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Research Article

Solid Leather Waste for Preparation of Value Added Composite Products: An Ethiopian Perspective -

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Abstract

The utilization of livestock by products like hides and skins in Ethiopia is limited due to different constraining elements such as deteriorated quality and in advanced technologies among others and these may result in huge waste generation. If these wastes are not managed properly can impose environmental and societal health problems. The objective of the present study therefore was, to prepare composites of solid leather waste incorporated with sisal plant fiber using three different binders namely synthetic resin, polyurethane and natural rubber latex. The composites prepared were characterized for their physical properties. In all of the binders 40 percent sisal composite in those prepared using resin binder, 40 percent in those prepared using polyurethane binder, and 30 percent sisal composite in those prepared using natural rubber latex had optimum values in their tensile strength (MPa) which is the major parameter. These prepared composites can be used for preparation of items like stiff hand bags, ladies' purse, keychain, chappal upper, wallet, wall cover, mouse pad and other interior decorating products. By preparing such value added products from solid waste leather, we can reduce solid waste; minimize environmental pollution and thereby securing environmental sustainability and/or can be used as income generation and employment opportunity.

Keywords: Ethiopia; Composit; Solid waste; Plant fiber; Binder

INTRODUCTION

In Ethiopia the recent livestock population estimates is about 57.83 million heads of cattle, 28.04 million sheep, 28.61 million goats and 60.51 million poultry that contributes 19 percent of GDP and 16-19 percent of the foreign exchange earnings of the country [1]. Poor quality of hides and skins, poor animal husbandry, improper preservation of hides and skins, lack of price incentives based on quality products, absence of quality grading at the time of purchase, reflections of the economic policy, be short of market information, and requirements from the tanneries and end market are main challenging elements observed in the hide and skin value chain [2], and these challenges enormously contribute to generation of huge amount of waste in the tanning industry.

The leather industry, though it is well-known in world leather trade, is blamed for its negative environmental health impact. This industry is highly environment polluting sector by generating organic and inorganic pollutants which may pose major challenge to the surroundings and ecosystem [3]. The environment now a days is under increasing pressure from solid and liquid wastes emanating from this industry because waste generation is an inevitable by-product of the leather manufacturing process and causes significant pollution unless treated in safe manners prior to it is being discharged [4].

The solid wastes generated during leather processing are significant since leather industry makes uses of only 20 -25 percent of the raw material in the finished leather, 75 -80 percent end up as wastes in the environment [5]. To reduce these threats, preparation of composite materials with better mechanical properties and agreeable use is a need of the time for the reason that it is eco-friendly [6]. Since finished leather scrap and used leather waste material contribute a major portion of solid leather waste, research on the conversion of this waste into useful value-added composite products for consumer application can be considered as means of generating income as well as an economically beneficial besides reducing environmental pollution.

The objective of the present study therefore is to:

- Prepare value added composite products, from finished leather waste and compare sisal fiber composites in terms of their mechanical properties using three different binders like resin, polyurethane and natural rubber latex binders.

MATERIALS AND METHODS

Materials

Finished leather scraps were collected from ELICO (Ethiopian Leather Industry Corporation). Synthetic resin, Polyurethane and Natural rubber latex, Polyethylene Glycol (PGE) and Al_2 (SO_4) were purchased from Addis Ababa chemical shops. The Plant fiber of sisal (Agave sisalana) was collected from Ethiopian shops in Addis Ababa and other chemicals used in this study were of Laboratory grade chemicals.

Methods

Preparation of Leather Fiber (LF) and Plant Fibers (PFs): Finished leather scrap was cut into small pieces of convenient size to use in the pulverizing machine (length 5–10 cm and width 2-3 cm) using Swing ARM Clicker (Porielli S. 20, VIGEVANOITALIA) and converted into leather fiber (LF) with the help of Hinged Hammer Pulverizing machine (Sturtevant, SDL868, USA). Similarly, all long uneven plant fibers were cut into small pieces to convert them into smooth and short fibers. The average fiber size ranged between 1.5 and 2.5 cm in length and 0.2-0.7 mm in width according to the procedure of [7].

Optimization of binders: Leather composite was prepared using leather fiber and three different binders namely Resin Binder (RB), Polyurethane Binder (PUB) and Natural Rubber Latex (NRL) at different levels of (30, 60, 90, 120 and 150 ml by volume) and tested for their tensile strength to take the optimum result and this optimum result (120 ml) was taken as reference for the binders.

Preparation of resin-leather composites: About 130 g of fiberized leather fiber was soaked in 1000 ml of water for 12 hr, minced three times to reduce the particle size in the food mincing machine (La Minerva C/E 680 N) (three times minced to reduce the particle size) and made into fine paste. To this paste 120 ml of RB, 10 ml of PEG and 4 percent of Al_2 $(SO_4)_3$ was added and mixed thoroughly. Later, 10 ml of 1:3 ratio diluted H_2SO_4 is added and pH adjusted to below 5 by thorough mixing, the mixture was diluted using 4000 ml water so that slurry was formed. Then the sample was poured into the sheet making machine of (30 cm by 30 cm) and wet composite was pressed using hydraulic press (polyhydron 4DL10SGS-10) at a pressure of 217.5 kPa for 10 s. The pressed composite was air dried and plated using hydraulic press at a pressure of 13,789 kPa at 80°C for 10s.

The procedure is the same for all except the change in binder i.e. RB was replaced PUB and NRL.

Characterization of control and composites: Waste Leather Scraps (WLS) and Composites (Cs) were characterized for their physical properties such as mechanical studies.

Mechanical properties: Mechanical properties were assessed using three dumbbell shaped specimens of 4 mm wide and 10 mm length. Tensile strength (MPa), elongation at break (percent) and stitch tear strength (N/mm) were measured using Universal Testing Machine (INSTRON model 3369) at an extension rate of 5 mm/min. Water absorption and desorption (percent) capacities of the different control leather and composite sheets were determined according to Sekar, et al. [8]. Flexing endurance was also assessed using SATRA fiber board flexing (TER 74) machine according to (STM 129) test method.

DATA ANALYSIS

Measurements on physical characteristics of control and composite sheets were recorded and mean values were compared between leather with fibers of sisal plant and different types of binders used. Descriptive statistics was employed using Statistical Package for Social Sciences (SPSS version 20) software as mean and standard deviation of the four individual trials (n = 4).

RESULTS AND DISCUSSION

Mechanical properties of composites

The mechanical studies of composites are important properties because the products produced have to bear the mechanical stress when used by the consumer. Products with good mechanical properties last long and are commercially viable in the market [9]. Keeping these facts in mind, mechanical properties of the composites prepared in this trial were examined. The mechanical properties such as tensile strength, elongation at break, stitch tear strength, flexing strength were examined. Apart from these properties water absorption and desorption properties of the composites prepared were also determined.

Three trials were made to test the mechanical properties such as tensile strength (MPa), elongation at break (%), stitch tear strength (N/mm), water absorption (%), water desorption (%), flexing index (%) and each parameters are evaluated as mean values of solid leather waste using three different binder (Resin binder-RB, polyurethane binder-PUB and Natural rubber latex-NRL) against their controls. The controls are 100 percent leather wastes but the others as presented in the above table 1 0-40 present Sisal fiber using the different binders.

In the composite products prepared using synthetic resin binder, the tensile strength values of 30 and 40 present sisal (8.57 ± 0.85 MPa and 9.08±0.91 MPa respectively) have greater values than the control (6.05 ± 0.57MPa) and these results are better than the results of the same author done in [9] which was (3.39 ± 0.49 MPa) for sisal at 10 percent using NRL. In this result the better value in tensile strength of the composites than their the control might be attributed to the fiber. The tensile strength values of all the composites except the one prepared at 10 percent PUB (3.71 ± 0.91 MPa) in this study did meet the required standard set by Central Leather Research Institute shoe design and development center (CLRI-SDDC) (4.0-7.0 MPa) for the insole/shank board of footwear as per the SATRA TM2: 1995 test method because their value is in the range of (4.59 ± 0.70-9.09 ± 0.16 MPa). When we see the Elongation at Break in percent, 30 percent sisal has maximum value (7.84 ± 0.08

Table 1: Mechanical property of the composite product (Sisal-finished leather).

Tensile Strength (MPa)	Elongation at Break (%)	Stitch tear strength (N/mm)	Water absorption (%)	Water desorption (%)	Flexing index (%)	Sample ID
	RB (Resin binder)					
6.05 ± 0.57	5.73 ± 0.23	52.63 ± 0.89	103.37 ± 1.56	73.65 ± 2.34	0.15 ± 0.00	Control-T-1
4.61 ± 0.68	7.78 ± 0.95	39.87 ± 0.49	92.07 ± 3.19	94.51 ± 2.53	0.44 ± 0.13	S-10-T-1
5.33 ± 0.95	6.34 ± 0.94	56.35 ± 0.04	92.31 ± 386	82.14 ± 2.19	0.52 ± 0.20	S-20-T-1
8.57 ± 0.85	7.84 ± 0.08	61.92 ± 0.19	97.04 ± 0.71	81.34 ± 0.65	1.08 ± 0.09	S-30-T-1
9.08 ± 0.91	7.73 ± 1.34	57.69 ± 0.25	99.44 ± 2.45	90.97 ± 0.12	1.94 ± 0.44	S-40-T-1
	PUB (Polyurethane binder)					
6.25 ± 0.24	12.34 ± 0.16	43.82 ± 0.35	71.44 ± 4.74	86.10 ± 1.65	1.61 ± 0.17	Control-T-2
3.71 ± 0.91	4.50 ± 0.71	62.51 ± 0.10	77.32 ± 1.28	117.19 ± 2.76	0.23 ± 0.07	S-10-T-2
4.59 ± 0.70	4.06 ± 0.40	37.11 ± 0.04	129.30 ± 0.88	87.96 ± 2.96	0.34 ± 0.16	S-20-T-2
6.45 ± 0.78	3.95 ± 0.71	43.02 ± 0.28	106.24 ± 3.54	87.05 ± 1.49	1.03 ± 0.06	S-30-T-2
8.02 ± 1.62	4.19 ± 0.58	46.36 ± 0.21	138.67 ± 4.93	88.43 ± 2.45	1.65 ± 0.40	S-40-T-2
	NRL (Natural rubber latex binder)					
9.43 ± 2.74	15.17 ± 8.56	62.88 ± 0.21	21.27 ± 0.76	77.39 ± 0.40	3.71 ± 0.01	Control-T-3
5.39 ± 0.66	33.23 ± 6.13	70.14 ± 0.04	17.76 ± 3.61	156.01 ± 7.11	3.46 ± 0.09	S-10-T-3
6.02 ± 0.23	24.23 ± 1.73	77.95 ± 0.05	29.69 ± 2.48	78.41 ± 3.11	3.42 ± 0.12	S-20-T-3
9.09 ± 0.16	26.01 ± 0.78	74.87 ± 0.66	37.23 ± 0.38	86.78 ± 2.97	3.72 ± 0.03	S-30-T-3
7.81 ± 1.17	13.28 ± 2.43	74.83 ± 0.21	31.04 ± 0.45	91.19 ± 3.77	3.41 ± 0.06	S-40-T-3

*T: Represent for trials; S: Represents for sisal percent), 10 percent sisal (7.78 ± 0.95), 40 percent sisal (7.73 ± 1.34 percent), 20 percent sisal (6.34 ± 0.94 percent) which, in all cases sisal composites have better values than their control (5.73 ± 0.23 percent) and this might be attributed due to the fiber composition. Results in elongation at break of the present have shown better values than those reported by the same author Teklay, et al. [9] and this better value in the results might be due to the different preparation method followed. This indicates that if we conduct different trials in various approaches we can achieve even better results than the present one.

If we see the Stitch tear strength values, 40, 30 and 20 percents have better values in their respective order of (57.69 ± 0.25 N/mm), (61.92 ± 0.19 N/mm), (56.35 ± 0.04 N/mm) than their control (52.63 ± 0.89 N/mm). When we evaluate the water absorption (percent), the control has better value (103.37 ± 1.56 percent) than the other composites, but in case of water desorption values, all composites have better values than their control (7.65 ± 2.34 percent) and the flexing value is also better in the composites prepared using resin binder.

In the composites prepared using polyurethane binder (PUB), the tensile strength values of the composites were evaluated. In these 40 percent and 30 percent composites have better values (8.02 ± 1.62 MPa and 6.45 ± 0.78 MPa respectively) than their control (6.25 ± 0.24 MPa), while the 10 percent and 20 percent composites have lower values(4.59 ± 0.70 MPa and 3.71±0.91 MPa respectively) than their control(6.25 ± 0.24 MPa). When we see the Elongation at Break in percent, all composites prepared using PUB, have lower values than their control. In case of the Stitch tear strength values, composites having 10 percent, 40 percent and 30 percent of sisal have better values (62.51 ± 0.10 N/mm, 46.36 ± 0.21 N/mm and 43.02 ± 0.28 N/mm respectively) than their control (43.82 ± 0.35 N/mm).

When we see the water absorption in this case all composites have better results than their control and the same holds true with their desorption values. However, the flexing values of composites prepared using PUB have lower values except in the 40 percent sisal (1.65 ± 0.40 percent) which has better value than its control (1.61 ± 0.17 percent).

The other trial conducted in this research was using Natural rubber latex binder and the tensile strength values of the composites were lower than the value of their control (9.43 ± 2.74 MPa) with the optimum result being at 30 percent sisal composite (9.09 ± 0.16 MPa) followed by the 40 percent composite (7.81 ± 1.17 MPa) though lower than their control (9.43 ± 2.74 MPa). These are very attractive results that can be used for the preparation of high quality shoe raw materials.

The elongation at break (percent) values of composites is better (33.23 ± 6.13 percent, 26.01 ± 0.78 percent, and 24.23 ± 1.73 percent in their respective order of 10 percent, 30 percent and 20 percent) than their control (15.17 ± 8.56 percent) except in the 40 percent sisal which showed lower result (13.28 ± 2.43 percent).

The stitch tear strength (N/mm) values of the composite prepared using NRL binder all have better values than their control sample. When we see the water absorption values all composite samples except the 10 percent sisal have better values than their control (21.27 ± 0.76 percent). The water desorption properties of all the composites prepared have better values as compared the control. If we see the flexing values in this trial, the 30 percent sisal has better value than its control. The rest results are lower than their control however; they fulfill the requirement for high quality shoe insole preparation.

If we see the binders based on their optimum values of tensile strength, NRL binder is better (9.09 ± 0.16 MPa) followed by RB (9.08 ± 0.91 MPa) and then PUB (8.02 ± 1.62 MPa), when we see the elongation at break(percent) and stitch tear strength (N/mm), results of NRL binder are better than the others. The flexing results are also better in the NRL than the others. This better result indicates that NRL binder is preferred over the other binders.

If we compare the optimum values of the present study with others, they are much better than values of previous studies done by Sekar et al. [10] from chrome shaving boards (2.96 ± 0.06 MPa) and that of [11] from regenerated leather boards (5.88 ± 0.09 MPa) and this difference or higher values of the present study might be attained due difference in the nature of the waste to that of sekar or it might be due to different method of preparation to both authors Sekar, et al. and Senthil, et al. [10,11].

CONCLUSION AND RECOMMENDATION

Therefore, based on these results, it is concluded that, composites prepared in this study are of good mechanical property that can be used as raw material for the preparation of light consumer goods such as chappel, high quality shoe inners, light hand bags, wallets, mouse pads, false roofing, wall partitioning, components of furniture and interior decorations. Among the different composites the optimum results of all binders 40 percent sisal in RB and PUB but 30 percent in NRL were taken as best results. When we see the binder comparison those products prepared using NRL binder are better in all parameters than those prepared using RB and PUB and this can be preferred than others.

As a recommendation, the solid leather waste/composite preparation and utilizing it for various economic benefits in Ethiopia are untapped that calls for further study to be conducted for more exploration and achievement of better results. Since we observed variation in strength of the products in different ratio and different binders the author recommended that if future work is conducted in different mechanism with different binder's ratios, there might occur a possibility to improve the limitation and obtain better results.

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