Production of Bamboo Children`s Garment Fabrics Using Figured Double-Sided Jacquard Technique

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Abstract:
The weave structure of double-cloth fabrics permits using various structures for both sides of the fabric, and this can be beneficial in the functionalization of the produced fabrics. Since children's clothing fabrics are produced using conventional techniques, and regarded as one of the most clothes that gets soiled and one the most financial burdens on the family, the intent of this research was to obtain figured double-sided jacquard fabrics used for children's clothes that achieve aesthetic, functional, and commercial values. In addition to the production technique used for the children's clothing fabrics, bamboo material was used as weft yarn threads. This is because the use of environmentally friendly materials is one of the most important modern trends in the manufacture of clothes in general and particularly children's clothes to be safe on the environment and on the health and skin of children. Hence the importance of this study lies in creating novel visions in fabric design that is capable to compete other fabrics in the local and international market. Three samples of different densities of bamboo wefts (40-44-48) weft/cm were produced using the double-sided jacquard technique. Laboratory tests were conducted on the produced samples (tensile strength and elongation - weight - thickness - air permeability - resistance to friction). The results of the research showed that the higher the density of the bamboo wefts, the greater the tensile strength, elongation, weight, and thickness, as well as the frictional resistance of the produced samples, and the lower the air permeability.

Keywords:
Figured Double Face,
Double Cloth,
Jacquard Fabric,
Bamboo,
Children's Clothes,
Aesthetic Values,
Functional Values.

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Introduction

Figured double-faced jacquard fabric reveals intricate pictorial patterning effects since it has different colour impacts on both sides of the fabric. It is considered as one of the most value-added textile products. [1], [2]. In addition to the colour effects, miscellaneous weave structures and yarn materials can be used for the face and the back layer of the fabric which can be beneficial in the functionalization and aesthetic aspects of garment fabrics [3]. Furthermore, over last few years, there has been a growing interest of Bamboo fibers due to its unique properties like excellent permeability, hygroscopicity, soft feel [4], and high strength with low density [5]. Therefore, Bamboo was the ideal choice to produce children's clothing.

Problem

Using classical techniques in the production of children`s garment fabrics and, the resulted fabrics have –accordingly- a traditional view which may affect their ability to compete other fabrics in the markets.

Research Importance

Enriching the functional and aesthetic properties of children`s clothes by using novel visions in the fabric design to compete with other fabrics in the local and international markets and to reduce the coast of garments production.

Objectives

Production of children`s garment fabrics from Bamboo materials as weft yarns by using figured double-sided jacquard technique to accomplish aesthetic and functional values.

1.1 Double Face Jacquard Fabrics

A distinctive form of jacquard fabric is double-faced cloth which is also known as two-ply fabrics. There is no other way to emulate its artistic impact [6]. It is a type of multi-layer fabric, and can be produced using classical weaving looms [7]. Various stitching techniques are used to join the two layers of the double cloth [8]. Figure (1) illustrates the interlacements between the top layer and the bottom layer of the double facric [9].

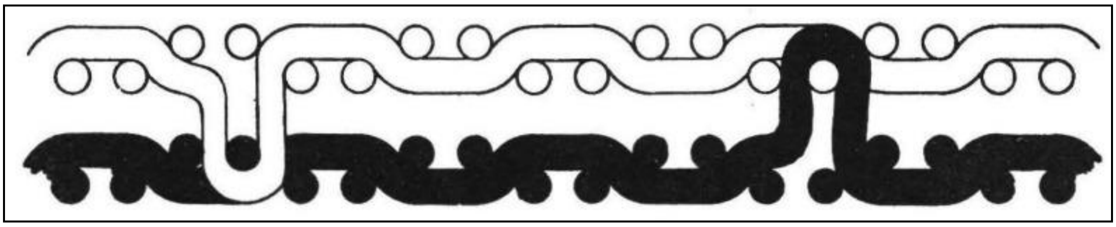


Figure (1) Interlacings between Face and Back Layers in Double Cloth

The double fabric's performance and aesthetic characteristics are both influenced by the raw material and yarn types used [8]. Varied weave kinds, yarn structures, raw materials, yarn colours, and settings on the fabric's face and back can be used to create various aesthetic designs [7]. Designers have to create jacquard fabrics with exquisite impact and an abundant colours as customers choose fabric mostly based on their visual images. [1].

In addition, it is crucial to note that a specified weave type and yarn settings rule the array of face and back yarns in warp and weft directions [8]. Besides, more attention have to be paid when scheming the color plans of face and back warp and weft yarns if the double cloth has a color effect on both layers [8].

Moreover, it is essential for the face ends to be arranged in definite order with the back ends, and the face picks with the back picks as the relationship between the face and back layers in the design of figured double fabric is exceedingly complex [8], [10].

1.1.1 Double-Cloth Construction Principle

Basically, double-faced fabrics consists of two yarn layers that are woven one on top of the other and stitched together [11]. It is made up of at least two warp thread series, one of which is referred to as the face warp and the other as the back warp. Similar to how, there are two series of weft, one series is known as face weft and the other series is known as back weft [12]. The face warp and face weft threads are interlaced to create the upper layer, and the back warp and back weft threads are interwoven to produce the lower layer of the fabric. [13].

Such technique enables two distinctive design figures to be obtained separately in a piece of fabric by substituting two groups of warp and weft threads [14].

1.1.2 Purpose of Producing Double-Faced Fabrics

- Enhancing the air permeability of the fabric[11].
- Improving hand feel and appearance [13].

1.2 Bamboo

Bamboo, a perennial plant with regenerated cellulose fiber, is regarded as sustainable and eco-friendly[5], and it is being employed in a variety of industries across a wide range of sectors as the idea of green ecology gains momentum [15].

The largest bamboo in the world, Phyllostachys Edulis, sometimes known as "Moso," is the primary source of bamboo fibers [16], [17]. Due to its distinctive rhizome dependent system, it is regarded as one of the fastest-growing plants [18]. It just takes 45 to 60 days for it to grow to a height of 75 feet [19].

There are two types of bamboo fiber used in textile production: natural bamboo fiber and regenerated bamboo fiber. Natural bamboo is generally produced as a fiber bundle using a special chemical and physical process. The regenerated bamboo fiber is made from bamboo pulp, which has a similar viscose processing technique. [20].

Bamboo fibers feature a longitudinal section that is thin, long, and tapering, frequently bifurcated at the ends, and an uneven serrated cross section that is covered in micro-gaps and holes. Fibers are peppered with striped fissures. [21].

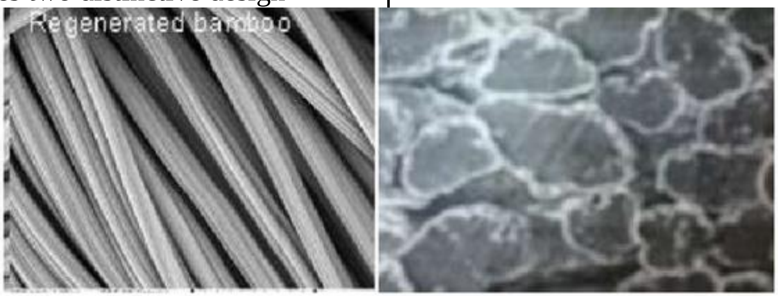


Figure (2) Cross-Sectional/Longitudinal View of Bamboo Fiber [22]

Bamboo fiber's length is quite short and ranges from 1 mm to 5 mm [5] and in diameter from 10 mm to 50 mm. scientific studies have shown that bamboo fiber with a wider diameter offers better fiber quality [23].

Among all plant fibers, bamboo fiber has a comparatively higher mechanical strength [24]. This is attributed to the high cellulose and lignin content as well as the relatively tiny microfibril angle of the bamboo plant [25]. Compared to other natural fibers, it has the lowest density [18] and a better ability to recover moisture (13.3%) than fibers like cotton (8.5 %) [16].

Table (1) Chemical Composition, Physical and Mechanical Properties of Bamboo Fibers [21], [26]

Cellulose%	Hemicellulose%	Lignin%	Density %	Tesile Srtength(Mpa)	Youngs Modalas(Gpa)	Elongation at Break (%)
26–43	30	21–31	0.6–0.8	140–800	11–30	1.3

1.2.1 Properties of Bamboo Fibers

- Bamboo fiber has a hollow cross-section that provides great air permeability and moisture absorption.
- Sodium copper chlorophyll in the bamboo fiber provides refreshing and anti-ultraviolet effect [27].
- Light weight, high strength, biodegradability [28].
- High sorption of dyes and better color clarity [20].

1.2.2 Application of Bamboo Fiber

Bamboo fiber has a long list of applications some of which are:

- Due to its antibacterial and temperature-regulating qualities, bamboo fiber has a place in the sports apparel business.
- Because of its UV protection abilities and low crumple susceptibility, bamboo fiber is an ideal material for summer collections [16].
- Bamboo fibers have been used in traditional apparel, protective gear, and medical fabrics, among other industries. Bamboo fibers are utilized in wound bandages, sanitary and odor-resistant clothes [5]

2 Research Methodology and Experiments

The aim of this research is to produce figured double-sided jacquard fabrics used for children's clothes that achieve aesthetic, functional and commercial values. The research samples were produced through three parameters which were three weft yarn setts (40, 44, 48 picks /cm).

2.1 Design Patterns for Figured Double Cloth

Two designs were constructed using CAD textile software, one for face side, and the other for the back side. The designs are portrayed in Figures (3) and (4), respectively. The application of the two designs with color codes is illustrated in Figure (5).

Figure (3) Design of Face Side

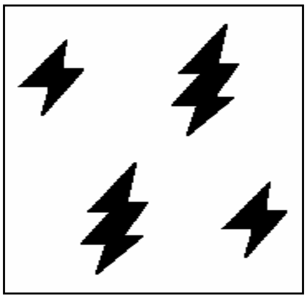


Figure (4) Design of Back Side

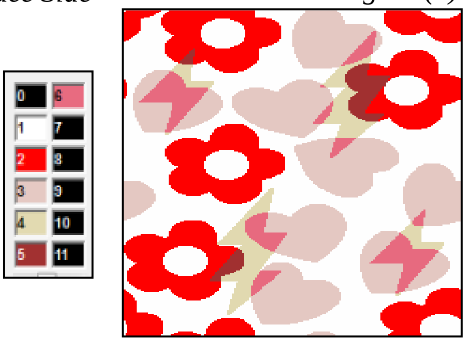


Figure (5) Color-Coded Combination Design of Face Side and Back Side

2.2 Technical Specifications

2.2.1 Machine Specifications Used for Manufacturing the Samples for the Study

The produced fabrics was implemented in Textile Design Center in the Faculty of Applied Arts, Helwan University. The specifications of the loom used for producing the fabrics under study are shown in Table (2).

Table (2) Specifications of the Loom Used to produce Samples under Study in Textile Workshop

No.	Item	Specifications
1	Loom Type/ Model	ITEMA/ R9500
3	Manufacturing Country	Italy
4	Manufacturing Year	2014
5	Machine Width (Reed Width)	190 cm
6	Machine Speed	300 Picks/ Min.
7	Weft Insertion Method	Rapier
8	Weft Selector	8 Fingers
9	Reed Used (Dents/ cm)	9 Dents/ cm
10	Denting	4 Ends/ Dent
11	No. of Colors of Warp Threads	2
12	Warp Threads Arrangement	1 Black: 1 Red

2.2.2 Jacquard Specifications Used for Producing Samples under Study

The specifications of the jacquard used for producing the fabrics under study are illustrated in Table (3).

Table (3) Specifications of the Jacquard Used in Manufacturing the Study Samples

No.	Item	Specifications
1	Jacquard Model	BONAS
2	Number of Hooks	6144 Hooks
3	Design Hooks	5800
4	No. of Repeats	1
5	Repeat Width	161.1 cm

2.2.3 Produced Samples Specifications

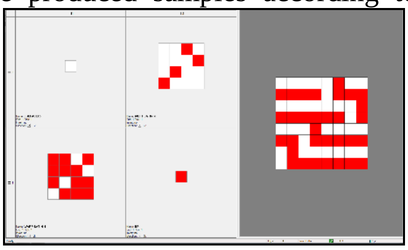
The basic specifications of the produced samples are depicted in Table (4).

Table (4) Basic Specifications of the Produced Samples

No.	Property	Specifications
1	Warp Yarn Material	Cotton
2	Weft Yarn Material	Regenerated Bamboo
3	Count of Warp Yarns	30/1
4	Count of Weft Yarns	30/1
5	Warp Sett (Ends/ cm)	36
6	Weft Sett (Picks/ cm)	40,44,48

2.3 Fabric Structures

Six weave structures were used for producing samples under study. The selected weave patterns depended on sateen weave and plain weave. Figures (6) to (11) represent the weave structures used for the produced samples according to the color codes in the combination design of the face side and the back side that is illustrated in Figure (5). The partial weaving card zoomed in, and the fabric simulation with selected weave structures are shown in Figures (12) and (13), respectively.



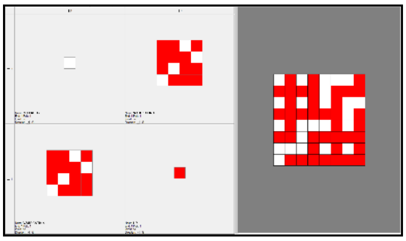
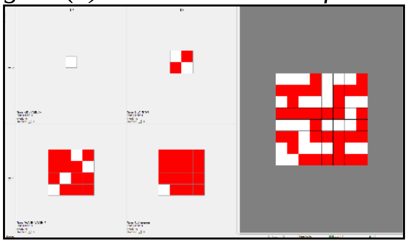


Figure (7) Weave Structure of Color 2

Figure (6) Weave Structure of Color 1



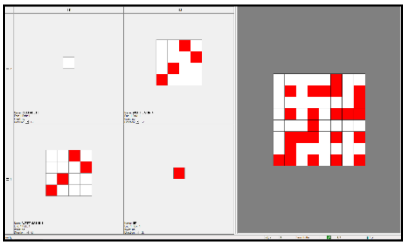
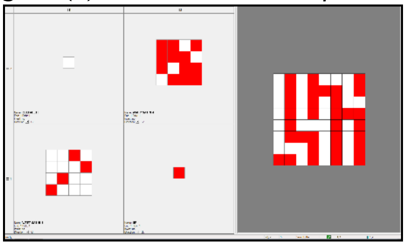


Figure (8) Weave Structure of Color 3

Figure (9) Weave Structure of Color 4



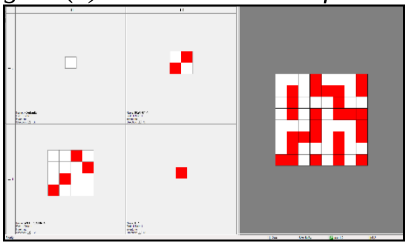


Figure (10) Weave Structure of Color 5

Figure (11) Weave Structure of Color 6

2.3.1 The Selected Weaves Used in the Research

1- Figure (6) shows the weave structure used in color 1 of the combination design, where the face side weave structure is weft sateen 4, and the back side weave is warp sateen 4.

2- Figure (7) depicts the weave structure used in color 2 of the combination design, where the face side of the cloth weave structure is warp sateen 4, and the back side weave is warp sateen 4.

3- Figure (8) illustrates the weave structure used in color 3 of the combination design, where the face side weave structure is plain 1/1, and the back side weave is warp sateen 4, and, in this structure, the two layers of the double cloth are stitched to each other making a coherence between the face side weave and back side weave, therefore the face side fabric and back side fabric are not separated due to this weave structure.

4- Figure (9) represents the weave structure used in color 4 of the combination design, where the face side weave structure is weft sateen 4, and the back side weave is weft sateen 4.

5- Figure (10) clarifies the weave structure used in color 5 of the combination design, where the face side weave structure is warp sateen 4, and the back side weave is weft sateen 4.

6- Figure (11) elucidates the weave structure used in color 6 of the combination design, where the face side weave structure is plain 1/1, and the back side weave is weft sateen 4.

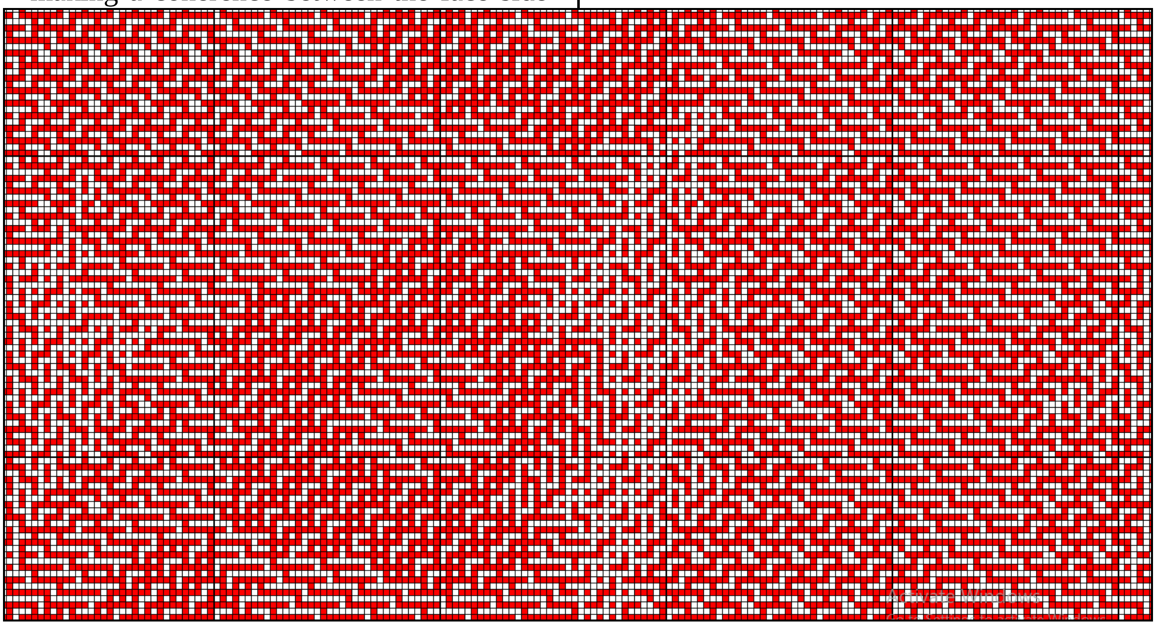


Figure (12) Partial Weaving Card Zoomed In

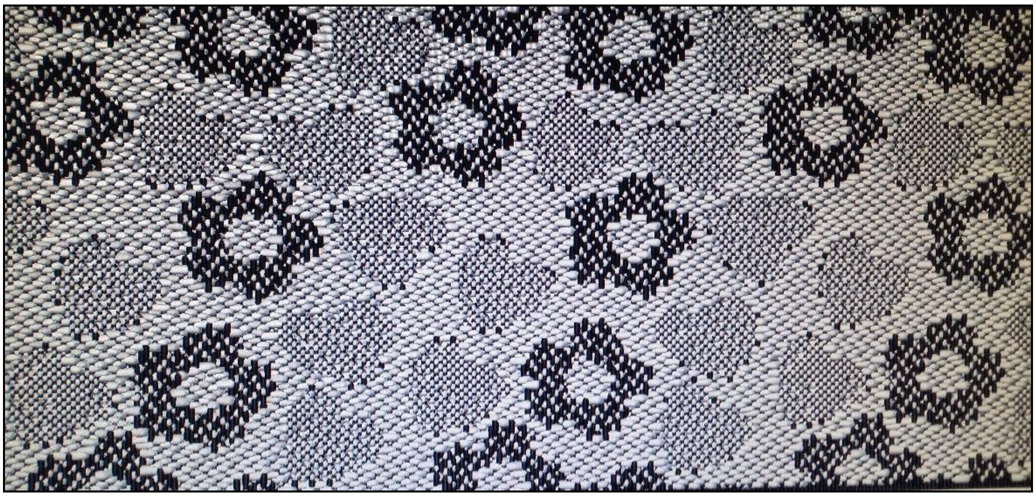


Figure (13) Fabric Simulation with Selected Weave Structures

2.4 The Produced Fabrics

Figure (14) shows pictures of the produced samples with overall effect detailed effect.

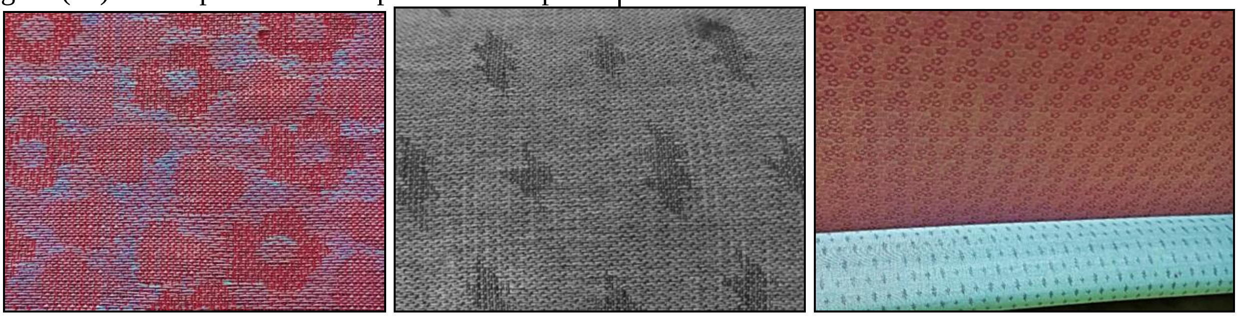


Figure (14) Produced Fabrics with Overall Effect and Detailed Effect

2.5 3-D Presentation of the Designs

Figure (15) depicts the 3-D presentation graphics of the face side and back side designs for the produced samples.

Figure (15) 3-D Presentation Illustrations of the Face Side and Back Side Designs for the Produced Fabrics

2.6 Laboratory Tests Applied to Produced Fabrics

To determine the functional characteristics that are appropriate for its use as garment fabrics, laboratory testing of the manufactured samples was conducted. According to the American Standard Society of Testing Materials (ASTM), these tests were applied for 24 hours at standard humidity (65% ± 2 RH) and temperature (20°C + 2°C). Table (5) indicates tests and standards used for samples under study.

Table (5) Tests and Standards Used for Produced Fabrics

No.	Test	Device Name	Standard Specification
1	Tensile strength (N)	Titan [10] Model No. 1710/10	ASTM D 5035
2	Elongation (%)	Titan [10] Model No. 1710/10	ASTM D 5035
3	Fabric Thickness (mm)	Hans Schmidt Gauge	ASTM D 1777
4	Mass per Unit Area (Weight of Fabric) (g/m^2)	Digital Balance	ASTM D 3776
5	Air Permeability (mm/s)	TEXTEST	ASTM D737
6	Weight loss Due to Friction (%)	Martindale	ASTM D4966

3 Results and Discussions

3.1 Designs Story Board

3.1.1 Story Board for Design of Face Side

The design consists of roses and hearts with similar sizes that are repeated in an irregular sequence.

3.1.2 Story Board for Design of Back Side

The design expresses the electrical lightning that is glimmered and consists of patterns that is fluctuated in a half drop repeat.

3.2 Technical Analysis for Designs

3.2.1 Technical Analysis for Design of Face Side

1. The curvilinear shapes form a sense of relief and comfort.
2. The repetition of the patterns provides a feeling of regular rhythm.
3. The movement between patterns increases visual excitement.
4. Using value in tones makes shapes appear to merge.
5. Using red color forms, a sense of passion.
6. The recurring patterns suggest harmony.

3.2.2 Technical Analysis for Design of Back Side

1. The feeling of an interesting contrast is obtained by using proportion between patterns.
2. The way of distributing elements convey a sense of movement.
3. Using colors black and white in the design assures the principle of contrast.
4. The geometric shapes used in the design stands out rigidity.
5. Using the pattern in different sizes creates an illusion of space.
6. The repeated patterns imply unity.

3.3 Data Collection and Statistical Analysis

3.3.1 Collection of Data

The following data in Table (6) represents the results of the applied tests to the produced samples.

Table (6) Results of the Applied Tests to the Executed Samples

Sample	Tensile Strength (N)	Elongation (%)	Fabric Thickness (mm)	Fabric Weight (g/m2)	Air Permeability (mm/s)	Weight Loss Due to Friction (%)	
						Face	Back
Sample (1) 40 picks /cm	566.69	25.57	0.85	170	5527	1.63	3.65
Sample (2) 44 picks /cm	662.14	31.26	0.9	180.3	5177	1.52	2.51
Sample (3) 48 picks /cm	728.17	29.44	0.94	194	4913	1.4	1.65

3.3.2 Analysis of Data

In this study the relationship between variables was evaluated by the One-way analysis of variance (ANOVA). It was used for the statistical analysis because there was more than one independent variable. ANOVA was used to analyze the independent variables which interact among themselves, and how these interactions impacted the dependent variable.

- **Effect of Weft Sett (Picks /cm) on Fabric Tensile Strength in Weft Direction**

Table (7) ANOVA Test for Fabric Tensile Strength Property Measurements In Weft Direction

Source	Sum of Squares	DF	Mean Square	F	Significant (P)
Between Groups	39549.880	2	19774.940	43.11	0.001***
Within Groups	2752.296	6	458.716		
Total	42302.176	8			

It can be seen from Table (7) that the value of (F) was (43.11), which is a statistically significant value at [P-value 0.001], and this indicates that there are significant differences between the characteristic's average measurements (tensile strength in weft direction).

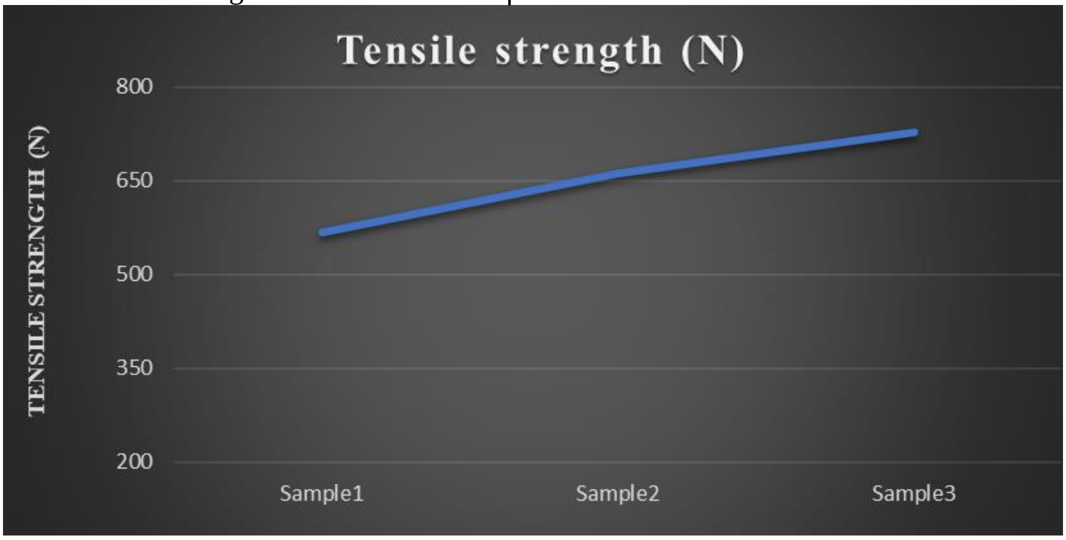


Figure (16) Relationship between Weft Sett (Picks/cm) and Fabric Tensile Strength in Weft Direction

In addition, it can be noticed from Figure (16) that there is a strong direct proportional relationship between weft sett and tensile strength in weft direction. It is obvious that sample (3) produced with 48 picks/cm has recorded the highest values of tensile strength in weft direction followed by sample (2) and sample (1) respectively, and this could be explained that as the weft sett increases, the number of picks per cm increases, as a result the weft yarns will be closer together, and the fabrics become more rigid leading to increase in the fabric tensile strength in weft direction.

- **Effect of Weft Sett (Picks /cm) on Fabric Elongation in Weft Direction**

Source	Sum of Squares	DF	Mean Square	F	Significant (P)
Between Groups	50.625	2	25.312	17.75	0.003**
Within Groups	8.558	6	1.426		
Total	59.182	8			

Table (8) ANOVA Test for Fabric Elongation Property Measurements In Weft Direction

It can be observed from Table (8) that the value of (F) was (17.75), which is a statistically significant value at [P-value 0.003], and this means that there are significant differences between the characteristic's average measurements (Elongation

in weft direction).
Also, it is crystal clear from Figure (17) that sample (2) has recorded the highest rates of elongation in weft direction followed by sample (3) and sample (1) respectively. This could be clarified that as the weft sett increases, the number of intersections in the unit area of fabric increases, and this directs to increase in fabric elongation in weft direction.

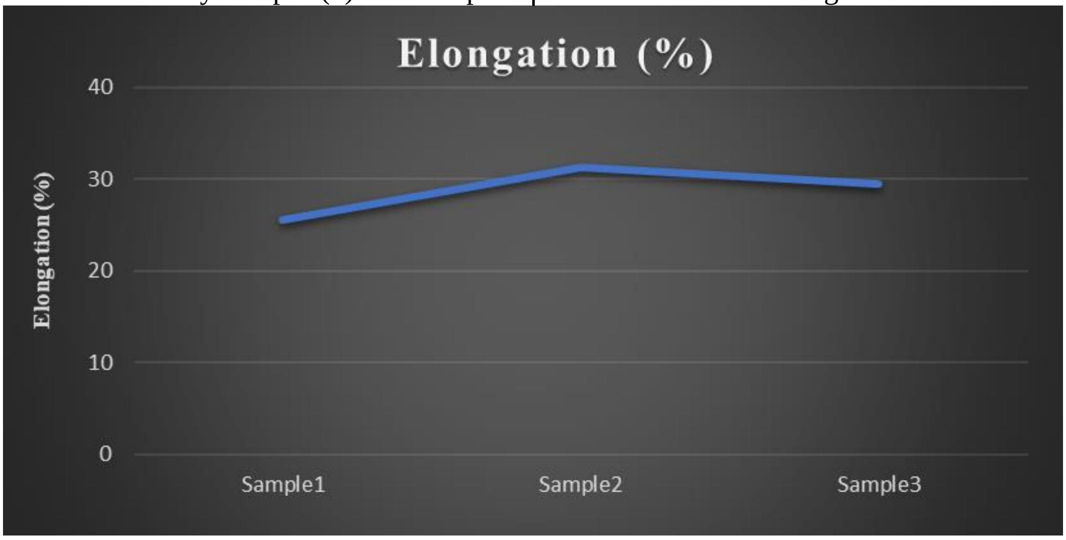


Figure (17) Relationship between Weft Sett (Picks/cm) and Fabric Elongation in Weft Direction

- **Effect of Weft Sett (Picks /cm) on Fabric Thickness**

Table (9) ANOVA Test for Fabric Thickness Property Measurements

Source	Sum of Squares	DF	Mean Square	F	Significant (P)
Between Groups	0.012	2	0.006	49.72	0.001***
Within Groups	0.001	6	0.000		
Total	0.013	8			

It can be seen from Table (9) that the value of (F) was (49.72), which is a statistically significant value at [P-value 0.001], which indicates that there are significant differences between the characteristic's average measurements (Thickness).
Also, it can be noticed from Figure (18) that there is a strong direct proportional relationship between weft sett and fabric Thickness. It is obvious that sample (3) produced with 48 picks/cm has scored the highest values of thickness followed by sample (2) and sample (1) respectively, and this could be summarized that as the weft sett increases, the number of picks per unit area increases, and that leads to increase in fabrics thickness.

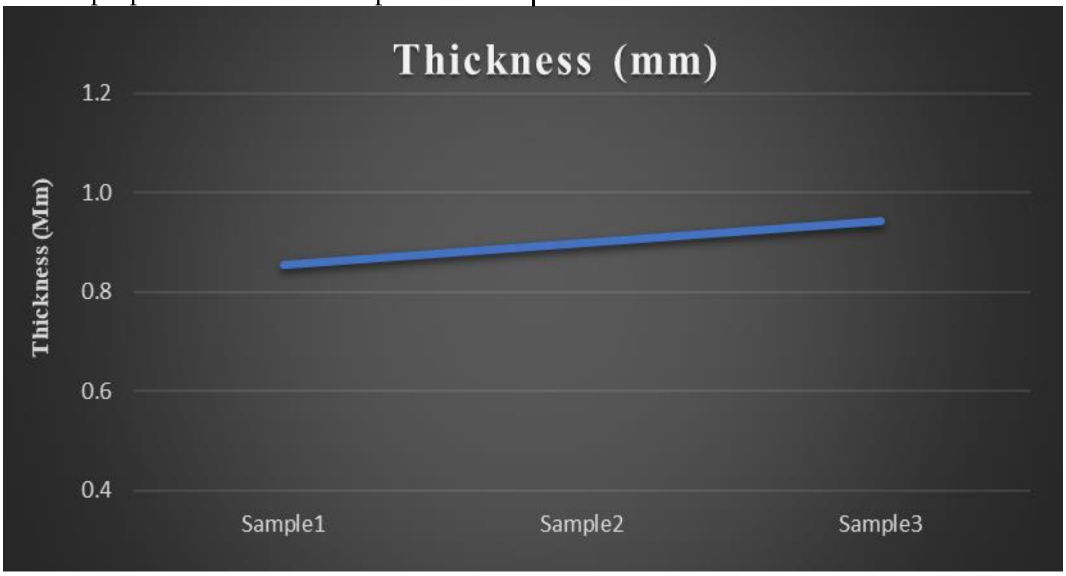


Figure (18) Relationship between Weft Sett (Picks/cm) and Fabric Thickness

- **Effect of Weft Sett (Picks /cm) on Fabric Weight**

Table (10) ANOVA Test for Fabric Weight Property Measurements

Source	Sum of Squares	DF	Mean Square	F	Significant (P)
Between Groups	864.76	2	432.38	4578.15	0.001***
Within Groups	0.57	6	0.09		
Total	865.33	8			

It can be noticed from Table (10) that the value of (F) was (4578.15), which is a statistically significant value at [P-value 0.001], and this indicates that there are significant differences between the characteristic's average measurements (weight).

And from Figure (19) it can be realized that there is a strong direct proportional relationship between weft sett and fabric weight. It shows that sample (3) produced has scored the highest values of weight followed by sample (2) and sample (1) respectively, and this could be summarized that as the weft sett increases, the number of picks per unit area increases, and that leads to increase in fabrics weight.

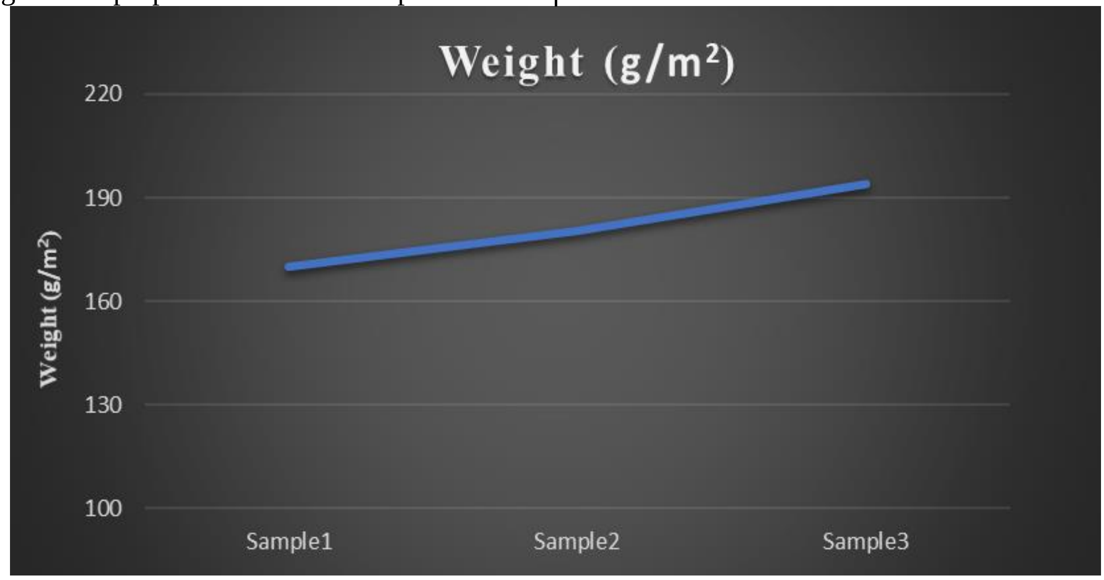


Figure (19) Relationship between Weft Sett (Picks /cm) and Fabric Weight

- **Effect of Weft Sett (Picks /cm) on Fabric Air**

Table (11) ANOVA Test for Fabric Air Permeability Property Measurements

Source	Sum of Squares	DF	Mean Square	F	Significant (P)
Between Groups	616200.00	2	308100.00	44.44	0.001***
Within Groups	41600.00	6	6933.33		
Total	657800.00	8			

It can be seen from Table (11) that the value of (F) was (44.44), which is a statistically significant value at [P-value 0.001], which indicates that there are significant differences between the characteristic's average measurements (air permeability**).**

In addition, it can be noticed from figure (20) that there is an inverse proportional relationship between weft sett and air permeability. It is obvious that sample (1) produced with 40 picks /cm has recorded the highest value of air permeability followed by sample (2) and sample (3) respectively, and this could be explained that as the weft sett increases, the number of picks per cm increases, as a result the gap spaces area in the fabric will be reduced, and as known, increasing number of picks per cm results in a tightly woven structure. So, it is believed that the air permeability of the woven fabric is reduced.

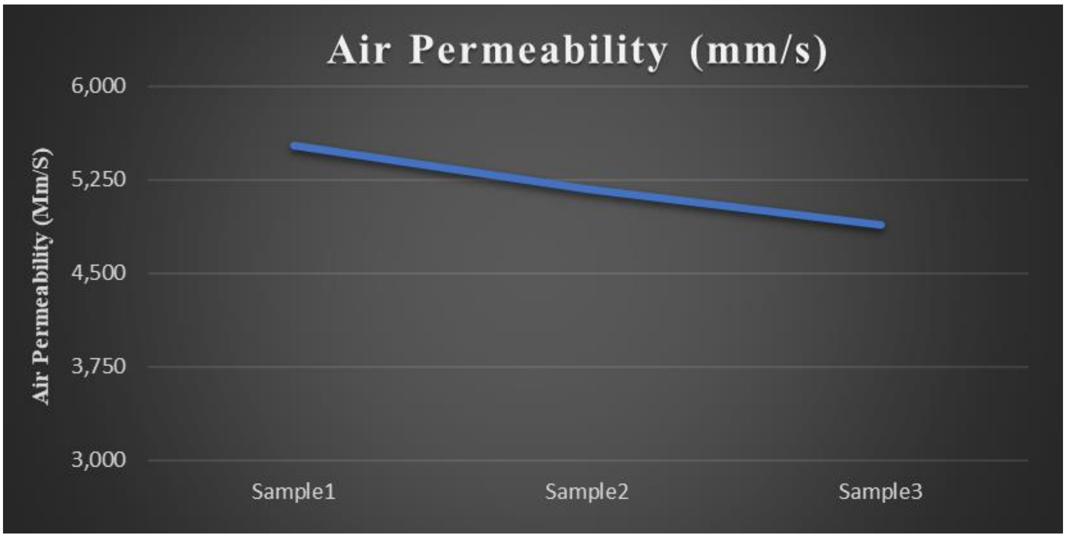


Figure (20) Relationship between Weft Sett (Picks /cm) and Fabric Air Permeability

- **Effect of Weft Sett (Picks /cm) on Fabric Abrasion Resistance**

In this study, abrasion resistance of the produced samples was evaluated by the percentage of fabric weight loss.

Table (12) ANOVA Test for Abrasion Resistance (Weight Loss) Property Measurements

Site	Source	Sum of Squares	DF	Mean Square	F	Significant (P)
Face	Between Groups	0.07	2	0.04	0.16	0.858
	Within Groups	1.39	6	0.23		
	Total	1.46	8			
Back	Between Groups	6.04	2	3.02	9.69	0.013*
	Within Groups	1.87	6	0.31		
	Total	7.90	8			

It is clear from Table (12) that there are significant differences between the research samples in the characteristic's average measurements (weight loss (back)) only as the value of (F) was (9.69), which is a statistically significant value at [P-value 00.013]. Also, it is crystal clear from Figure (21) that sample (1) (in both sides of the fabric) has recorded the highest rates of weight loss followed by sample (2) and sample (3) respectively. This could be clarified that as the weft sett increases, the frictional forces between warp and weft threads increases, and this leads to increase the abrasion resistance (weight loss decrease) .

Figure (21) Relationship between Weft Sett (Picks /cm) and Fabric Abrasion Resistance

- **Overall Evaluation of Research Samples**

Table (13) Relative Values and Quality Coefficients for the Research Samples

Sample	Tensile strength (N)	Elongation (%)	Thickness (mm)	Weight (gm)	Air permeability (mm/s)	Abrasion Resistance (Weight Loss %)		Quality Factor
						Face	Back	
Sample (1)	77.82	81.80	100	100	100.00	86.53	45.21	**84.48%**
Sample (2)	90.93	100	95.05	94.69	93.67	93.67	76.26	**92.04%**
Sample (3)	100	94.15	90.46	87.66	88.42	100	100	**94.38%**

Table (13) and Figure (22) shows the relative values and quality coefficients of the research samples. Sample (3) has recorded the best results according to quality factor followed by sample (2) and sample (1) respectively. This means that the increase in the weft sett of the produced samples give the best performance according to the quality coefficient.

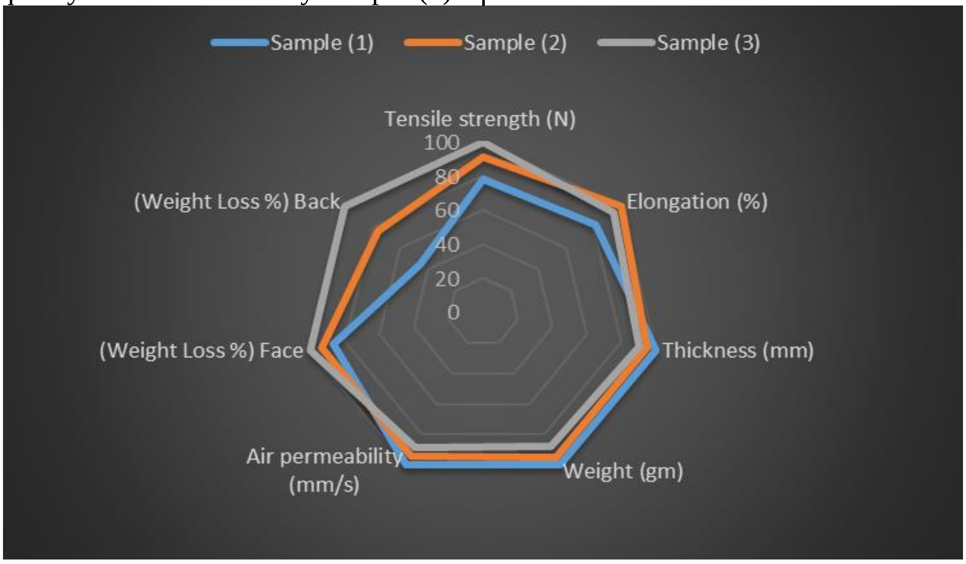


Figure (22) Relative Values of Measured Characteristics of the Research Samples

Conclusion

- Figured double-face jacquard technique enrich the functional and aesthetic properties of children's clothing fabrics.
- There is a strong direct proportional relationship between weft sett of Bamboo and fabric tensile strength and elongation in weft direction.
- There is a strong direct proportional relationship between weft sett of Bamboo and fabric thickness and fabric weight.
- There is an inverse proportional relationship between weft sett of Bamboo and fabric air permeability.
- There is a direct proportional relationship between weft sett of Bamboo and fabric abrasion resistance.

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