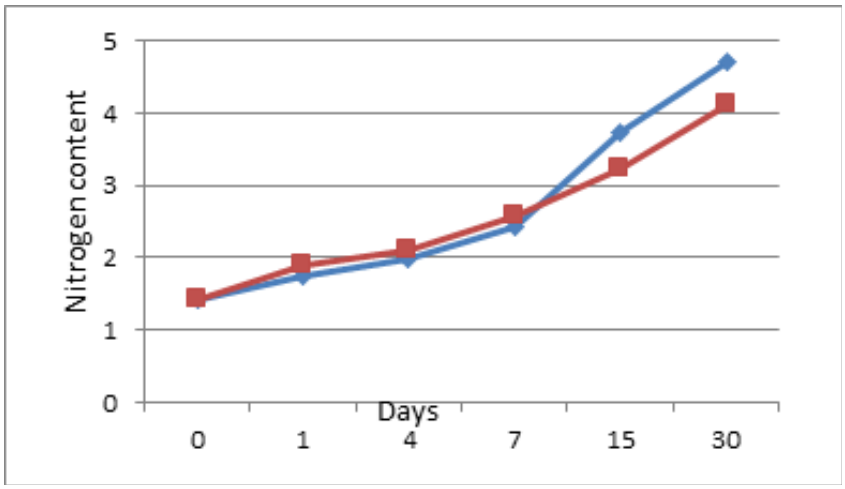


Figure 6: Nitrogen Content of preserved skins- lower value of the experimental preservative combination is in no risk of putrefaction. **Note:** (■) Experimental trial; (■) Control trial.

Table 3: Bacterial count in the preserved skins showed

Days	Experimental (CFU/g)	Control (CFU/g)
0	3×10^{8}	3×10^{8}
1	5.5×10^{7}	4×10^{8}
4	4×10^{7}	6.2×10^{7}
7	4.5×10^{6}	5×10^{7}
15	7×10^{5}	3.7×10^{7}
30	3.1×10^{5}	6.3×10^{6}

Shrinkage temperature

Shrinkage temperature serves as a barometer for any structural alterations in the skin matrix because putrefaction causes collagen to become less stable [31]. The shrinkage temperature is a quantitative assessment of the degradation of stabilising linkages present within the collagen matrix [32]. Shrinkage temperature variations of the both trials have been depicted at the Figure 7. The initial shrinkage temperature was 66°C. The shrinkage temperature value of the experimental trial stability was determined to be 68.50°C after a 30-day preservation period. In a similar manner, the control trial exhibited consistent results and ultimately reached a temperature of 67.70°C on the 30th day.

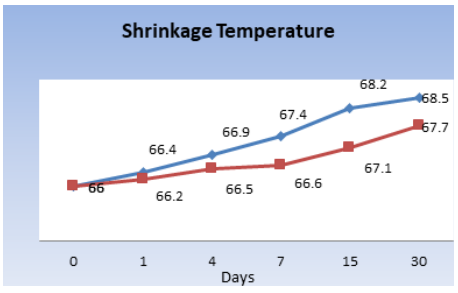


Figure 7: Shrinkage Temperature (°C) of preserved skins showed comparable value with control sample. **Note:** (■) Experimental trial; (■) Control trial.

The observed decrease in temperature, known as the shrinkage temperature, can be attributed to the disruption of the collagen intermolecular network. This disruption is characterized by the loss of long-range order. The thermal stability of collagen exhibits significant variability across different sources. The thermal properties of collagen exhibit variability depending on the specific curing agents and processing conditions employed [33]. Therefore, based on the data, it can be inferred that the developed curing system did not induce any adverse structural alterations in the skin matrix.

Pollution load analysis

To assess environmental effect of the experimental preservation, soak liquor was allowed to undergo few test parameters and has been illustrated in the Figure 5. The figure displays the pollution load generated during the soaking process of the optimized experimental and corresponding control samples, including BOD, COD, TDS, and chlorides. There were a significant reduction in TDS and chloride content. Since the 50% salt was used in the experimental trial, there was around 48% reduction in chloride content. On the other hand, approximately 43% minimization of Total Dissolved Solid (TDS) was obtained in the experimental trial. There was a comparable value of BOD. The COD value of experimental trial found slightly elevated it might be due to incorporation of any germane non-biodegradable compound during preservation Table 4.

Table 4: Pollution load analysis of soak liquor of preserved goat skin

Parameter	Experimental(g/L)	Control (g/L)	Reduction (%)
Total Dissolved Solid (TDS)	18 ± 0.17	42 ± 0.21	43
Chloride content (Cl-)	8 ± 0.11	16.5 ± 0.09	48
Biological Oxygen Demand (BOD)	1.4 ± 0.07	1.3 ± 0.08	-
Chemical Oxygen Demand (COD)	4.5 ± 0.06	4.7 ± 0.06	-

Physical properties study

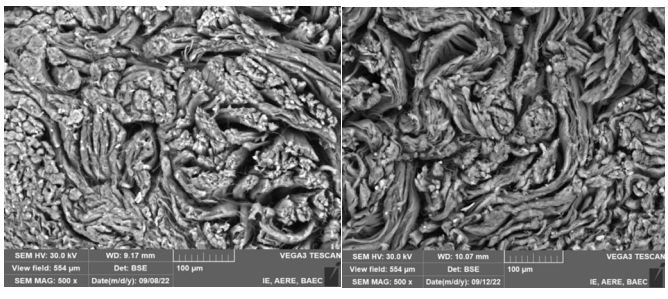
The tabulated physical properties in Table 5 indicate the physical strengths e.g., tensile strength, elongation at break, tear strength and grain crack of the experimental trial and the control trial. Values of both trials are much above the minimum requirement and comparable to each other. Hence, the SKFC preservation technique does not affect the physical properties of preserved skins.

Table 5: Physical properties of processed crust leather

Parameter	Experimental	Control	Standard requirement (ISO)
Tensile strength (kgf/cm^2)	285 ± 7	290 ± 7	200
Elongation at break (%)	50.6 ± 5	47.8 ± 5	30-40
Tear strength (N)	43 ± 6	46.2 ± 6	30
Grain crack strength (N)	22.2 ± 4	24.0 ± 4	20

SEM analysis

High-resolution imaging, surface analysis, examination of fibre structure, cross-section analysis, defect detection, and comparative studies are all made possible by SEM, making it an indispensable tool for the study of leather's form [34]. SEM images of the leather processed crust leather from all trials have been illustrated in the Figure 8.



A B

Figure 8: SEM images of processed wet blue goat skin showed no any significant change in the leather prepared from the experimental goat skin compared to the goat skin preserved with control trial. **Note:** A: SEM image of cross section of experimental trial; B: SEM image of cross section of control trial

CONCLUSION

In pursuit of attaining sustainable industrialization, diligent researchers are tirelessly endeavouring to render each industrial operation ecologically sound. This study aimed to explore the potential of utilizing Sky Fruit Seed Crush (SFSC) in conjunction with conventional salt as a means to decrease its overall consumption. The concept of utilizing phyto-based methods for leather preservation is an innovative proposition. The FTIR study found presence of flavonoids, ester and fatty acids in the experimental substance. Studies have demonstrated the inhibitory effects of flavonoids on the proliferation and maturation of fungal pathogens. These effects may manifest through diverse mechanisms, such as the disruption of fungal cell membranes, the interference with fungal enzymes, and the impact on fungal cell signalling [35]. Flavonoids possess antioxidant properties that aid in the mitigation of oxidative stress caused by fungal assault [36]. All ester and fatty acids show strong antimicrobial activity [22].

The experiment was conducted and compared with the conventional salt curing method. Similar to other phyto-based preservation techniques, this preservation method necessitates the utilization of a 10% concentration of crushed sky fruit seeds and 10% concentration of sodium chloride. Evaluation of Bacterial colony found advantageous. In the first day of preservation, the results indicate that the bacterial population in the experimental sample is comparatively lower than that of the control sample, during the preservation period. At the end of 30 days the bacterial population of experimental and control trial was 3.1×105 CFU/g and 6.3×106 CFU/g respectively. The decreased number of bacterial colonies might be due to the antimicrobial activities of the SKFC. Henceforth, it can be stated that there was stronger inhibition against bacterial propagation in the experimental trial.

The nitrogen content, moisture content, bacterial count, and shrinkage temperature properties of the leather preserved in the experiment were found to be satisfactory. The analysis of the immersed solution yielded remarkable findings. The preservation method demonstrated a significant impact on environmental pollution control, with the TDS accounting for 59% and salinity control accounting for 44% of the overall effectiveness. There was no statistically significant decrease observed in the levels of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

The Scanning Electron Microscopy (SEM) analysis revealed that the fibre structure observed in the experimental trial was similar to that of the control trial. It demonstrates that there is no any significant change in the leather prepared from the experimental goat skin compared to the goat skin preserved with control trial. This proves that the texture and quality of the goat skin were almost same in the introduced preservation method. As a result, it is possible to draw the conclusion that the developed fatliquor demonstrated efficiency during fatliquoring that was comparable to that of the control trial. The strength properties under consideration include tensile strength, tearing strength, and the percentage of elongation exceeding the specified value as outlined in the International Organization for Standardization (ISO) guidelines. The novel preservation technique with reduced salt content exhibited exceptional performance. Furthermore, sky fruit exhibits extensive availability and presently lacks tangible economic worth.

For a nominal charge, one can acquire the substance and employ a simple method of pulverization and amalgamation to render it suitable for the purpose of leather conservation. With a focus on environmental sustainability, we foresee the potential utilization of sky fruit extract in the preservation of leather materials.

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