Assessment of the Quality of Leather Footwear for School Children Made by SMEs in Kariokor Kenya

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Abstract: Footwear is the man-made outer covering of human foot. It is an assembly of top and bottom parts and each part is composed of various components. They are mainly produced from various materials such as textile fabric, leather and synthetics. Leather shoes contain an upper made of leather and the sole varies from leather, rubber, PVC, PU or other material. Various component plays a vital role in the quality and performance of the shoe and failure of one may affect the overall performance of the shoe. The quality of footwear is evaluated based on whether or not the shoe carries out its intended function, its effects on the wearer, and the extent to which it meets the requirements of the user. Poor quality shoe can result from poor quality of inputs, lack of quality control of the shoe during fabrication process and poor workmanship. The shoe made by SMEs in Kariokor are often not subjected to quality check hence their quality is unknown. A study was conducted to assess the quality of school children's leather shoes produced by SMEs of Kariokor market in Nairobi, Kenya. Shoe samples were collected from SMEs for laboratory analysis. Samples were analyzed using IUP/IUC methods. The tests carried out were tensile and tear strength, elongation, flex endurance, thickness, distension and strength of grain, pH, sole hardness, abrasion resistance, total chromium among others. The findings indicated that the samples tested failed Kenya Bureau of Standards (KEBS) standards. Although the majority of the shoe uppers met KEBS requirements, the soles for the samples tested failed to meet the requirements. In conclusion, the shoes failed the quality tests as per the KEBS requirement. In line with the outcome, there is a need for a strategy to improve the quality of leather footwear fabricated by the SMEs in Kariokor Market.

Keywords: Leather, quality, KEBS, SMEs

1. INTRODUCTION

A shoe is an assembly of top and bottom parts as shown in Figure 1 and each part is composed of various components (Motawi, 2017). The upper is the entire part of a shoe that covers the human foot. It consists of all parts of the shoe above the sole (Ganguly, 2013). These parts are attached by stitches or more likely moulded to become a single unit then the insole and outsole are attached (Ganguly, 2013). Shoe uppers are mainly produced from materials such as textile fabric, leather, synthetics among others.). A leather shoe contains an upper made of leather and the sole varies from leather, rubber, PVC, PU or other material (Ganguly, 2013). The sole is an important part of the shoe. It is the part in contact with the ground and protects the foot from injury thus required to have superior qualities. The quality of inputs used in the production of shoes affect the quality and hence performance of the shoe as each part plays a key role and failure of one may affect the overall performance of the shoe.

Footwear come in different kinds and for all purposes. They are used to protect human foot from injury, in fact the health of feet is largely affected by type and condition of shoes (Kuklane, 2009).

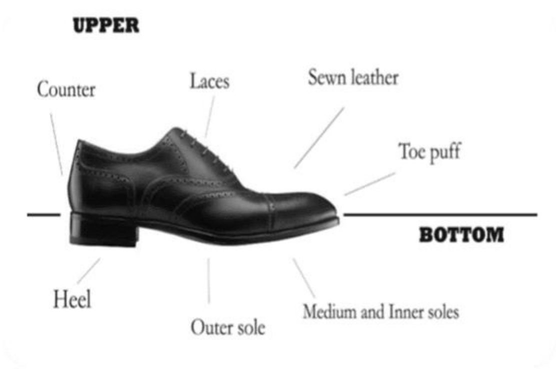

Figure 1 Anatomy of a shoe (Source: Ganguly, 2003)

An accurate choice of a good quality shoes will be able to maintain the health and vitality of feet (Bari et. al., 2010). The quality of footwear is generally evaluated based on whether or not the shoe carries out its intended function, its effects on the wearer, and the extent to which it meets the requirements of the user.

Given the remarkable flexibility of the foot, it is essential that the foot be accommodated in a manner that enables it to function as designed (Wilson and Kiely, 2016). Ergonomics dictate that good posture and other specific areas such as perception and biomimetics can be reasonably well integrated into the design and development of footwear therefore, shoe making requires high skills and diverse knowledge in many aspects that may affect the appearance, quality and the functions of a shoe. As a result, standardization of size and quality control measures are important aspects in the production of shoes (Boër et. al., 2007).

Leather is flexible yet durable (Sorenson, and Audia, 2000). Its elastic, so it can be stretched yet it resists tearing and abrasion. It's a breathable material and it insulates heat, helping to regulate temperature of the foot (Kozar, et. al., 2014). These properties make leather shoes conform to the feet of the wearer like no other shoe material can. Hence making it widely used.

Generally, the performance properties of upper leather depend on the origin of the raw material, how it is prepared for chemical modification and how it's processed to make leather (Bitlisli et. al., 2004). Comfort associated with a good quality leather shoe can be explained in terms of comfort provided by the structural formation of the leather together with its various physical and chemical properties (Bitlisli et. al., 2013).

Prolonged use of unsuitable shoe can lead to detrimental changes that alter the protective nature of the shoe into a barrier between the contact surface and the normal behaviour of the foot (McPoil, 1998). These changes can lead to altered foot morphology, reduced or impaired postural stability, muscle imbalance and the development of a sensitive foot (McPoil, 2000). Failure to give due emphasis to footwear quality can have a negative health impact on the consumer and can also hurt the goodwill of the business organization and result in decline in market share (Parasuraman, and Grewal, 2000). Wrong shoes can also lead to longer lasting orthopedic problem (McKenzie, 1985).

There are common feet problems associated with poor quality shoes as shown in the subsequent figures below. Blisters and corns are as a result of ill-fitting shoes. Fit is a quality parameter in footwear technology (Ganguly, 2003).

Figure 2 Corns (Source: Wikipedia)

Figure 3 Blisters (Source: Wikipedia)

2. MATERIALS AND METHODS

Pairs of school children's shoes of sizes 7,8,9, 10, 12, and 13 were samples from SMEs of Kariokor market for laboratory testing. They were subjected to physical and chemical testing following IULTCS methods as outlined in the subsequent sections.

2.1. Visual Inspection of the Shoe

The shoe samples were visually inspected for the presence of any defects. The defects/problems were noted and pictures taken

2.2. Sample Preparation

The shoe samples were dismantled to obtain various clicked components. Whereby the upper parts of the shoes were separated from the bottom parts. Sampling of the upper parts was carried out in accordance with the official sampling method IUP 2, 2001 (IUP 2, 2001). The obtained samples were subjected to physical and chemical analysis

2.3. Measurement of Thickness

The thickness was measured in accordance with the official method IUP 4, 2001 (IUP 4, 2001).

The apparatus was placed on a flat, horizontal surface. The sample was placed in the gauge grain side up. The load was applied gently for a specified time and the thickness recorded after full loading was reached. The results were expressed in arithmetic mean. The thickness test was carried out on each of the following components of a shoe; Inner lining, insole, sock, stiffener, toe puff, upper material(leather).

2.4. Tensile Strength and Elongation at Break

Tensile strength was determined in accordance with IUP 6 (2001). Half of the test pieces were taken in one direction and the other half at right angles to the initial directions on the upper parts of the shoes. The press knife cuts out the specimen and slot in one operation (template machine) with the angle formed at the cutting edge between the internal and external surfaces of the press knife being about 20°.

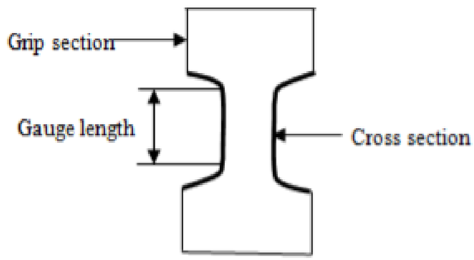

Figure 4 Dumb bell shape for tensile strength

The jaws of the tensile testing apparatus (Instron) was set 50 mm apart. The six test pieces were clamped in the jaws of the Instron instrument one at a time. The machine was run until the test pieces broke and the highest force exerted recorded as the breaking force.

2.5. Tear Strength

Tear strength was determined in accordance with IUP 8, 2001 (IUP8, 2001).

The specimens were clamped in the jaws of a tensile test machine with the slit edge of each tongue centred in a manner that the originally cut edges of the tongue formed a straight line joining the centres. Six rectangular specimens were cut, each 5 cm long and 2.5 cm wide as shown in Figure 3. The tearing force and elongation were recorded by the machine.

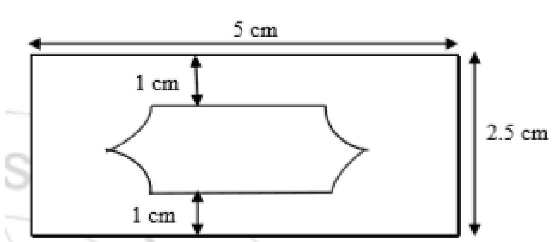

Figure 5 Dumb bell for tear strength

2.6. Flex Endurance

The experiment was carried out according to IUP 20 (2001), the test piece was folded and clamped at each end to maintain it in a folded position in a flexometer machine. One clamp was fixed as the other moved backwards and forwards causing the fold in the test piece to run along it. The test piece was examined periodically to assess whether damage has been produced.

2.7. Distension and Strength of Grain

This test was determined in accordance with IUP-9 (2001), a circular specimen was tightly clamped in the machine. The sample was bent, grain outwards around a mandrel of known diameter under minimum required force to keep the sample and mandrel in contact. The grain was kept under observation and any cracking noted. The machine was started by forcing the plunger at the rate of 0.2±0.05 mm/s. The surface of the specimen was continuously observed at the center for initial crack on the grain. The maximum distance and force were recorded.

2.8. pH

The pH of the upper leather was determined in accordance with IUP 11 (2001). The ground samples were soaked in distilled water over a given period of time and the pH of the solution was be determined with a glass electrode pH meter.

2.9. Sole Hardness

Sole hardness was measured in accordance with ISO 7619-1. The hardness of a soling material was determined by measuring the penetration of a rigid ball into the test piece under specific condition by apparatus known as hardness tester.

2.10. Abrasion Resistance

Abrasion resistance of the sole was determined in accordance with IUP 26 (2001). A circular test specimen was rubbed against standard fabric abradant under a constant force. The relative movement between the abradant and specimen is a complex cyclic pattern which produces rubbing in all directions. The test was stopped after a prescribed number of cycles and the damage to the specimen was assessed subjectively.

2.11. Total Chromium Analysis

The leather uppers were ground by milling them into powder form in accordance with IUC3, 2001. Total chromium in leather was determined in accordance with IUC 18, 2001.

2.12. Data Analysis

The data was subjected to statistical analysis using the Statistical Package of Social Sciences (version 21.0; Inc, Chicago IL) software. One-way analysis of variance (ANOVA) was performed for all the data. Duncan's Multiple Range Test was used for the analysis to compare the mean values amongst samples. Results are presented as the mean and the standard deviation of the mean (± SD).

3. RESULTS AND DISCUSSION

3.1. Quality Analysis of the Leather Shoe

A number of quality tests were carried out on the shoe products obtained from the SMEs. The findings are discussed in the subsequent subsections below.

3.2. Visual Examination of Shoes

The shoe samples were visually inspected and were found to have a number of defects. The defects range from poor pattern cutting, poor finishing, poor edge treatment, poor sole attachment among others. Some of these defects are caused during production whilst others are as a result of poor-quality raw materials (Ganguly, 2003). Figure. 5 shows the defects captured on the shoe samples and their possible causes.

Defect

Poor finishing.

Poor edge treatment. Asymmetrical

Poor sole attachment, wrinkles on the upper

Causes

Poor workmanship during edge treatment, lasting and attachment of the sole. Poor quality raw materials and accessories.

Figure 6 A pair of school shoe

Figure 6 shows the defects captured on the shoe sample and their possible causes.

Defect

Hole on the upper

Holes on the sole

Causes

Poor quality of sole

Poor workmanship during sole attachment and finishing

Figure 7 Upper and bottom parts of a school shoe

Figure 7 shows the defects captured on the inner part of the shoe sample and their possible causes.

Defect

Poor edge treatment

Poor stitching of upper and insole

Causes

Poor workmanship during stitching and edge treatment

Figure 8 Inner part of a school shoe

Figure 8 shows the defects captured on the inner part of the shoe sample and their possible causes

Defect

Poor finishing on the inside of the shoe

Poor attachment of insole

Poor pattern cutting

Causes

Poor workmanship during attachment of the insole and pattern cutting

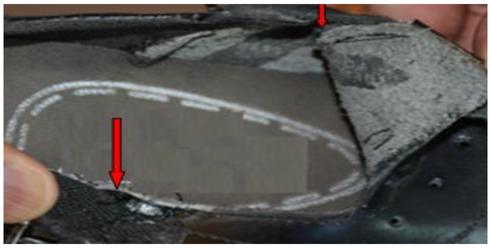

Figure 8 Inside part of a school shoe

Figure 9 shows defects captured on the inner part of the shoe and their possible causes.

Defect

Poor attachment of the insole

wrinkles on the insole, poor edge treatment

Poor attachment of lining material

Causes

Poor workmanship during attachment of the insole

Poor edge treatment

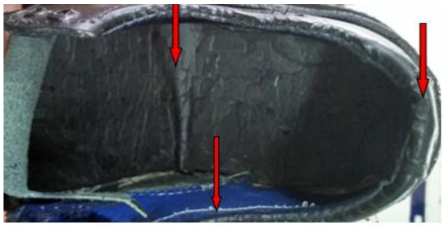

Figure 8 A school shoe

Figure 10 shows defects captured on the inner part of the shoe and their possible causes.

Defect

Poor attachment of lining material on the upper, holes on the insole

Poor finishing

Causes

Use of poor-quality adhesives

Poor workmanship during attachment of the lining on the upper

The above defects as shown in figures are associated with poor-quality raw materials, lack of necessary machinery and poor workmanship of the footwear SMEs with regard to unskilled or little training on shoe fabrication. The findings are in agreement with those obtained from the field survey where majority of the footwear SMEs in Kariokor use low quality adhesives and low-quality soles, they carry out hand lasting and use old machines. A number of them have not received formal training on footwear technology as they learnt the art through on job training (Mudungwe, Kenya, 2012).

3.3. Analysis of the Physical Properties of Leather Upper

The leather uppers were subjected to analysis. Triplicates were carried out for each sample and the average values are reported in subsequent tables below.

The shoe uppers were analysed and their thickness ranged between 1.78 ± 0.03 mm to 2.42 ± 0.23 mm as shown in Table 1. The results conform to the minimum required thickness of 1.00 mm recommended by KEBS. Therefore, all the leather upper for the shoe samples passed the thickness test as the values obtained were within KEBS minimum requirements. As shown in Table 1, the upper leather for shoe sample 4 presented slightly higher thickness of 2.42±0.23 mm and shoe sample 1 showed a slightly lower thickness of 1.78 ± 0.03 mm than others. These results are similar to those obtained by Zengin et al. 2017 (Zengin et al., 2017), whose values ranged between 0.78mm to 2.04 mm. The findings are also comparable with those of Ferrer et al. 2012 (Ferrer, et al., 2012), whose findings were 2.2 mm. Thickness of upper leather ranges between 1.00 mm to 2.00 mm depending on the type of shoe to be made (UN Report, 1997).

Table 1 Thickness of upper leather

Sample	Thickness (mm)
1	1.78±0.03
2	2.02±0.18
3	1.96±0.18
4	2.42±0.23
5	1. 85±0.20
6	1.82±0.22
KEBS standard*	1.00 mm Minimum

*Kenya Bureau of Standards (KEBS) specification for thickness of leather upper

The results for tensile strength are illustrated in Table 2, and the outcome ranged from 6.26

± 0.57 Mpa to 25.17 ± 1.23 Mpa. These values are within the minimum tensile strength requirement of 15.00 Mpa recommended by KEBS except for shoe sample 1 which recorded a significantly lower tensile strength of 6.26 ± 0.57 Mpa. These results were comparable with those Ferrer et al. (2012) and their findings were 20.40 Mpa and Ali et al. 2013 (Ferrer, et.al., 2012) whose findings were 25.52 Mpa.

Tensile strength determines the structural resistance of upper leather to tensile forces hence its state and usability. During the lasting process, the footwear uppers are submitted to a tensile stress that occurs when they are pulled on the last and they have to maintain their spatial shape (Harnagea, and Secan, 2008). The variation in tensile strength among the upper leather across the shoe samples could be due to variation in origin of the raw materials, how the materials were prepared for chemical modification and how they were processed. Similarly, animal breed, sex and age, environmental conditions among others are among the factors that influence the quality of hide and the resulting leather (UNIDO, 1996).

Table 2 Tensile strength of upper leather

Sample	Tensile Strength (Mpa)
1	6.26 ± 0.57
2	19.59 ± 0.54
3	23.50 ± 1.91
4	16.63 ± 2.55
5	25.17 ± 1.23
6	21.41 ± 1.55
KEBS standard*	15.00 Mpa Minimum

*Kenya Bureau of Standards (KEBS) specification for tensile strength of upper leather

The results for elongation are reported in Table 3. From the results, the hedonic rating for the shoe samples ranged between 36.73 ± 0.65% to 45.39 ± 1.41%. The percentage elongation for all the shoe samples were within KEBS requirement of 30-80% elongation. These results were comparable with those obtained by Ali et al. 2013 (Ali et al., 2013) and their findings were 65.48±3.80 and 67.16±9, 42. These findings are also similar to those of Habib, et al. 2015 (Habib et al., 2015) and their results ranged between 32.90 ± 11.72 and 46.14 ± 7.11.

The behaviour of upper leather in the manufacturing process and use is established through its elongation which determines its flexibility and elasticity and highlights the deformation capacity of upper leather during the lasting process. Upper leather should possess maximum flexibility to prevent the appearance of cracks and tears in the ball area due to prolonged motion. High elasticity allows the upper leather to withstand the elongation stresses to which it is subjected during footwear lasting, especially on the toe area (Bitlisli et al., 2009).

Table 3 Elongation of upper leather

Sample	Elongation (%)
1	40.10 ± 0.36
2	37.60 ± 0.53
3	36.73 ± 0.65
4	45.10 ± 0.20
5	45.39 ± 1.41
6	43.39 ± 0.41
KEBS standard*	30-80 %

*Kenya Bureau of Standards (KEBS) specification for elongation of upper leather

The results for tear strength are shown in Table 4. Shoe sample 1 recorded the lowest value of tearing force 35.21 ± 0.72 N whereas shoe sample 5 recorded the highest value of tearing force 99.77 ± 1.21 N. As shown in

Table 4, shoe samples 1 and 4 failed the tearing strength test as they recorded a tearing force of 35.21 ± 0.72 N and 38.31 ± 0.73 N respectively which is lower than the minimum tearing force of 50 N recommended by KEBS. These values are comparable with previously found results by Ali et al. 2013 (Ali et al., 2013), whose findings were 42.92 ± 7.56 N and 43.43 ± 3.56 N. However, there was a significance difference in tear strength among all the shoe samples. The observed variation could be attributed to the structural properties of the upper leather that vary depending on the origin, sex and chemical modification of the leather (Rezić and Zeiner, 2009).

Table 4 Tear strength of upper leather

Sample	Tear Strength (N)
1	35.21 ± 0.72
2	83.75 ± 2.10
3	70. 47 ± 1.49
4	38.31 ± 0.73
5	99.77 ± 1.21
6	79.33 ± 1.32
KEBS standard*	50.00 N Minimum

*Kenya Bureau of Standards (KEBS) specification for tear strength of upper leather

The results for pH of the leather upper are illustrated in the Table 5 above. The pH ranged from 4.08 ± 0.48 to 5.18 ± 0.60 for the shoe samples. The upper leather for all the shoe samples had a pH within the range except sample 3 which recorded a pH higher than the recommended pH range of 4.0-4.5 by KEBS. However, the pH level of shoe samples 2 and 6 were within the range of 4.5-5.0 and in agreement with literature reports (UNIDO, 1996). where the recommended pH should be 4.8 to 5. pH indicates the acidity of the upper leather and possible oxidation of chromium oxide.

Table 5 pH of upper leather

Sample	pH
1	4.14 ± 0.33
2	4.57 ± 0.43
3	5.18 ± 0.60
4	4.08 ± 0.48
5	4.45 ± 0.54
6	4.6 ± 0.36
KEBS standard*	4.00-4.50

*Kenya Bureau of Standards (KEBS) specification for pH of upper leather

The results for distension at grain crack are shown in Table 6. From the results, shoe sample 1 recorded lowest value of 6.30 ± 0.19 mm whereas shoe sample 4 recorded highest value of 7.90 ± 0.07 mm. Shoe samples 1, 2 and 5 failed the distension at grain test as they recorded values of 6.30 ± 0.19 mm, 6.52 ± 0.17 mm and 6.91 ± 0.05 mm respectively, which are lower than the minimum value of 7.00 mm recommended by KEBS. Shoe samples 3, 4 and 6 passed the distension at grain test. These results are compared with those of Ali et al. 2013 (Ali et al., 2013) whose findings were 9.46 ± 0.42 mm and 10.22 ± 0.74 mm. These findings are also similar to those of Habib et al. 2015 (Habib et al., 2015), whose findings ranged between 6.60 ± 0.32 mm and 8.54 ± 0.30 mm.

The distension at grain crack test is intended particularly for use with shoe upper leather where it gives an evaluation of the grain resistance to cracking during top lasting of the shoe uppers. The resistance of the grain to cracking depends on the humidity content of the leather, the test is performed on conditioned leather, low results can give good information to the shoe manufacturer about the need to humidify, damp or wet the leather before lasting (UNIDO, 1996).

Table 6 Distension at grain crack of upper leather

Sample	Grain Crack (mm)
1	6.30 ± 0.19
2	6.52 ± 0.17
3	7.06 ± 0.14
4	7.90 ± 0.07
5	6.91 ± 0.05
6	7.33 ± 0.55
KEBS standard*	7.00 mm Minimum

*Kenya Bureau of Standards (KEBS) specification for distension at grain crack of upper leather

The results for flex endurance of upper leather are illustrated in Table 8. From the results, all the shoe samples had no cracks at 50,000 cycles which is the minimum required number of flexes before a leather upper cracks during flexing as recommended by KEBS. Flex resistance test determines the resistance of a material to cracking and other types of failure on flexing. The results imply that the upper leathers for the shoes sampled were potential for the manufacture of footwear as they can withstand maximum flexes during walking. These results are compared with those obtained by Ferrer et al. (2012), whose leather had no cracks at 200,000 cycles.

The results for thickness of lining material are illustrated in Table 7. The thickness ranged between 0.43±0.11 mm to 1.06±0.79 mm. A wide range of thickness of lining materials across the shoe samples was observed. However, all the linings for the shoe samples passed the thickness test as they recorded a thickness higher than the recommended thickness of 0.6 mm by KEBS except shoe sample 2. The variation in thickness of the lining could be attributed to the fact that the linings were made of different materials obtained from different sources.

Table 7 Thickness of lining material

Sample	Lining (mm)
1	0.87±0.09
2	0.43±0.11
3	0.75±0.12
4	0.62±0.09
5	0.98±0.27
6	1.06±0.79
KEBS standard*	0.60 mm Minimum

**Kenya Bureau of Standards (KEBS) specification for thickness of lining material*

Samples 1, 4 and 6 passed a thickness test. A significance difference in thickness of the insole across the shoe samples were identified. This fact necessitates that, a varied insoles thickness was obtained from different sources hence processed differently.

3.4. Analysis of Dimensions of other Shoe Components

The shoe components were subjected to dimensional analysis. Triplicates were carried out for each sample and the average values are reported in subsequent tables below.

Table 9 depicts the results of the thickness of insole. Shoe sample 1 recorded the highest value of thickness of 2.38±0.02 mm whereas shoe sample 2 recorded the lowest value of thickness of 1.04±0.06 mm. Shoe samples 2, 3 and 5 recorded a thickness lower than minimum thickness of 1.50 mm recommended by KEBS, while shoe samples 1, 4 and 6 recorded a thickness that is higher than the minimum requirement.

Table 7 Flex endurance of upper leather

Parameter	Upper leather					
Sample	1	2	3	4	5	6
Flex endurance	No damage After 150,000	No damage After 150,000	No damage After 150,000	No damage After 150,000	No damage After150,000	No damage After 150,000
KEBS Standard*	No damage after 50, 000 cycles	No damage after 50, 000 cycles	No damage after 50, 000 cycles	No damage after 50, 000 cycles	No damage after 50, 000 cycles	No damage after 50, 000 cycles

*Kenya Bureau of Standards (KEBS) specification flex endurance of upper leather

Table 9 Thickness of insole

Sample	Insole (mm)
1	2.38±0.02
2	1.04±0.06
3	1.11±0.20
	1.98±0.11
5	1.30±0.07
6	1.60±0.51
KEBS standard*	1.50 mm Minimum

Kenya Bureau of Standards (KEBS) specification for thickness of insole.

Toe puff retains the last shape and solidify the toe portion of the shoe. As shown in Table 10, the thickness of the toe puff for the shoe samples ranged between 1.01±0.21 mm to 1.72±0.34 mm. The toe puff of shoe samples 5 and 6 passed a thickness test as they recorded a thickness that is higher than the minimum thickness of 1.30 mm recommended by KEBS. However, the toe puff of shoe samples 1, 2, 3 and 4 failed the thickness test as the toe puffs recorded a thickness lower than the minimum required thickness of 1.30 mm recommended by KEBS.

Stiffeners are usually inserted at the counter/seat portion of the shoe to keep the shape of the shoe intact. As illustrated in Table 10, the stiffener for shoe sample 2 recorded the lowest value of 0.56±0.20 mm for thickness whereas the stiffener for the shoe sample 1 recorded the highest value of 1.31±0.39 mm for thickness. The stiffener for shoe sample 2, 3, 5 and 6 failed a thickness test as they recorded a thickness lower than the minimum thickness of 1.00 mm recommended by KEBS. However, the stiffener for shoe sample 1 and 4 passed the thickness test as they recorded a thickness higher than the minimum thickness recommended by KEBS.

Table 10 Thickness of toe puff and stiffeners

Sample	Toe puff	Stiffeners
1	1.01±0.21	1.31±0.39
2	1.25±0.40	0.56±0.20
3	1.22±0.10	0.84±0.14
4	1.03±0.18	1.20±0.22
5	1.32±0.16	0.97±0.18
6	1.72±0.34	0.78±0.08
KEBS standard*	1.30mmMinimum	1.00mm Minimum

**Kenya Bureau of Standards (KEBS) specification for thickness of toe puff and stiffeners*

The results for thickness of the sock are shown in Table 11. The values ranged from 0.98±0.10 mm to 2.01±0.2 mm. All the sock for the shoe samples passed a thickness test as they recorded a thickness higher than the minimum thickness of 0.8 mm recommended by KEBS. The variation is thickness of the insole across the shoe samples could be attributed to the fact that the materials are from different sources thus possess different properties.

Table 11 Thickness of sock

Sample	Sock (mm)
1	0.98±0.10
2	2.01±0.25
3	1.24±0.08
4	1.77±0.60
5	1.71±0.25
6	1.63±0.08
KEBS standard*	0.80mm Minimum

**Kenya Bureau of Standards (KEBS) specification for thickness of sock*

3.5 Analysis of Physical Properties of Soles

The shoe soles were subjected to physical analysis. Triplicates were carried out for each sample sole and the average values are reported in subsequent tables below.

The results for tensile strength of the soles are shown in Table 12. The outcome ranged between 4.80 ± 0.74 Mpa to 7.6 ± 1.19 Mpa. Shoe samples 3 and 5 failed the tensile strength test as they recorded as tensile force of 4.80 ± 0.74 Mpa and 7.6 ± 1.19 Mpa respectively which is lower than the minimum tensile strength of 6.00 Mpa recommended by KEBS. This indicates that based on the effectiveness of the sole to tensile force, the two samples were not fit for use. However, shoe sample 1, 2, 4 and 6 passed the tensile strength test as they recorded a value which is above the minimum tensile strength required by KEBS. The results for tensile strength reveal information about the mechanical properties of the sole material. When a sole material can no longer withstand the stress applied on it, it causes failure or excessive deformity (Ganguly, 2003).

Based on elongation of the sole as s shown in Table 12. Shoe sample 3 recorded the lowest value of 149.00± 1.00% while shoe sample 1 recorded the highest value of 256.00 ±1.00%. However, all the soles for the shoes sampled passed the elongation test as they recorded a percentage elongation which is higher than the minimum required elongation of 100% recommended by KEBS. Elongation of a sole until it breaks helps to obtain the material's complete tensile profile. It highlights the deformation capacity of the sole material.

Table 12 Tensile strength and Elongation of soles

Sample	Tensile Strength (Mpa)	Elongation (%)
1	6.26 ± 0.57	256.00±1.00
2	7.57 ± 1.20	187.00± 2.00
3	4.80 ± 0.74	149.00± 1.00
4	6.35 ± 0.90	212.00± 2.00
5	5.58 ± 0.53	203.33 ± 3.51
6	7.60 ± 1.19	220.67 ± 2.08
KEBS standard*	6.00 Mpa Minimum	100% Minimum

**Kenya Bureau of Standards (KEBS) specification for tensile strength and elongation*

The sole hardness ranged from 31.90 ± 1.73 to 52.87 ±2.30 as shown in Table 13. All the soles for the shoe samples failed the hardness test as they recorded hardness lower than the recommended range of 50-60 by KEBS except shoe sample 6. This sample had a hardness of 52.87 ±2.30 that is within the range of 50-60 recommended by KEBS. However, based on ISO requirements for the shoe soles, all the soles for the samples tested failed a hardness test as they recorded hardness lower than the recommended range of 58-74 by ISO standards. The hardness of the sole influence the comfort and safety of the shoe. Flexing is also affected by hardness. A thin soft sole may not withstand mechanical irresolution whereas a hard-sole will be discomfort for flexing as well as tendency to slippery, it also relates to the durability due to variability in abrasion resistance which results to poor wear resistance. As a result, hardness within the range is required.

Table 13 Hardness of soles

Sample	Hardness IRHD (N)
1	695.00 ± 2.00
2	570.00 ± 1.00
3	587.00 ± 2.00
4	765.00 ± 2.00
5	471.00 ± 2.00
6	909.00 ± 1.00
KEBS standard*	50-60
ISO standard**	58-74

*Kenya Bureau of Standards (KEBS) specification for sole hardness

The results for abrasion loss are illustrated in Table 14. All the soles for the shoe samples failed the abrasion resistance test as they recorded values higher than 450mm^3 maximum value recommended by KEBS. This indicates that, based on abrasion resistance parameter, the soles for the shoe sampled were not fit for use. However, the study reported a higher variation in abrasion resistance across the shoe samples as there was a significance difference in abrasion resistance among all the shoe sampled. Even though the soles were obtained from the same company, the process modification involved during manufacturing is different. Thus, leading to variation in the abrasion resistance across the soles.

Table 3 Abrasion loss of soles

Sample	Abrasion Loss (mm^3)
1	695.00 ± 2.00
2	570.00 ± 1.00
3	587.00 ± 2.00
4	765.00 ± 2.00
5	471.00 ± 2.00
6	909.00 ± 1.00
KEBS standard*	450 mm^3 Maximum

***Kenya Bureau of Standards (KEBS) specification for shoe uppers*

3.6 Analysis of Total Chromium in Upper Leather

Total chromium was analysed in the upper leathers. Triplicates were carried out for each sample and the average values are reported in table below. The findings for chromium content are illustrated in Table 15. The upper leather for shoe sample 1 and 6 recorded a value of 3.9±0.86 and 3.90±0.17 respectively that exceeded the permissible limit of extracted 3mg of chromium per kg leather material as recommended by KEBS. This indicates that the two shoe samples would pose potential risk to the wearer. These results are in partial agreement with the results reported by Rezic. As the results obtained exceeded the permissible value of 50.0 mg/kg of total chromium in leather. The presence of chromium in chromium-tanned leather represents a considerable health problem as indicated in literature (Rezić, I. et.al. 2009). For this reason, they may pose a serious health problem. It is recommended to avoid direct contact of shoes with the skin. Also, there is need for quality analysis of upper leather prior to shoe fabrication.

Table 4 Total chromium of upper leather

Sample	Total Cr (mg/kg)
1	3.90 ± 0.86
2	0.28 ± 0.27
3	0.20 ± 0.33
4	0.86 ± 0.79
5	0.86 ± 0.79
6	3.90 ± 0. 17
KEBS standard*	3.00 mg/kg detection limit

Kenya Bureau of Standards (KEBS) specification for shoe uppers

Poor stitching, poor pattern cutting, poor edge treatment and poor finishing were the common defects that were observed. These defects are associated with poor workmanship of the footwear SMEs with regard to unskilled or little training on shoe fabrication. Majority of the shoe uppers were fit for use as they met KEBS standards. However, all the soles failed to meet KEBS standards. This finding is in agreement with the data that was collected from the field study, which indicated that 50% of the consumers of the SMEs produced footwear had reported complaints on non- durable soles. Thus, the overall quality of the shoe will be affected as each shoe component plays a vital role in the overall performance and hence quality. Failure of one component will affect the overall performance of the shoe.

4. CONCLUSION

The sampled footwear fabricated by SMEs in Kariokor failed to meet the KEBS standards. The defects result from poor workmanship and poor-quality soles. Even though some leather upper passed the recommended values, the whole product did not.

5. RECOMMENDATION

Owing to the failure of the shoe to pass the KEBS requirement there is need for the SMEs to be sensitized on the need of quality checks and quality assurance mechanism on footwear manufacture. Also, a corrective measure and strategy to be instituted to help SMEs in producing quality products.

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