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Utilizing Sustainable KOMBUCHA Laminated with Knitted and Woven Cellulosic Fabrics for Anti-microbial Headboard

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Abstract

The headboards on upholstered beds can become a breeding ground for harmful microbes, but this problem can be addressed by using antimicrobial upholstery materials. Researchers have developed vegan leather made from bacterial cellulose found in KOMBUCHA that can be used as a sustainable alternative to traditional leather. The goal of this study was to reinforce KOMBUCHA leather with fabrics to create an anti-microbial ergonomic s' comfort bed. The study used different cellulosic materials (KOMBUCHA, cotton and bamboo with woven and knitted constructions) to reinforce the KOMBUCHA SCOBY layer. Laboratory tests were conducted on the produced samples, including tests for anti-microbial properties, weight, thickness, thermal conductivity, tensile strength, elongation, young modulus, and peeling force. The results showed that all types of fabric had a significant effect on KOMBUCHA properties. The researchers used reinforced KOMBUCHA with bamboo knitted fabrics gauge 20 to create a miniature model of an antimicrobial bed with a comfortable headrest. A single layer of KOMBUCHA was utilized to create a lighting unit located next to the bed due to its transparency properties and low thermal conductivity.

"Keywords: Kombucha, cellulose, Bamboo, knitted fabrics, bed designs, anti-bacterial."

1. Introduction

In ancient time; beds were only intended for Kings and the upper classes, the most famous of which were found in the tombs of the ancient Egyptians, and the front panels contained various decorations associated with funeral rituals [1]. Over time, the shapes of the beds have varied, and the design of the headboards of the beds has often been aimed only at the aesthetic aspect. But now, many people began to use the headboards as a headrest while reading or browsing phones, hence, many upholstered parts were incorporated into the bed headboards, made of textiles or leather. Some textiles used in interior spaces, especially those that have undergone chemical treatment to give them unique properties, impair indoor air quality. [2]. Leather, an animal-derived item, is also used for a variety of purposes in general and upholstery in particular. This creates ethical, social and environmental concerns, though powerful [3] As with artificial leather, its manufacturing process, which relies on traditional solvents, cannot avoid contamination with organic solvents, and its final products carry potential chemical risks for users. [4]

Upholstery parts may become unhealthy when dust accumulates and bacteria grow on the surface, which negatively affects the user's health and causes many problems such as headaches, skin irritation, and cough [5]. The most famous microbes: (Candida, Staphylococcus aureus, Klebsiella pneumoniae)

Candidiasis is among the most common fungal infections, and individuals who are more susceptible to infection are those with weakened immunity [6]

Staphylococcus aureus is one of the most vicious strains that have developed antibiotic resistance. It is a bacterium well known for causing various harmful diseases, ranging from skin abscesses, joint infections, and pneumonia [7] Klebsiella pneumoniae is an infective microorganism of worldwide concern

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because of its varied manifestations and life-threatening potential [8]

Therefore bacterial cellulose from KOMBUCHA (KBC) was developed as vegan leather. KOMBUCHA SCOBY leather is not made of synthetic materials like plastic [3]. Instead, an intriguing technique for producing bacterial cellulose is to use a symbiotic consortium of bacteria and yeast (SCOBY), more popularly known as KOMBUCHA [9]

A by-product of the fermentation of KOMBUCHA tea is SCOBY, a biofilm of cellulose-containing a symbiotic culture of bacteria and yeast, Gluconobacter, Acetobacter, Zygosaccharomyces, Saccharomyces, and Schizosaccharomyces are the principal bacterial and yeast genera found in SCOBY. These microorganisms are Present in a symbiotic relationship in the KOMBUCHA tea and contribute to the production of cellulose fibrils forming a biofilm at the air-liquid interface [10] [11]

BC is typically created in synthetic or natural media by oxidative fermentation. These media comprise a mixture of sugars with a certain concentration that is kept at pH 3.0 and 28 °C [12].

The BC biofilm is extremely hydrophilic and the loss of thickness and weight indicates the removal of water content in drying process [13]

Compared to plant-derived cellulose, cellulose of bacterial origin is of high purity (free of hemicellulose, lignin, and pectin), highly crystalline, and made of microfibrils that are 100 times smaller than plant cellulose [14], [15]. The shape of BC is the nanoscale-width fibre form, similar to the natural silk fibre produced by the silkworm [16].

BC can be functionalized with medicinal substances and antibacterial agents [17]. Also, designers in the textile industry are frequently using cellulose sheets made from KOMBUCHA to make shirts, shoes, wristbands, and other types of clothing on a small scale to experiment with using bacterial cellulose to replace non-biodegradable fabrics and create eco-friendly clothing [18].

In Jane Wood et al. research; Tensile strength and elongation were evaluated for each of Animal leather, animal suede and BC (Vegetable leather sheet). It was found that BC is weaker than its animal counterparts but does display similar physical characteristics at the point of failure [19].

In Michael Meyer et al. research; Tensile Strength and Tear Strength were evaluated for bovine leather and KOMBUCHA It was found that bovine leather represented the highest value for tensile strength and tear strength [20].

For that, this research aims to reinforce KOMBUCHA leather with cellulosic fabrics by pressure and apply it in an anti-microbial bed.

Fabrics can be created from textile fibres in a variety of ways. The most popular and intricate type of fabric is one composed of interlaced threads. Weaving, in which two sets of threads (warp and weft) cross and interlace with one another, is the most popular type of interlacing [21]. Knitting is another form of technique used to produce fabric by interlacing yarn with needles in a series of linked loops [22]. Due to its distinctive qualities; it has expanded quickly in many products [23]. Knitted fabrics gave higher comfort. and can be produced by different constructions which affect properties of the produced fabrics [24], [25]. Knitted fabrics have good stretch properties as a result of their looping structure [26], can apply in different applications regarding its unique construction [27], [28].

New types of regenerated fibres, which are an alternative to conventional fibres like cotton, have become more important in the manufacturing of garments and home textiles as a result of the growing demand for more comfortable, healthier, and ecologically friendly products [29].

Bamboo rayon is a regenerated cellulosic fibre made from bamboo pulp and is processed similarly to regular viscose fibre [30-32]. It is a unique form of regenerated cellulose fibre with unique properties, including the ability to absorb moisture, be hygroscopic, be deodorizing [33], Bamboo presence increasing thermal conductivity and comfort [34]. highly durable and lightweight, Bamboo fibres can be used to create a wide variety of products [35], [36]. In addition to its conventional use in furnishings and clothes [35], bamboo fibres are the foundation for the high-tech composite materials that are available today and provide lightweight, high-performance substitutes [37].

As people spend the third of their lives sleeping [38]. There is a need to produce beds that reduce pollutants to improve indoor air quality in rooms and improve sleep quality. For that, this work aims to prepare sustainable KOMBUCHA leather and reinforce it by lamination with different constructions of produced cellulosic fabrics to gain the advantage of combining fabrics with kombucha to obtain sustainable leather that is resistant to bacteria with good durability properties and test its properties to choose the best samples for the application of upholstered bed headboard with comfort ergonomics design at the same time. Also put a new design for this purpose and apply it with suitable materials.

2. Experimental Work

2.1Material

Branded tea, 7% sucrose, previously fermented liquid tea broth, freshly grown tea fungus and a sterile plastic box were used for the preparation of KOMBUCHA tea for preparing KOMBUCHA SCOBY cellulosic layers. This investigation concentrated on the preparation of bacterial cellulose from KOMBUCHA. The method used was as follows; Branded tea was used for the preparation of KOMBUCHA tea. 1% tea was added to boiling water and allowed to infuse for 15 minutes. The infusion was filtered through a sterile sieve. 7% sucrose was dissolved in hot tea and the preparation was left to cool. 2 % previously fermented liquid tea broth was aseptically added in to the fresh tea. The tea was then poured into a sterile plastic box to which 3% freshly grown tea fungus that had been previously cultured in the same medium for 28 days was added. The bottles were covered with sterile muslin cloth and fastened tight. The fermentation was carried out at room temperature (RT) in static conditions and the dark for 28 days [39].

This study used different cellulosic materials and constructions to reinforce the KOMBUCHA layer after removing it from the solutions' surface. KOMBUCHA layers were studied in this study as a single layer, double layer, reinforced with cotton plain woven fabric layer, reinforced with bamboo rib 2x2 knitted fabric gauge 14, and reinforced with bamboo rib 2x2 knitted fabric gauge 20.

Bamboo yarns of 30 Ne were used for knitting rib 2x2 structures with two different machine gauges (gauge 14 and gauge 20). Mayer& Cie machines made in Western Germany, 18 Inch cylinder diameter were used for producing these samples.

The cotton woven fabric was formed from cotton yarn count 10 NE for both warp and weft by 25 ends/Inch and 25 picks/Inch.

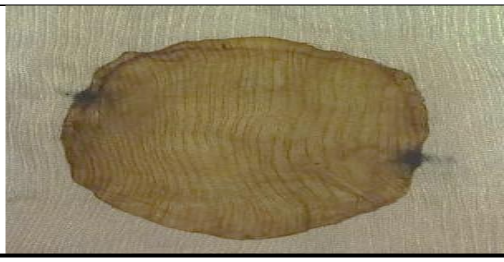
2.2 *Preparation*

The BC biofilms were removed from KOMBUCHA SCOBY fermented tea and splinted into two groups of samples. The first group were directly dried at 60°C for 24 to 36 hours without any specific cleaning procedures for preparing one-layer KOMBUCHA SCOBY leather.

In the second group of KOMBUCHA SCOBY samples, for preparing reinforced KOMBUCHA with cellulosic materials; After the KOMBUCHA SCOBY layer is formed on the surface of the KOMBUCHA tea. This layer was taken while it is still wet and placed on the surface of each of another KOMBUCHA SCOBY layer, the cotton woven fabric, and bamboo knitted fabrics, with a load of 2 kg placed on it, for a period of 48 hours to stick it to the cloth for preparing the study samples.

Table 1. KOMBUCHA SCOBY samples reinforcing variables. 'Source: Author's creation'

Sample specification	Sample photo
KOMBUCHA single layer	
KOMBUCHA double layer	
KOMBUCHA laminated with a woven plain fabric layer	
KOMBUCHA laminated with bamboo rib 2x2 gauge 14 knitted fabric layer	

KOMBUCHA laminated with bamboo rib 2x2 gauge 20 knitted fabric layer	

2.3 Characterization

Antimicrobial activity was tested as the dried Scopy was cut into small pieces according to each analytical technology. The pathogenic microbial strains were inoculated into sterile cold moulted NA medium (1-2 × 108 CFU/ml) and then poured into sterilized Petri dishes for bacteria and yeast. The agar plates were left to solidify and then small discs from each textile were made using a sterilized cork-borer (0.25 cm), added on the surface of agar plates then incubated at 37 for 24 hrs. After the incubation period, the zones of inhibition (ZOI) were measured in millimetres (mm). All experiments were done in duplicate [40].

Transparency and light transmission were evaluated for the prepared KOMBUCHA before and after lainating KOMBUCHA samples with cellulosic fabrics using an ordinary light source as shown in (Fig. 1). and (Fig. 2). It is observed that after being reinforced with cellulosic fabrics from the back, aesthetic effects appeared due to the contrast caused by the penetration of lighting to the surface.

The weight of the square meter was recorded by a high precision balance PB-100H (range 1 mg-110 g, Taiwan) according to standard ASTM D3776 -2013 [41].

The thickness was measured by thickness gage 0-10X0.01 mm, code 2364-10 (INSIZE, China) according to standard ASTM D1777 – 2011 [42].

The thermal conductivity was realized by KES-F7 Thermo Labo by Measuring the ease with which heat is transferred from one heat plate with a constant temperature of 30°C through a sample to another with a different temperature of 20°C using a constant thermal conductivity measurement.

The tensile force, Young's Modulus, and elongation % were determined by the use of an Instron testing machine 5000N load cell (Instron, USA). According to ISO 13934-1, the samples were prepared, and the tensile properties testing was carried out. With a 2 N pre-load force and a 100 mm/min test speed, specimens measuring 5 X 20 cm (width X length) were created for this purpose [43].

Fig. 1. Transparency to light on surface of KOMBUCHA 'Source: Author's own creation'

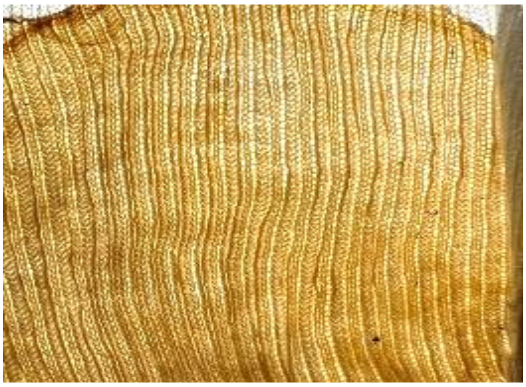


Fig. 2. Transparency after reinforcing with knitted fibrics from the back 'Source: Author's own creation'

2.4 Design

A bed with a headrest upholstered by KOMBUCHA leather reinforced with cellulosic fibres and a built-in lighting unit was designed and applied as follows:

2.4.1 Aesthetic and Formal Values of The Applied Product

The outlines of the headboard were inspired by The Shape of the Tea Leaf. It has gone through stages of abstraction to fit the function.

2.4.1.1 Steps of Inspiration

(Fig. 3) show the shape of a tea plant in nature, the Leaf was divided into sections representing the shape of the headboard of the bed and the background of the commode in (Fig. 4).

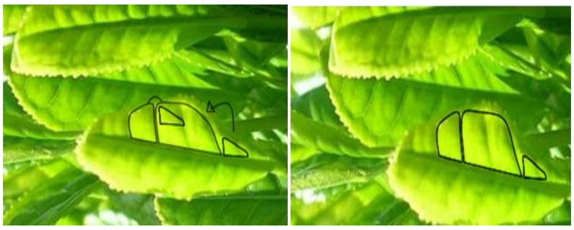

(a) (b)

Fig. 3. (a)Switching parts to form headboard, (b) tea leaf and its division into parts. 'Source: Author's own creation'

Fig. 4. The Applied Product shape after the abstract of the tea plant leaf with some modifications to achieve the product functional value and aesthetic value. 'Source: Author's own

2.4.1.2 Applied Product Materials

Anti-bacterial Laminated Blockboard (18 mm), KOMBUCHA leather was used in upholstery parts and as a cover for the indirect lighting unit located behind the commode as shown in (Fig. 5).

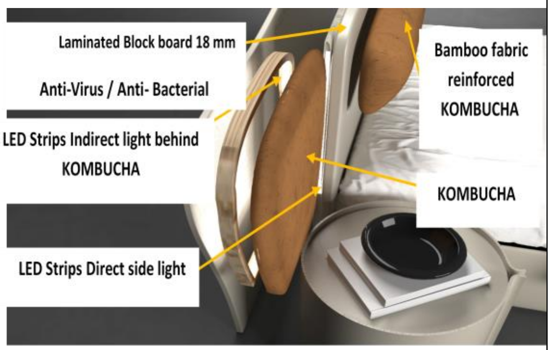


Fig. 5. A disjointed perspective shows the parts of the bed back 'Source: Author's own creation'

2.4.2 Applied Product Functional and Technical Values

2.4.2.1 Headboard Details

The headboard of the bed is designed to have a headrest and support the neck and shoulders area (Fig. 6). The lower part of the headrest is tilted to achieve a flexible range of comfort for the user and fits the average height difference between males and females (Fig. 7). The dimensions adopted by Anthropometric parameters measured by Cai and Chen [44]

Due to KOMBUCHA properties, the upholstered headrest of the headboard will be suitable for patients suffering from a weakened immune system, as the surface of KOMBUCHA SCOBY has achieved good results in resisting the types of bacteria such as the most famous bacteria: (Candida, Staphylococcus aureus, Klebsiella pneumonia).

Fig. 6. headboard of the bed 'Source: Author's own creation'

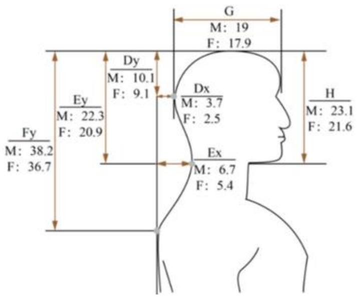


Fig. 7. width from ear to shoulder for male &female [44]

2.4.2.2 Lighting Unit Behind the Commode Details

People are paying more and more attention to the distribution of lighting in interior design because this achieves beauty through the contrast between illuminated spaces and shadows. Good lighting design also provides people with a comfortable and healthy living environment and improves work efficiency [45]. Therefore, the design of the bed relied on the integration of a light part behind the commode (Fig. 8); to fit the reading function and work on the mobile or laptop, a strip of LED lighting was used and the lighting levels can be controlled according to the nature of the activity to be performed as the simulated (Fig. 9).

Fig. 8. The Applied bed with a built-in lighting unit that shows KOMBUCHA transparency 'Source: Author's own creation'

Fig. 9. Simulation of person using the designed bed 'Source: Author's own creation'

3. Results and Discussion

All samples were tested for antimicrobial, thermal conductivity, thickness, weight and mechanical properties. Results were recorded and analyzed by ANOVA analysis and T-test as follows.

3.*1 Anti-microbial*

As shown in (Table 2) and (Fig. 10) The untreated SCOPY discs inhibited Candida albicans because it is acidic nature. The acids are produced from the metabolism of the yeasts and bacteria found in the KOMBUCHA tea. Candida albicans prefer the alkaline medium [46] so, it is not affected by the treated SCOPY with sodium hydroxide. It has been recorded that the neutralization of KOMBUCHA only reduced its activity against C. albicans [47]. It is suggested that the KOMBUCHA beverage is bactericidal toward S. aureus, suggesting the potency of the beverages against the bacteria [48].

The treated SCOPY discs with sodium hydroxide inhibited S. aureus because it is highly alkaline which affected negatively on S. aureus. It is found that reactive oxygen species (ROS) might be generated from the reaction between carboxylic acids and NaOH producing carboxylic acid sodium salts (R-COONa) which have been documented as antibacterial agents [49]. Sreeramulu et al. (2001) also showed that the antibacterial activities of KOMBUCHA against E. coli, Shigella sonnei, Salmonella enterica serovar Typhimurium, and Salmonella enteritidis were unaffected by neutralization, suggesting that the acidity of KOMBUCHA is not the sole factor that contributes to the antibacterial properties of KOMBUCHA [50]. It is reported that the neutralized KOMBUCHA could retain its antimicrobial activities to some extent. It is clear that acetic acid is not the sole contributor to KOMBUCHA's antimicrobial properties [51]. Catechins, whose presence has been identified in conventional KOMBUCHA. [48] comprise a class of polyphenols with known antibacterial [48], [52], [53]. Permeabilization assays confirmed that the fraction disrupted bacterial membrane integrity in both time- and dose-dependent manners, which were proportional to the production of intracellular reactive oxygen species (ROS). Furthermore, each of the polyphenols catechin and isorhamnetin showed the ability to permeate bacterial cell membranes by generating oxidative stress, thereby suggesting their role in the anti-microbial potential of KOMBUCHA. Klebsiella pneumonia is multidrug-resistant and produces capsules which increase its resistance to any antibiotics. It was reported that it showed resistance to 13 antibiotics.

3.2 Analysis of Variance (ANOVA) For Thickness, Weight, Thermal Conductivity, And Mechanical Properties

As indicated in Table 3, an ANOVA test with a p-value of (0.05) has been established to demonstrate the efficacy of various variables for single layer of fabric/ KOMBUCHA and reinforced KOMBUCHA samples. The results indicated that different single layers (Woven fabric, Knitted fabrics or KOMBUCHA layer) have a highly significant effect on samples' thickness, weight, thermal conductivity, tensile force, young modulus and elongation horizontal direction with non-Signiant effect on elongation in vertical direction also reinforcing KOMBUCHA leather with woven and knitted fabrics affect high significantly on the reinforced samples' thickness, weight, thermal conductivity, tensile force, elongation, and young modulus with signific effect on tensile force horizontal direction and young modulus horizontal direction of the non-reinforced and reinforced fabrics/ KOMBUCHA samples.

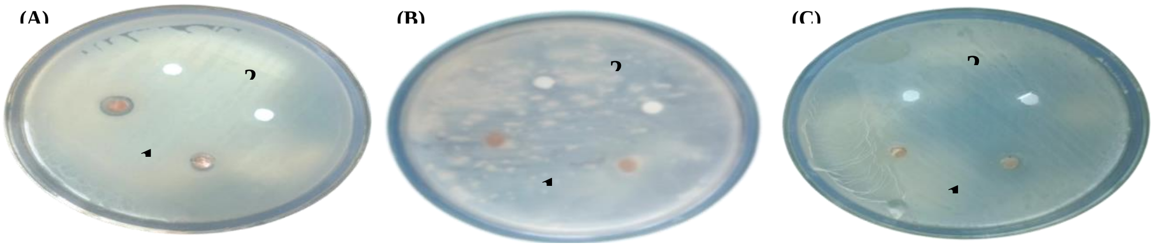


Fig. 10. Antimicrobial activity against Candida albicans; (A), Staphylococcus aureus; (B), and Klebsiella pneumonia; (C).

Table 2. Antimicrobial activity using agar well diffusion method.

KOMBUCHA discs	Zone of inhibition (mean ± SD, mm)		
	Yeast (*Candida albicans*)	Gram-positive bacteria (*Staphylococcus aureus*)	Gram-negative bacteria (*Klebsiella pneumonia*)
1	8 ± 0.2	-ve	-ve
2	-ve	7 ± 0.14	-ve

1 Untreated, 2 neutralized with sodium hydroxide

Table 3. Analysis of variance significance of reinforced and non-reinforced Fabrics/KOMBUCHA SCOBY

Characteristic	**P-value**	
	A single layer of fabric/ KOMBUCHA	Reinforced KOMBUCHA
Thickness (mm)	9.91E-11***	1.55E-09***
Weight (g/m2)	6.29E-10***	4.34E-11***
Thermal conductivity (W/cm*ºC)	1.41E-07***	3.81E-10***
Tensile force vertical direction (kgf)	0.0004***	0.0002***
Elongation vertical direction (%)	0.2580~	1.77E-10***
Young modulus vertical direction (kgf/mm2)	8.01E-07***	0.0001***
Peel strength vertical direction (kgf)	---------------	5.04E-08***
Tensile force horizontal direction (kgf)	3.51E-10***	0.0401**
Elongation horizontal direction (%)	1.74E-08***	1.391E-07***
Young modulus horizontal direction (kgf/mm2)	8.59E-07***	0.0233**
Peel strength horizontal direction (kgf)	------------------	0.0071***

***High signific, **Signific, ~Non-signific

3.3 *Effect Of KOMBUCHA Layer And Effect Of Knitting Machine Gauge On Different Properties*

3.3.1 Effect on Thickness

By applying T-test it was found that laminating the KOMBUCHA layer with fabrics significantly affected the thickness of the fabric by p-value= 3.335E-05 with the woven fabric, p-value= 4.060E-06 with the knitted fabric gauge 14, p-value= 0.0001 with the knitted fabric gauge 20, and p-value= 0.0009 while laminating with same another layer of KOMBUCHA. This effect is related to adding a layer to the fabric which must increase the thickness.

Also, by applying a T-test between different gauges in knitted fabrics, it was found that knitting gauge significantly affected thickness between blank knitted fabrics with p-value= 2.82E-05, and with p-value= 2.804E-05 between reinforced KOMBUCHA layer with different knitted samples. This effect is regarding to the increase in stitch density of the fabric which effect the thickness by increasing in the higher machine gauge.

(Fig.11) showing the effect of laminating the KOMBUCHA layer with different fabrics and the effect of machine gauge on the thickness, as it is shown that KOMBUCHA SCOPY single layer has the least thickness followed by doble SCOPY layers, woven fabric, knitted fabrics with gauge14 and 20, gauge 14 with SCOPY, woven with SCOPY, and finally gauge 20 with SCOPY is the higher in thickness.

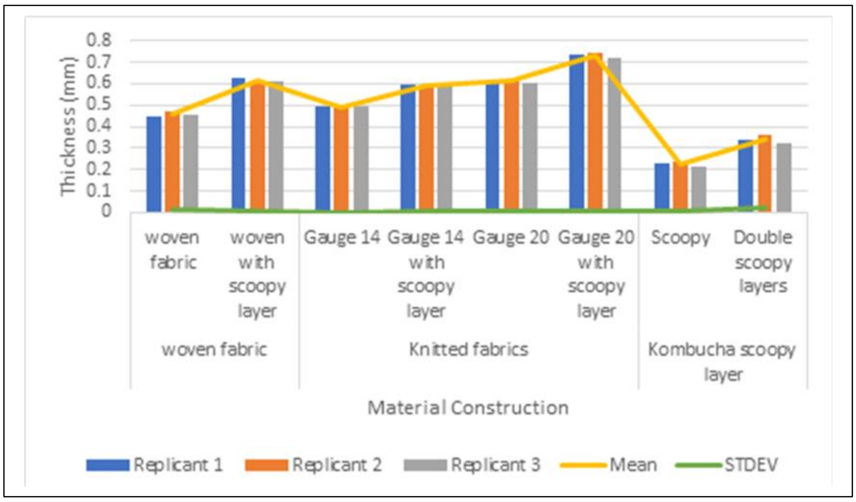


Fig. 11. Effect of laminating KOMBUCHA layer with different fabrics and the effect of machine gauge on the thickness 'Source: Author's own creation'.

3.3.2 Effect on Weight

By applying T-test it was found that laminating KOMBUCHA layer with fabrics significantly affect the weight of fabrics by p-value= 1.570E-07 with the woven fabric, p-value= 2.792E-07 with the knitted fabric gauge 14, p-value= 7.484E-08 with the knitted fabric gauge 20, and p-value= 1.443E-07 while laminating with same another layer of KOMBUCHA This effect is related to the density of the aterial which is laminated with. Thus when the higher material density make higher impact in the weight result.

Also, by applying a T-test between different gauges in knitted fabrics, it was found that knitting gauge significantly affected weight between blank knitted fabrics with p-value= 2.631E-06, and with p-value= 0.006 between reinforced KOMBUCHA layer with different gauge in knitted samples. This is regarding to the amount of the fabric used in the unit of the fabric which increased by increasing the machine gauge, then as a result affected the fabrics weight.

(Fig.12) showing the effect of laminating the KOMBUCHA layer with different fabrics and the effect of machine gauge on the weight, as it is shown that KOMBUCHA SCOPY single layer has the least weight followed by woven fabric, knitted fabrics with gauge14 and 20, then laminating KOMBUCHA layer affected the samples weight by increasing as after reinforce woven with SCOPY has the least weight, followed by gauge 14 with SCOPY, gauge 20 with SCOPY, and finally double SCOPY layers which are the higher in weight.

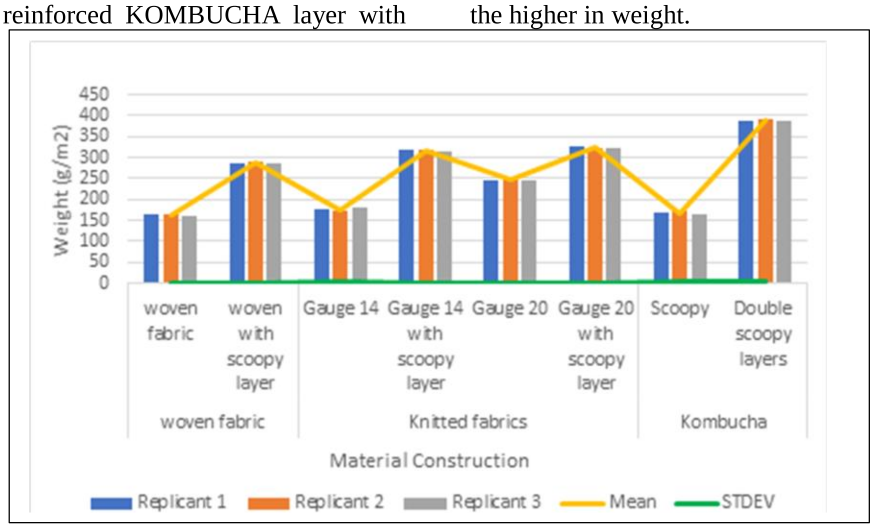


Fig. 12. Effect of laminating KOMBUCHA layer with different fabrics and the effect of machine gauge on the weight ‘Source: Author's own creation'

3.3.3 Effect on Thermal Conductivity

By applying T-test it was found that laminating the KOMBUCHA layer with fabrics significantly affected the thermal conductivity of the fabrics by p-value= 3.1859E-06 with the woven fabric, p-value= 3.588E-05 with the knitted fabric gauge 14, p-value= 4.326E-07 with the knitted fabric gauge 20, and p-value= 4.326E-07 while laminating with same another layer of KOMBUCHA. Also, by applying a T-test between different gauges in knitted fabrics, it was found that knitting gauge significantly affected thermal conductivity between blank knitted fabrics with p-value= 0.004, and with p-value= 0.0005 between reinforced KOMBUCHA layer with different gauge in knitted samples.

(Fig. 13) showing the effect of laminating the KOMBUCHA layer with different fabrics and the effect of the machine gauge on the thermal conductivity, as it is shown that all single layers from KOMBUCHA or fabrics were enhanced in thermal conductivity when laminated with the KOMBUCHA layer. KOMBUCHA SCOPY single layer has the least thermal conductivity followed by doble SCOPY layers, woven fabric, knitted fabrics with gauge14 and 20, gauge 20 with SCOPY, gauge 14 with SCOPY, and finally woven with SCOPY is the higher in thermal conductivity. It is observed that laminting KOMBUCHA with all samples increased th thermal conductivity. While KOMBUCHA in the single layer case showed the least thermal conductivity between all samples. which is may be attribute to its effect on thickness, as thickness is a factor in the thermal conductivity equation.

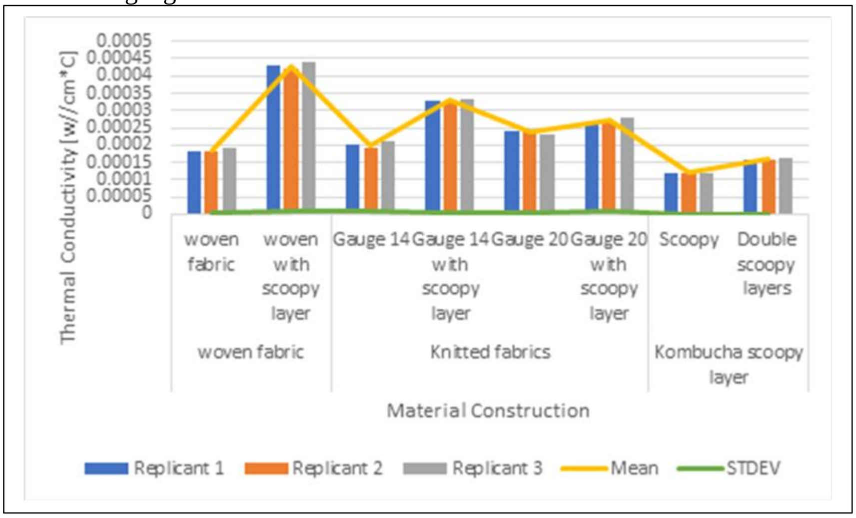


Fig. 13. Effect of laminating KOMBUCHA layer with different fabrics and the effect of machine gauge on thermal conductivity 'Source: Author's own creation'

3.3.4 Effect on Tensile Force In Vertical Direction

By applying the T-test it was found that laminating the KOMBUCHA layer with fabrics significantly affected the tensile force in the vertical direction of fabrics by p-value= 0.0002 with the woven fabric, p-value= 0.054 with the knitted fabric gauge 14, and p-value= 0.0014 while laminating with same another layer of KOMBUCHA, but it's non-significant on with the knitted fabric gauge 20 with p-value= 0.707. Also, by applying the T-test between different gauges in knitted fabrics, it was found that the knitting gauge has a non-significant effect on the tensile force in the vertical direction between blank knitted fabrics with p-value= 0.272, and with p-value= 0.182 between reinforced KOMBUCHA layer with a different gauge in knitted samples.

(Fig.14) showing the effect of laminating KOMBUCHA layer with different fabrics and the effect of machine gauge on the tensile force in the vertical direction, as it is shown that reinforcing KOMBUCHA SCOPY with fabrics gave higher tensile in the vertical direction that double SCOPY, woven with SCOPY, gauge 20 with SCOPY, gauge 14 with SCOPY gave higher tensile than SCOPY one layers, woven fabric, knitted fabrics with gauge14 and 20. It is illustrated that laminating samples with KOMBUCHA in all samples increased the Tensile Force In Vertical Direction. This is regarding to the stick force which add a resistance force to deformation.

Fig.14. Effect of laminating KOMBUCHA layer with different fabrics and the effect of machine gauge on the tensile force vertical direction 'Source: Author's own creation'

3.3.5 Effect on Tensile Force in Horizontal Direction

By applying the T-test it was found that laminating the KOMBUCHA layer with fabrics significantly affected the tensile force in the horizontal direction of fabrics by p-value= 0.0008 with the woven fabric, p-value= 0.0005 with the knitted fabric gauge 14, p-value= 0.0002 with the knitted fabric gauge 20, and p-value= 0.029 while laminating with same another layer of KOMBUCHA. This is related also to the stick force between layers. Also, by applying the T-test between different gauges in knitted fabrics, it was found that the knitting gauge affected non-significantly tensile force in the horizontal direction between blank knitted fabrics with p-value= 0.8, and with p-value= 0.073 between reinforced KOMBUCHA layer with different gauge in knitted samples. As the tensile force of the different gauge fabrics in horizontal direction are around same but its is just affected when it become laminated with KOMBUCHA.

(Fig.15) showing the effect of laminating the KOMBUCHA layer with different fabrics and the effect of the knitting gauge on the tensile force in the horizontal direction, as it is shown that reinforcing KOMBUCHA SCOPY with fabrics gave higher tensile in horizontal direction that double SCOPY, gauge 20 with SCOPY, woven with SCOPY, gauge 14 with SCOPY gave higher tensile than SCOPY one layers, woven fabric, knitted fabrics with gauge14 and 20. Also, it is shown that gauge 20 with SCOPY gave a higher tensile than gauge 14 with SCOPY showing the effect of the machine gauge.

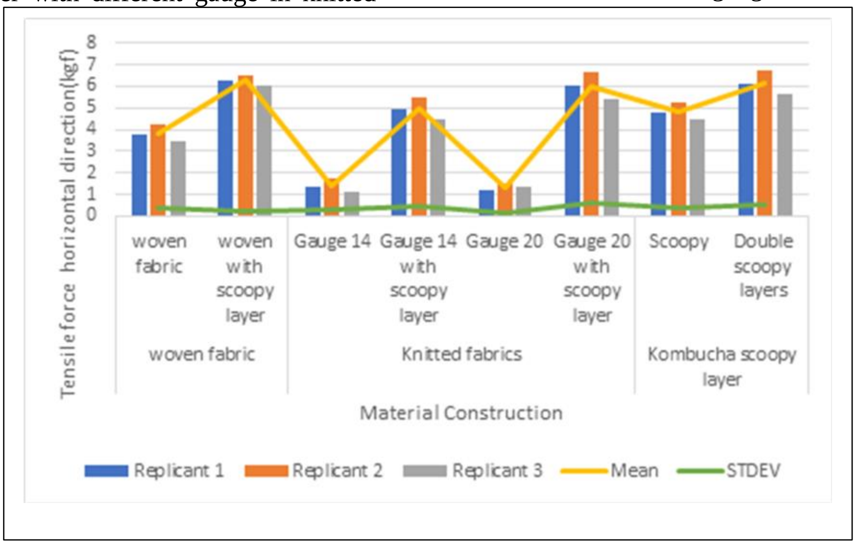


Fig. 15. Effect of laminating KOMBUCHA layer with different fabrics and the effect of machine gauge on the tensile force horizontal direction 'Source: Author's own creation'

3.3.6 Effect on Elongation in Vertical Direction

By applying the T-test it was found that laminating the KOMBUCHA layer with fabrics has a non-significant effect on the Elongation in the vertical direction of fabrics by p-value= 0.660 with the woven fabric, p-value= 0.374 with the knitted fabric gauge 14, and p-value= 0.467 while laminating with same another layer of KOMBUCHA. But it is only a significant effect with the knitted fabric gauge 20 p-value= 0.003. Also, by applying the T-test between different gauges in knitted fabrics, it was found that the knitting gauge significantly affected the elongation in the vertical direction between blank knitted fabrics with p-value= 0.345, but it affected significantly with p-value= 0.0004 between reinforced KOMBUCHA layer with a different gauge in knitted samples.

(Fig.16) showing the effect of laminating the KOMBUCHA layer with different fabrics and the effect of machine gauge on the elongation in the vertical direction, as it is shown that knitted fabrics with gauge 14, followed by gauge 14 with SCOPY, knitted fabric gauge 20, gauge 20 with SCOPY are the higher in elongation in the vertical direction, although it is shown that SCOPY single and double layers, woven fabric and woven with SCOPY have no compared elongation in the horizontal direction with the knitted fabrics which enhanced KOMBUCHA s' elongation when laminated with it regarding to the knitting construction technique.

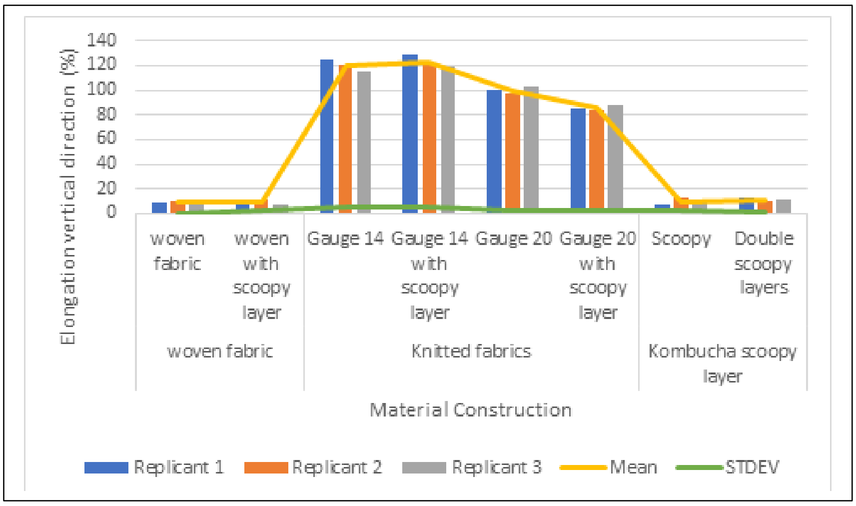


Fig.16. Effect of laminating KOMBUCHA layer with different fabrics and the effect of machine gauge on the elongation vertical direction 'Source: Author's own creation'

3.3.7 Effect on Elongation in Horizontal Direction

By applying the T-test it was found that laminating the KOMBUCHA layer with fabrics significantly affected the elongation in the horizontal direction of fabrics by p-value= 1.33131E-05 with the knitted fabric gauge 14, p-value= 2.04186E-05 with the knitted fabric gauge 20, But it is non-significant by p-value= 0.8 with the woven fabric, and p-value= 0.084 while laminating with same another layer of KOMBUCHA. (Fig.17). Also, by applying the T-test between different gauges in knitted fabrics, it was found that knitting gauge has a non-significant effect on Elongation in the horizontal direction between blank knitted fabrics with p-value= 0.39, and with p-value= 0.37 between reinforced KOMBUCHA layer with different gauge in knitted samples. As Samples with gauge 20 gave higher stretchability than sample s with gauge 14 regarding to the higer yarn length used in unit according to higher stitch density.

(Fig.11) showing the effect of laminating the KOMBUCHA layer with different fabrics and the effect of the machine gauge on the elongation in horizontal direction, as it is shown that knitted fabrics with gauge 20 and 14, followed by gauge 14 with SCOPY, gauge 20 with SCOPY are the higher in elongation in horizontal direction, although it is shown that SCOPY single and double layers, woven fabric and woven with SCOPY have no compared elongation in horizontal direction with the knitted fabrics which enhanced KOMBUCHA s' elongation when laminated with it. Also it is showed tha knitted fabrcs gave the highest elongation in horizontal direction as nitting technique is nown by its loop formation which allow the fabric to stretch higher than woven fabric which only weft insertwd in straight shape. Laminating with KOMBUCHA affected knitted and woven saples by decreasing elongation because of its low streatchability.but laminate KOMBUCHA with fabrics enhanced its elongation with high percentage as shown regarding to the stick force.

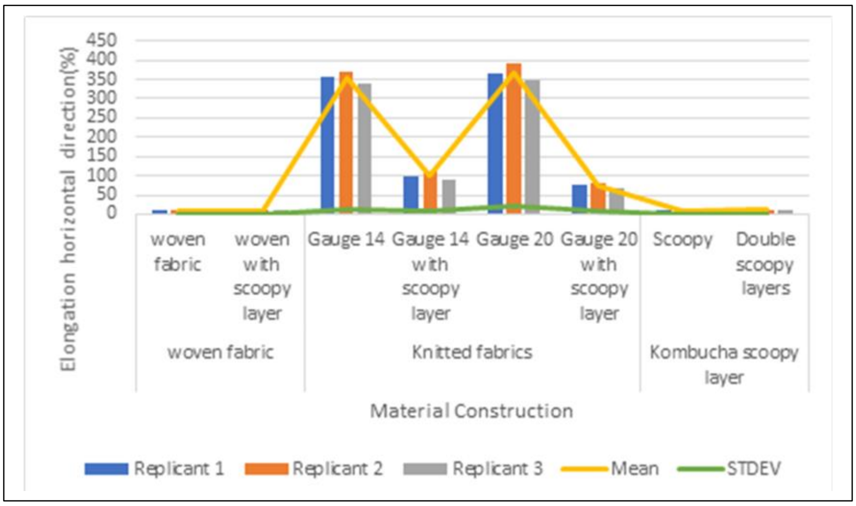


Fig. 17. Effect of laminating KOMBUCHA layer with different fabrics and the effect of machine gauge on the elongation horizontal direction 'Source: Author's own creation'

3.3.8 Effect on Young Modulus in Vertical Direction

By applying the T-test it was found that laminating the KOMBUCHA layer with fabrics significantly affected the young modulus in the vertical direction of fabrics by p-value= 0.0297 with the woven fabric, p-value= 0.0001 with the knitted fabric gauge 14, p-value= 0.0002 with the knitted fabric gauge 20, and p-value= 0.080 while laminating with same another layer of KOMBUCHA. Also, by applying the T-test between different gauges in knitted fabrics, it was found that knitting gauge is non-significant on Young Modulus in the vertical direction between blank knitted fabrics with p-value= 0.114, and with p-value= 0.326 between reinforced KOMBUCHA layer with different gauge in knitted samples.

(Fig.18) showing the effect of laminating the KOMBUCHA layer with different fabrics and the effect of the knitting gauge on the young modulus in the vertical direction, as it is shown that doble SCOPY layers have the highest young modulus in the vertical direction, followed by gauge 20 with SCOPY, KOMBUCHA SCOPY single layer, gauge 14 with SCOPY, woven with SCOPY, woven fabric, knitted fabrics with gauge14, and finally gauge 20 is the least in young modulus in vertical direction.

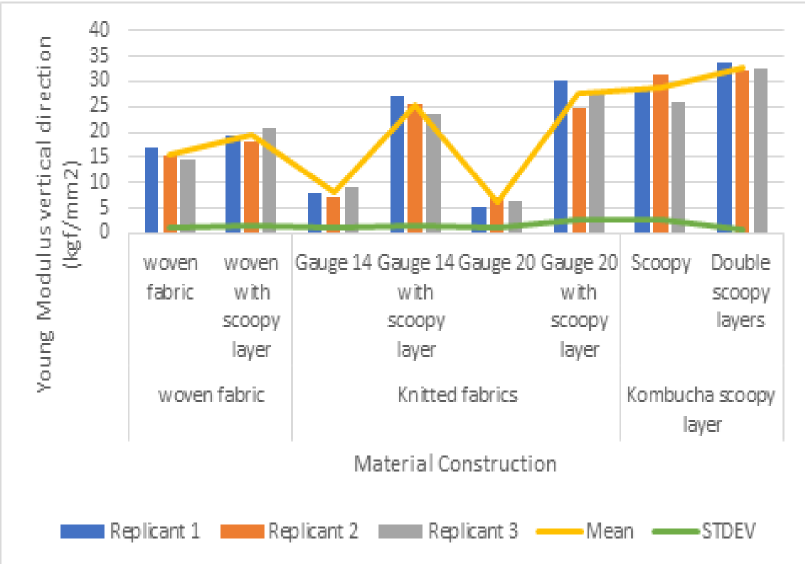


Fig. 18. Effect of laminating KOMBUCHA layer with different fabrics and the effect of machine gauge on the young modulous vertical direction 'Source: Author's own creation'

3.3.9 Effect on Young Modulus in Horizontal Direction

By applying the T-test it was found that laminating the KOMBUCHA layer with fabrics significantly affected the young modulus in the horizontal direction of fabrics by p-value= 0.000211708 with the knitted fabric gauge 14, p-value= 0.000247862 with the knitted fabric gauge 20, but non-significant by p-value= 0.304 with the woven fabric and p-value= 0.212 while laminating with same another layer of KOMBUCHA. Also, by applying a T-test between different gauges in knitted fabrics, it was found that knitting gauge significantly affected Young Modulus in the horizontal direction between blank knitted fabrics with p-value= 0.024, but non-significant with p-value= 0.651 between reinforced KOMBUCHA. layer with different gauge in knitted samples.

(Fig.19) showing the effect of laminating the KOMBUCHA layer with different fabrics and the effect of the machine gauge on the young modulus in the horizontal direction, as it is shown that doble SCOPY layers have the highest young modulus in the horizontal direction, followed by gauge 20 with SCOPY, KOMBUCHA SCOPY single layer, gauge 14 with SCOPY, woven with SCOPY, woven fabric, knitted fabrics with gauge14, and finally gauge 20 is the least in young modulus in the horizontal direction

Young's modulus can determines the deformation amount of the tested material under a known applied load.As lower Young's Modulus of the materials mean higher deformation experience, from (Fig.18) and (Fig.19); its observed that liminating KOMBUCHA with fabrics in all samples enhahanced deformation experience than blank samples, and it is shown that the double SCOPY layers sample hasw the highest deformation resistance between the study samples in both vertical and horizontal direction.

3.3.10 Effect on Peeling Force in Vertical Direction

By applying a T-test between different gauges in knitted fabrics, it was found that knitting gauge was affected significantly with p-value= 0.006 on the Peeling force in the vertical direction between the reinforced KOMBUCHA layer with the different gauges in knitted samples.

(Fig. 20) showing the effect of machine gauge on the peeling force in the vertical direction, as it is shown that double KOMBUCHA SCOPY has the highest peel force followed by woven with SCOPY, gauge 20 with SCOPY, and finally gauge 14 with SCOPY has the least peel force in the vertical direction.

3.3.11 Effect on Peeling Force in Horizontal Direction

By applying the T-test between different gauges in knitted fabrics, it was found that knitting gauge affected non-significant with p-value= 0.551 on the peeling force in the horizontal direction between reinforced KOMBUCHA layer with different gauges in knitted samples.

(Fig. 21) showing the effect of machine gauge on the peeling force in the horizontal direction, as it is shown that double KOMBUCHA SCOPY has the highest peel force followed by gauge 20 with SCOPY, gauge 14 with SCOPY, and finally woven with SCOPY has the least peel force in the horizontal direction.

From the behaviour of peel force in all samples (Fig. 20)and (Fig. 21) ; it is found that peel force affected by fabric type may be regarding to the suface nature of the sample which can give higher sticking area and then higher peel force between saple and KOMBUCHA layer and that's varied between vetical and horizontal direction in the knitted fabrics onle because the formation of the knitting loop varied between both directions. Although it doesn't varied between woven or KOMBUCHA double layer as both of them have the same formation in vertical and horizontal direction.

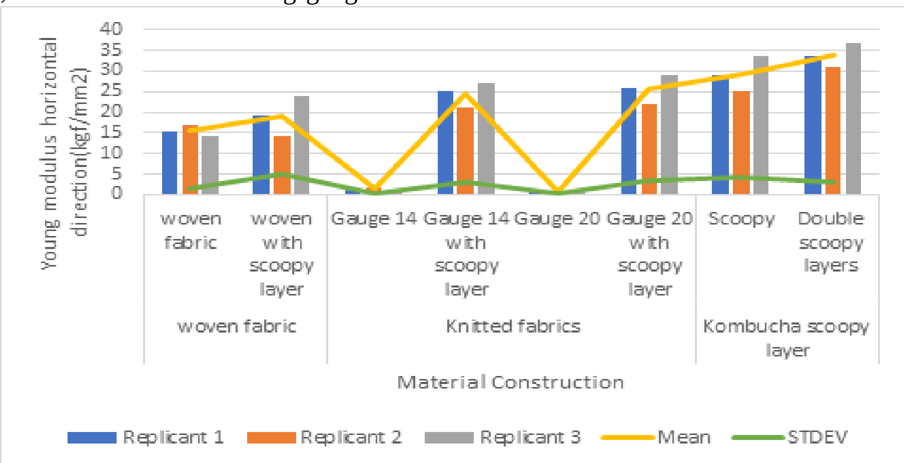


Fig. 19. Effect of laminating KOMBUCHA layer with different fabrics and the effect of machine gauge on the young modulus horizontal direction 'Source: Author's own creation'

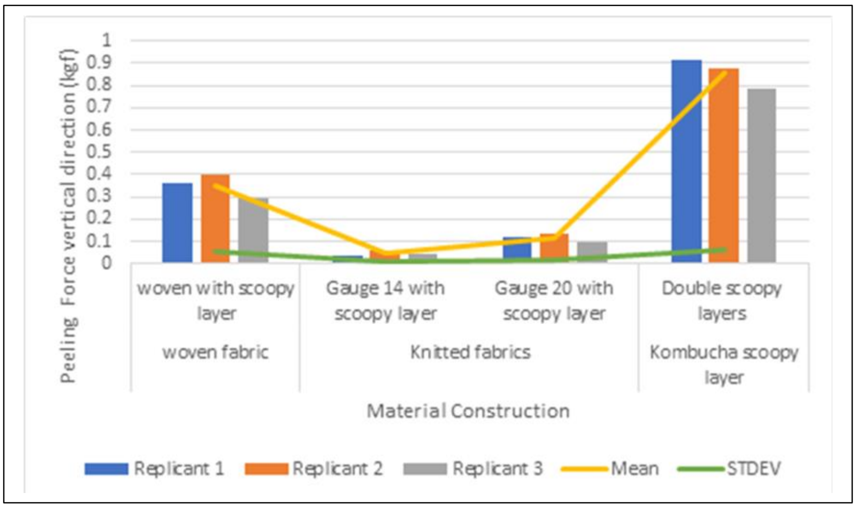


Fig. 20. Effect of laminating KOMBUCHA layer with different fabrics and the effect of machine gauge on the peeling force vertical direction 'Source: Author's own creation'

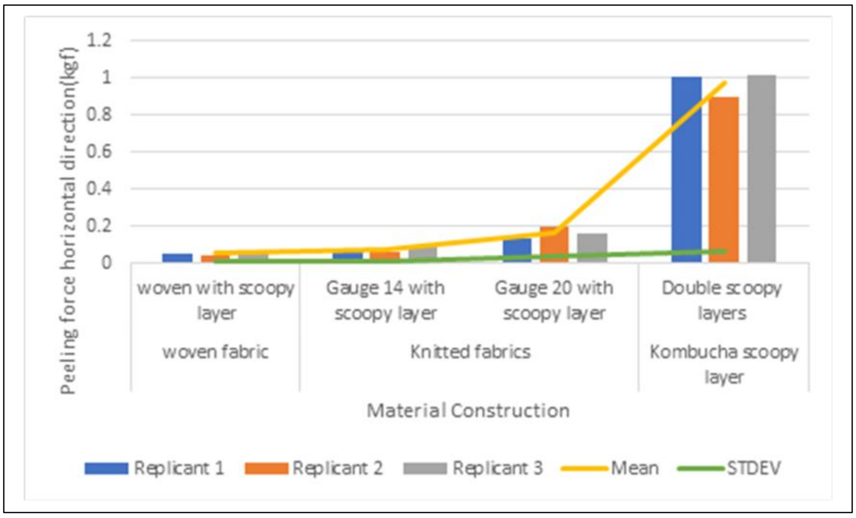


Fig. 21. Effect of laminating KOMBUCHA layer with different fabrics and the effect of machine gauge on the peeling force horizontal direction 'Source: Author's own creation'

5. Conclusion

In this study eco-friendly KOMBUCHA SCOPY were prepared in the lab and laminated with cellulosic woven, knitted textiles and also laminated with the same layer from KOMBUCHA, after testing its properties, it was found that all reinforced fabrics' types were enhanced KOMBUCHA mechanical properties such as tensile strength, elongation, young modulus, peel strength, and thermal conductivity with an effect on weight and thickness. By using ANOVA analysis, it was found that fabrics type in both single layers and reinforced KOMBUCHA; all properties were significantly and highly significantly affected except elongation in the vertical direction. Also, by applying T-test analysis it was found that the machine gauge in knitted fabrics Significant affected thickness, weight, thermal conductivity, young modulus, elongation and peel force but didn't affect tensile strength. From that reinforced value were added to antimicrobial value of KOMBUCHA to produce an anti-microbial bed head board with special design of ergonomics' comfort. Finally, the prepared design was actually applied; as the higher light transparence sample was chosen to be applied in the lighting unit of the bed for good light transmission. The higher sample in both elongation and tensile force was closed for upholstered headrest of the headboard for achieving a comfort bed for special use.

6. Conflicts of interests

"There are no conflicts to declare".

7. Formatting of funding sources

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