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ASSESSMENT OF THE PHYSICOMECHANICAL PROPERTIES OF LEATHER AND LEATHERETTE USED FOR SHOE UPPER

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ABSTRACT

Nowadays, there are a variety of emerging competitive materials intended for shoe uppers, with the most critical being leather and leatherette (leather imitation). To this end, a comparative assessment of the physicomechanical properties of leather and leatherette was carried out. This was necessary to establish the differences between the two materials and present the one with a comparative advantage. The analysis was carried out following the methods described in the official analysis methods by the Society of Leather Technologists and Chemists (SLTC) 1996, except where otherwise stated. Furthermore, the end-user performance properties result for both leather and leatherette, respectively, such as tensile strength (37.5 N/mm^2 and 25.3 N/mm^2), water vapour permeability (20.6 mg/cmh and 6.8 mg/cmh), fullness (1649 kg/cm^2 and 289715 kg/cm^2), lastometer (11.5 mm and 8.5 mm), among others were discussed. The results lend credence to the comparative advantage of leather over leatherette and, therefore, the most recommended material for shoe uppers.

KEYWORDS
Leather, leatherette, shoe upper, performance properties

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INTRODUCTION

Shoes are generally used in life by all types of men and women. The primary aim of using shoes is for foot protection and comfort (Bitlisli *et al.*, 2013). Shoes are made up of different parts such as upper leather, lining, insole and sole, with each playing its own role (Fig. 1). The performance of every shoe is mainly dependent on the type of upper leather used for the shoe (Bitlisli *et al.*, 2013). This, of course, upholds the process input and other auxiliary materials used. Suppose the essence of producing shoes will be achieved without compromise. In that case, the upper's properties must be considered to ascertain whether or not it will deliver the expected quality.

Since immemorial, leather, made from hide/skin, has found sound and practical applications in the shoe industry and is well known for better performance (Falcao & Araujo, 2014). Chemical and process input aside, the nature of the raw material (collagen) also contributes to a greater extent to the quality performance of the material (leather) produced from it (Covington, 2009). Efforts have been made to produce or synthesise leather using several chemicals, such as polyvinyl chloride (PVC), polyurethane (PU) and others, to compete favourably with leather (Meyer *et al.,* 2021; www.fidden.com accessed 2019). Despite their aesthetic look, such synthesised leathers are believed to need more of the properties that genuine leather possesses. These leather imitations, also called leatherette, are today championing the course of shoe production in the country, limiting the use of leather without considering its performance properties (Dancing Feet, 2019; www.buzzle.com accessed 2019).

Various reasons are thought to contribute to this fact. One of the reasons is the widespread availability of synthetic chemicals used in the production of leatherette as a substitute for natural leather. Natural leather production depends on the number of animals slaughtered and flayed skins. This and other reasons, such as consuming the raw skin as "pomo" have reduced to a large extent the number of skins available for the leather industry to process into leather for the shoe industry (Makun, 2023). Shoe upper leathers have been found to demonstrate positive results for foot comfort and foot health, and this can be explained in terms of the comfort that is provided by the structural formation of the leather together with its various physical and chemical properties (Bitlisli *et al.*, 2004), even though the extent of this advantage is yet to be established. This is why it is necessary to assess the performance properties of these materials so as not to compromise foot health and comfort in the choice of upper leathers, regardless of occupation or taste.

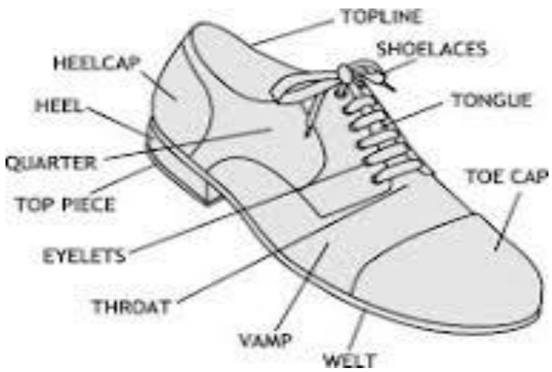

Fig.1 parts of the shoe (dancing feet, 2019)

MATERIALS AND METHODS

Full grain pigment finished side leather purchased from Kano, polyvinyl chloride film finish leatherette from Zaria, Nigeria. Analysis was conducted in the quality control laboratory, Nigerian Institute of Leather and Science Technology, NILEST, Zaria, and the mechanical engineering department at Ahmadu Bello University, ABU Zaria, Nigeria. All analysis was carried out using the methods described by the official analysis method (SLTC, 1996). Weighing was done using Mettler AE 200 balance. Before analysis, the materials were kept under a temperature of 20 ^{o}C and relative humidity of 65 for 48hrs. Thickness was determined using Wallace dial micrometer screw gauge (ref. S 4/9).

Tensile strength, slit tear load, buckle tear load, stitch tear load, elongation and apparent stiffness tests were carried out using Monsanto tensometer type W. Lastometer test was carried out using muver lastometer. The flexing endurance test was carried out using the SATRA upper material flexing machine (STM 101). Water vapour permeability was carried out using a muver permeability machine. The water absorption test was carried out using the Kubelka apparatus. The abrasion test was done using the SATRA Martindale abrasion machine (STM 105). A heat resistance test was carried out using a finish heat resistance tester (STM 111), and a hydrothermal stability test was conducted using the SATRA leather shrinkage apparatus (STD 114).

RESULTS

Table 1: Physical properties of leather and leatherette

Properties	Leather	Leatherette
Thickness, mm	1.79	0.65
Apparent density,g/cm^3	0.76	0.47
Water vapour permeability, mg/cmh	20.64	6.82
Water absorption (kubelka, 2hrs.)	77	36
Fullness, kg/cm^2	1649	289715
Indentation index	18	13
Resistance to heat (250 ^{o}C, 5sec)		
Loss of gloss	wvd	wvd
Loss of finish	wwvd	wvd
Burning	wood	wvd
Hydrothermal stability, %	>100	>100

wwvd = without visible damage, wvd = with visible damage

Table 2: Mechanical properties of leather and leatherette

Properties	Leather	Leatherette
Tensile strength, N/mm^2	37.5	25.5
Lastometer distension, mm	11.5	8.5
Stitch tear load, N	120	32
Buckle tear load, N	612	192
Slit tear load, N	360	120
Elongation, %	82	80
Apparent stiffness, N/cm^2	679.35	506.59
Abrasion resistance	0.09	0.05
Resistance to compression, kgf/cm^2	3.02	2.87
Flexing endurance (1hr.)	wwvd	wvd

wwvd = without visible damage, wvd = with visible damage

DISCUSSION

An excellent upper leather should possess enough strength to withstand external influences. The result for leather and leatherette met the minimum tensile strength standard for shoe uppers, even though leather exhibited a better tensile strength than leatherette (Table 2). A good stitch tear strength should be above 40 N (BSI, 2007). Here, only leather exhibited good stitch tear strength. The result for slit and buckle tears (Table 2) shows that leather has better tear strength than the leatherette. This could mean that one may risk losing shoe strength when stitched or buckled if leatherette is used in producing it. The ability of any shoe (especially military shoes and boots) to withstand sharp objects is primarily a function of the fibre stiffness and collagen structure (Bitlisli *et al.,* 2013), a property lacking in leatherette. This is evident in the result for stiffness, abrasion and slit tear strength for both leather and leatherette, showing leather to be at an advantage.

Due to the continuous bending movement that the shoe will be subjected to, the shoe upper material must be made lighter than the sole of the shoe (Bitlisli *et al.,* 2004). The result for apparent density (Table 1) for both leather and leatherette certified this weight and thickness requirement for shoe upper. Since every shoe's upper material must last on a shoe, it must exhibit good lasting strength and fullness. The result for the lastometer (Table 2) shows that both leather and leatherette met the minimum requirement of 7 mm distension at a load of 61 N for leather and 38 N for leatherette, which is both above the minimum load standard of 25 N (BSI, 2007), even though leather has a better distension strength than leatherette. The case was not the same for fullness, where leather exhibited better fullness properties than leatherette (Table 1). This could mean that the leatherette will need a lining with better fullness and shape retention properties, or else it will not hold its shape after being lasted on a shoe last. The difference in their ability to stretch is insignificant because both demonstrated good stretching (elongation) ability of 82 % for Leather and 80 % for Leatherette.

Leather is known to have high water absorption properties due to its structural properties (Bitlisli *et al.,* 2013). Although this property of leather is not desirable, it is essential to note that leather also possesses the ability to transpire moisture due to its water vapour and air permeability property, which is inherent to the mammalian skin (Bitlisli *et al.,* 2013; Sarkar & Ajoy, 2005). The foot excrets about 72 ml of sweat daily in the resting moment and should transpire for foot comfort

(Bitlisli *et al.,* 2013). Leatherette is believed to lack these properties, and the results for water absorption and water vapour permeability for both leather and leatherette are proven (Table 1). Leather exhibited good water absorption, water vapour, and air permeability properties. In contrast, leatherette exhibited an excellent water absorption property but inferior water vapour and air permeability property, showing the inability of leatherette to transpire moisture.

The flexing endurance result shows that leatherette has poor flexing endurance with evidence of folding at 2000 flexes (Table 2), but not with leather. The ability of both materials to resist compression is appreciable, even though the result shows that leatherette can resist compression more than leather; of course, the structural properties of leather attest to this fact. Leather exhibited a better indentation index due to the skin's inherent property (fibre structure). This shows that the leather could bear on it any pattern embossed on its grain surface better than on the leatherette.

Shoes manufactured using the injection moulding machine will require high upper material heat resistance and high hydrothermal stability. While both leather and leatherette exhibited hydrothermal stability above 100°C, their ability to withstand the applied temperature differed. Leather exhibited high resistance to heat, while leatherette did not. This is quite an assurance for those with injection moulding machine production. The result also shows the ability of leatherette to lose its finish under elevated temperature, which is not the case with leather.

CONCLUSION

After conducting physical and mechanical tests on both materials in the comparison, namely upper leather and leatherette. The results obtained are proof of the advantages they both offer. This should serve as a guide to the choice of material during footwear production. As discovered from this study and presented, the advantages of shoe-upper leather over shoe-upper leatherette must be addressed. Leather has a comparative advantage over leatherette.

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