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# Mechanical Properties and Shrinkage Temperature of a Leather Tanned using Extract of Cashew Nut Testa (NILEST-Tan C)

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## ABSTRACT

Considering the environmental impact poised by chrome tanning agent in the leather industries, NILEST-Tan C was developed as an alternative tanning agent which is organic in nature and eco-friendly. The percentage offer of the tanning agent was varied as, 3 %, 6 %, 9 %, 12 %, 15 % and 30 % for control. Consequently, the tanned leathers were characterized based on their mechanical properties and shrinkage temperature. Mechanical properties such as tensile strength, percentage elongation and ball-burst of the tanned leathers increased with increase in the percentage offer of the tanning agent. The optimum tensile strength obtained at 15 % offers of the NILEST-Tan C was 25.41 MPa which is relatively higher than the control (crude testa powder) having 24.09 MPa at 30 % offers. In the case of % elongation, 12 % offer recorded the highest % elongation of 66.26 % and the control (crude testa powder) is 56.49 % at 30 % offer. The thermal properties of the tanned leathers in terms of shrinkage temperature were studied and 15 % offer of NILEST-Tan C has the highest shrinkage temperature of 72ºC, while the control (crude testa powder) at 30 % offer registered a shrinkage temperature of 74ºC. Thus, considering the good tensile strength recorded by the leathers, the tanned leathers can be used as shoe upper leather, upholstery and garment leather owing to the fact that the standard minimum value is 12 MPa.

**Keywords**: Crude testa, Leather, NILEST-Tan C, Shoe upper, Shrinkage temperature, Upholstery

## INTRODUCTION

Vegetable tannins are polyphenolic biopolymers and are secondary metabolites widely distributed in the various sectors of the higher plant kingdom (Bickley, 1992; Hua & Haslam, 1995). Traditionally, tannins are widely used as agents of converting animal hides/skins to leather ("tanning") by precipitating proteins found in the animal skins (Hagerman, 2002). Cashew nut testa are waste materials which have very little or no economic or nutritive value, particularly in Nigeria and contain lots of tannins (Nnaji *et al*., 2021). Results from the work of Ukoha *et al*. (2010) show that tannins of cashew nut testa are mainly condensed, revealing the presence of azaleatin, catechin, cyanidin, delphinidin, epicatechin, myricetin and quercetin in cashew nut testa. Vegetable tanned leathers are characterized with high tensile and tearing strength, elongation, breathability and insulating properties, capacity to absorbs and transmit moisture, lasting molding ability and flexing endurance (Jones, 2000). NILEST-Tan C is a natural product developed through research by the Directorate of Research, Development (DR&D), NILEST; Zaria. It is a vegetable product obtained from an indigenous plant material, *Anacardium occidentale* (Cashew nut) testa for leather production (Abdullahi *et al*., 2022). The research problems identified were the challenges associated with the extraction and preservation of the tannin extract. Vegetable tannins have been known to be used in tanning different types of leather as a complement to many other mineral tanning agents, but to have the tannins extracts in a refined environmentally friendly products has been the issues in Nigeria. While the mechanised tanners use milled crude powder direct on the hide/skin leading to low penetration, growth of micro-organism such as moulds, oxidation, high percentage offer and high exhaustion time.

## MATERIALS AND METHODS

### Materials

The cashew nut testa was purchased from the cashew nut processing plant, Kwara State. The Nilest-Tan C was obtained as a result of solvent extraction of the cashew nut testa. The fresh goat skins were purchased from Samaru market, Zaria, Kaduna State. The Digital Experimental Drum used for this work is Italprogetti – Giragiare (0956A-06-22-282).

**Methods**

***Method of Tanning Goat Skin using Nilest-Tan C***

The process was carried out using Digital Experimental Drum (Italprogetti Drum). The green goat skins (fresh) were collected from Samaru-Zaria market, Kaduna State and were washed to remove blood and dung stains. After the washing, the skins were unhaired using 3 % $Na_2S$ based on the weight of the skins for 45 mins. The liquor was discarded and 300 % water was added with 3 % $Ca(OH)_2$ for liming. It was then left overnight to saponify the fat and make it plump. The deliming process was done using 2 % $NH_4Cl$ for 30 mins at a pH value of 8 – 9. Bate powder of 0.5 % was added and run for 15 mins to make it soft in order to allow easy penetration of other chemicals. From there, the liquor was discarded. Next was drenching and this was done using 100 % water and 7 % NaCl salt for 20 mins. To obtain pH value of 5.0 – 5.5, formic acid was added to the liquor for 2 hrs and then left overnight. Afterward, the tanning was carried out using 3, 6, 9, 12 and 15 % Nilest-Tan C. The process was allowed to run for 2 hrs. Fatliquoring was done using 4 % fatliquor for 15 minutes and subsequently, 1 % formic acid was added for fixation. Finally, the leather was hosted to dryness overnight. The stretching of the leather was done mechanically through staking and toggling.

**Tensile Strength**

To determine the tensile strength of the leather, the test samples were cut according to a total length of 100 mm and gage length of 47 mm. The testing of the samples was done at Department of Polymer and Textile Engineering, Ahmadu Bello University, Zaria-Kaduna State, Nigeria in accordance with ASTM D638 (2014) standard. The samples were machined to dumb bell shape and then placed in Tensile Strength Test Machine TM2101-T7 model and the tensile strength and modulus were evaluated.

**Lastometer (Bursting Ball Test)**

To determine the grain crack distension and load when a circular leather test specimen is secured in between two circular rings of 25 mm diameter and stretched with the help of a spherical head. Unto grain crack appears on the grain surface of leather (IULTCS, 2002).

**Shrinkage temperature**

The shrinkage temperature of the leather obtained using the NILEST-Tan C was measured using the SATRA STD 114 test apparatus in accordance to the official method (IUP/16, 2001).

**RESULTS AND DISCUSSIONS**

Tensile strength of leather is the greatest longitudinal stress leather can bear without tearing apart. The tensile strength of leather was determined by fibrous structures that constitute the collagen network structure and the modification of structure by tanning agents (Kuria *et al*., 2016). Figure 3 illustrated the variation of tensile strength with increase in percentage offer. The tensile strength of the leather manufactured using NILEST-Tan C increases with increase in the percentage offer of the tanning agent. The increase could be attributed to the increase in the amount of tannins penetrating into the collagen fibres of the goat skin, leading to increase in fullness properties of the leather. This is in agreement with the postulation of Alim *et al*. (2016) stated that, total soluble and degree of tannage represented the fixation of tannins on the collagen fibers and the stability of leather. The optimum tensile strength was observed at 15 % offers having 25.41 MPa as compare to the control (crude testa powder) which has 24.09 MPa at 30 % offers. The tensile strength of the leathers tanned by NILEST-Tan C in this study was way above the expected minimum of 12 MPa.

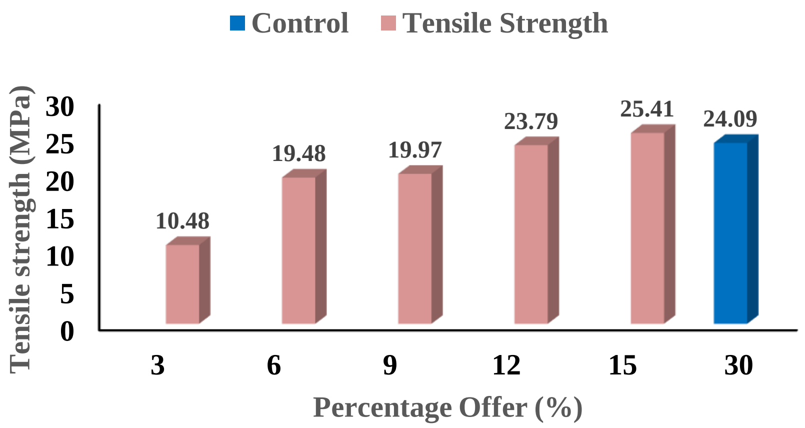


**Figure 3: Effect of percentage offer on tensile strength of the leather**

Elongation is the ability of a leather to extend when subjected to mechanical forces. Leather is said to be flexible when its fibre slides above one another. Figure 3 indicated increase in percentage elongation as the percentage offer of the NILEST-Tan C increases. The variation observed, may be as a result of flexibility, softness and elasticity of the tanned leather. This is in agreement with the report of Mohamed and Hassan, (2015), who reported that, stiffer materials have elongation properties at break. At 15 % offer, a steeply decrease in the percentage elongation was observed. This decrease could be as results of increase crosslinks of the collagen fibre structure of the skin (Farhad *et al*., 2020). From the result, it is indicative that 12 % offer recorded the highest % elongation of 66.26 % and the control (crude testa powder) is 56.49 % at 30 % offer. The acceptable range for percentage elongation is 40–80% (BASF, 1984).

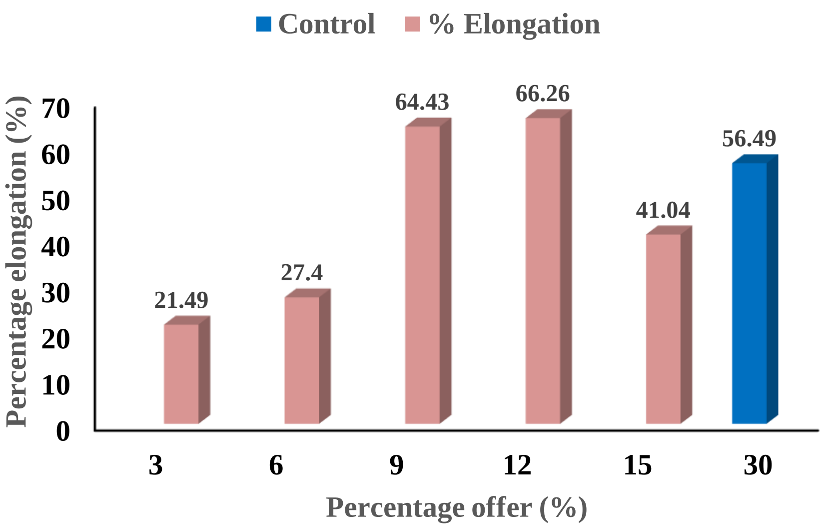


**Figure 3: Effect of percentage offer on % elongation of the leather**

The reason for this test is to determine the grain crack force (load) and distension properties of leather when used for shoe upper. Shoe upper leather often shows little crack in the toe area at the time of lasting operation despite the fact that, the leather has good tensile strength. Figure 3a and 3b indicated that, the highest distension properties of the NILEST-Tan C leather at different % offers was obtained at 15 % offer with a distension value of 10.39 mm and the highest load value was at 9 % offer with a load value of 40.38 kg. At 12 % offer, the distension properties of the leather tend to decrease due to the variation in the toughness of the animal skin before processing and also the varieties of conditions such as the age and breed of the animal, the weave of the collagen fibre bundles, the apparent density of the skin and glycosaminoglycan contents of the skin (Wang & Attenburrow, 1993).

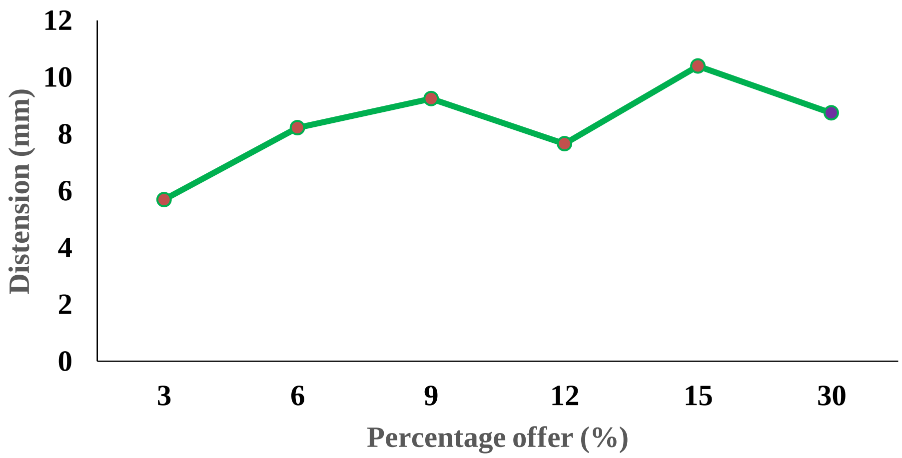


**Figure 3a: Distension properties of Leather tanned with NILEST-Tan C**

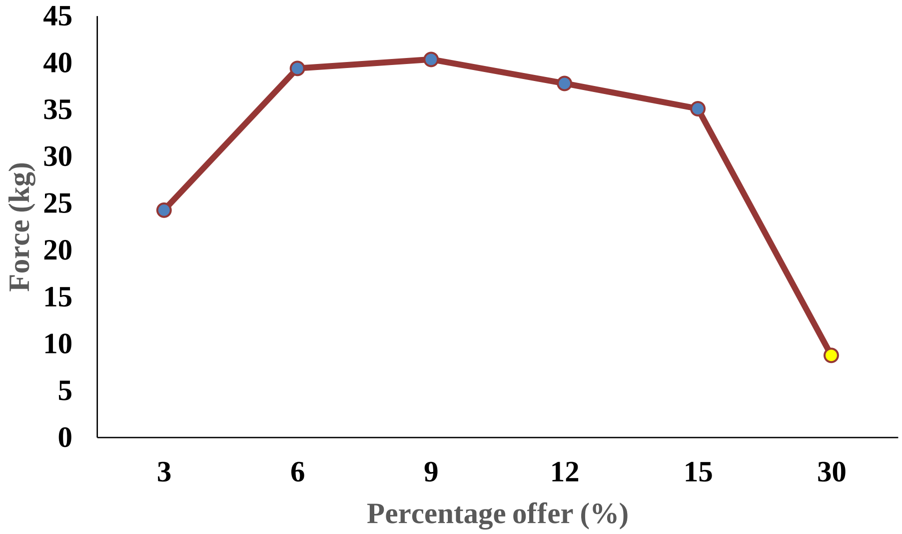


**Figure 3b: Force exerted by leather tanned with NILEST-Tan C**

Shrinkage temperature measures the hydrothermal stability of the leather. It is the temperature at which the leather sample starts to shrinks in water or over a heating media (Ali *et al*., 2013). It provides information about the degree of tanning because better crosslinking reaction between collagen fibres and tannins increases the shrinkage temperature (Heideman, 1993). Figure 3.4 depicts increase in shrinkage temperature as the percentage offer of the NILEST-Tan C increases. The increment of the shrinkage temperature may depend on the size of the polyphenol molecules and the numbers of –OH groups which is consistent with Covington *et al*. (2011) postulation who concluded that shrinkage temperature is determined by the effectiveness of tanning molecules to produce high molecular weight cross-linked moieties (Teklebrham *et al*., 2012). Also, they reported that thermal stability of leather depends on the kinetic stability of the interaction between the tanning molecules and the protein side chains. From the results, it could be observed that the highest shrinkage temperature 72ºC was obtained at 15 % offer, while the control (crude testa powder) at 30 % offer registered the highest shrinkage temperature of 74ºC when compared to the leather tanned with NILEST-Tan C.

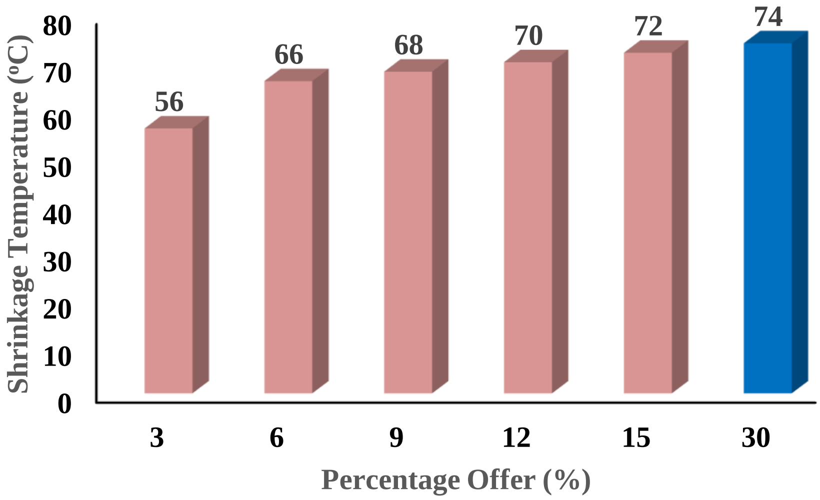


**Figure 3: Effect of percentage offer on shrinkage temperature of the leather**

**Plate I: NILEST-Tan C**

**Plate II: 3 % Offer**

**Plate III: 6 % Offer**

**Plate IV: 9 % Offer**

**Plate V: 12% Offer**

**Plate VI: 15% Offer**

**Plate VII: 30% Crude Offer**

**CONCLUSION**

Tensile strength, % elongation and shrinkage temperature showed increase as the percentage offer of the NILEST-Tan C increases. The experimental trial revealed good performance of the leather produced in terms of softness, fullness, grain stability and general appearance. From the excellent mechanical and thermal results obtained, we can say that, NILEST-Tan C has the potential ability to compete with other commercially viable vegetable tanning agent that are environmentally friendly to the ecosystem.

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