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EFFECT OFBED SHEET FABRICCONSTRUCTION ONTHEREDUCTIONOFBED SORES (PART I)

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ABSTRACT

Bed sores are considered the most dangerous side effects that happen to patients who suffer from problems that prevent them from moving and thusleading for them to be confined to their beds for a long time.The aim of this research is studying the effect of some constructionelements of bed sheetswhich may lead to the reduction in bed soresoccurrences. 11woven samples were produced bydifferent materials(bamboo, cotton, and stable rayon viscose), different weave structures (plain, basket 2/2, and satin 4) and different weft densities(16, 20, and 24 threads/cm).The results showed that in general bamboo fabrics demonstrated the best comfort properties.The plain structure was found to achieve the highest values for water vapor, air permeability, and thermal conductivity which are the most important comfort factors of textiles.

Keywords: Bed sores, bamboo, stable rayon viscose, eco- friendly material, water vapor permeability, thermal conductivity.

I. INTRODUCTION

Bed sores are the laceration that affects human tissue as a result of compressing them for long periods which in turn restricts blood from reaching blood vessels of the skin layers leading to thedeath of these parts of the skin and resulting finally in bed sores.In addition, moisture resulting from patient secretionsprovidesthe appropriate environment for the growth of micro-organisms which increases the problem of bed sores. Accordingly, Bed sores are considered one of the major problems facing those working inmedical fields such as physicians and nurses.**[1, 2, 3]**

To reduce the onset of bed sores different attempts have been made such as:

- Turning the patient side to side every two hours at least.
- Making water mattresses and pads.
- Using air mattresses and pads.
- Using special floatation bed systems.

However,despite all previous attempts to resist the occurrence of bed sores, it was found that bed sheets sticking to the body of the patient directly still have the greatest impact on the onset of bed sores. Accordingly, fabrics which aid in controlling and reducing bed sores are of utmost importance and should have aspecific set of properties.

IJARSE
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1.1.Properties of bed sheets to reduce the probability of bed sores

1.1.1-Moisture absorption

This is the most important property of fabric sheets covering beds in medical facilities because of the secretions of the patient's body such as sweat, humidity, and secretions associated with surgical operations.

The main factors which influence the absorption of sweat and humidity are:

- Water vaportransmission by simple diffusion of water vapor through inter and intra yarn spaces and the diffusion through individual fibers. **[4]**
- Moisture absorption throughinter and intra fiber spacesinside the fibers physically, and mechanicallybetween the fibers and between the yarns.
- The generated heat from absorption of moisture inside the fibers.
- The ability oftextile fabricstodry.**[5]**

1.1.2-Fabric texture

Fabrictextureisanimportant property that greatly affects the comfort properties of fabrics during its use. Accordingly,fabricsmust be chosen by the type and specifications of the fibers, as well as yarnand fabric structure, and finishing which contributesto thegood texture of the fabrics.**[6]**

1.1.3–Soiling resistance

Soiling resistance of fabrics are affected by thetype of fiber and structure as thick fibers,circular cross section, and smoothlysurfaced fiberslead to less dust retention. Moreover, textile structures that contain more pores lead to the entrapment of dirt particles inside those pores which in turn hinders its easy cleaning. **[6]**

1.1.4 – Resistant to microbial (Anti- Bacterial)

Anti-bacterial fabrics are the most used in the medical textiles segment. Those types of fabrics are used to prevent infection in medical clothing, wound dressing, and bedding. Approximately 70% of the bamboo fabrics still have antibacterial properties when they have been washed up to 50 washes.What makes bamboo fabrics more attractive in medical applications is the fact that when medical apparels are treated with chemical and anti-microbialagents it caused skin irritation and allergy.**[6]**

1.2-Factors affecting woven fabric properties

Fabric properties depend on fiberproperties, yarnstructure, fabric structure and the mechanical and chemical finishingtreatments.**[7]**

1.2.1 Textile materials used to produce bed sheets facing bed-sore

Generally, cotton and rayon fibers are used widely for medical purposes because of their affordability and easy cleaning properties they are the cheapest and easily cleaned as well as their excellentabsorption qualities.Recentlynovel fibers started to be an equal if not better alternative to commonly used natural fibers in the medical field. Bamboo fibers are one of those novel fibers which satisfymost human needs in a fabric to be used in close approximation to human skinsuch as; good durability, softness, hypoallergenic, stability, moderate tenacity; good spin ability, good hydrophilic nature, excellent permeability, excellent dyeing behavior naturally,antibacterial, UV protective, biodegradable, breathable, cool, flexible,and antistatic.Finally, it absorbs and evaporates sweat quickly. **[6, 8, 9, 10, 11]**

IJARSE
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ISSN (P) 2319 - 8346

Bamboo has a natural anti-bacterial property due to a bioagent which resists the growth of bacteria on the fiber. This is normally carried through the final product allowing it also to resist the growth of the bacteria that causes odor even after manyitems of washing. This eliminates the need for anti-microbial chemical treatments which cause allergic reactions**. [12]**

Natural antibacterial property of natural bamboo fiber was determined and compared with other textile fibers such as; jute, flax, ramie, and cotton fibers. In the results, it was revealed that compared with natural cotton the bacteriostatic rates of natural bamboo fiber against the bacteria were all zero; that of jute fiber and flax fiber were 48% and 8.7% respectively; that of ramie fiber was as high as 90.2%. **[13, 14, 15]**

Moreover, bamboo fibers are cost-effective, especially in areas where it is grown and readily available. In addition, transporting lightweight bamboo is less costly than transporting its heavier alternatives. As for the economic costs, it was found that the cotton ranges from $ 1.56 to $ 3per kg , while the bamboo from $ 3.9 to $ 7.14.**[16, 17]**

1.2.2 Fabricstructure

Fabric structures are considered the second most important element of the fabricconstruction, which affects all the properties of the fabrics such crease recovery,resistance to soiling, texture cloth…etc. **[4]**

1.3- Newdevelopmentsinbed sheetsused in reducing bed sores

A team ofresearchers has developed a new kind of bed linen with the intention of decreasing the occurrence of bedsores among bedridden patients .The new "dot matrix" linen is designed to reduce the contact. **[18]**

They designed a bed sheet system, the aim of this specialized bed sheet is to record the pressure distribution of the body while sleeping and then perform data analysis for medical applications.The bed sheet system is designed with the following consideration:

• High-resolution• Comfort • Low-cost. **[19, 20]**

Another teamdesigneda smart bed platform, it collects information from several sensors incorporated into the bed, analyzes the data to create a time-stamped, whole-body pressure distribution map, and orders the bed's actuators to periodically adjust its surface profile to redistribute pressure over the entire body. These abilities are combined to form a cognitive support system that augments the ability of a caregiver, allowing them to provide better care to more patients in less time**. [21]**

The aim of this paper is to study the effect of fabric construction;raw materials, weft setting and fabric structure on the reduction of Bed Sores.

II. EXPERIMENTAL WORK

To evaluate the effect of selected materials, weave structure and weft set of produced samples on theperformance of fabric which used to face the bed sores, 11 samples were produced as listed in thetable (1). For all samples, the warp material was cotton, its yarn count was 50/2 Ne and warp density was 36 / cm. On the other hand, weftmaterials cotton, rayon, bamboo, yarn count for bamboo was 36/2 Ne, for cotton and rayon were 32 / 2 Ne.Wefts densities were 16- 20- 24picks/cm respectively. All fabrics were plain 1/1, basket 2/2, and satin4. All samples were tested for perma test (skin model) and pilling.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Table (1) the specifications of produced samples

Sample no.	Warp material	Weft material	Warp density/cm	Picks density/cm	Count of warp yarns	Count of weft yarns	Weave structures
1	Cotton	Cotton	36	20	50/2	36/2	Plain
2		Rayon		20		36/2	Plain
3		Bamboo		16		36/2	Plain
4		Bamboo		20		36/2	Plain
5		Bamboo		24		36/2	Plain
6		Bamboo		16		36/2	Basket 2/2
7		Bamboo		20		36/2	Basket 2/2
8		Bamboo		24		36/2	Basket 2/2
9		Bamboo		16		36/2	Satin 4
10		Bamboo		20		36/2	Satin 4
11		Bamboo		24		36/2	Satin 4

III. RESULTS AND DISCUSSION

There is a general agreement that the transmission of air, heat and water vapor through fabrics are probably the most important factors in textile comfort.

Results of the experimental tests carried out on samples under study are presented in the following tables and graphs. Results were also statistically analyzed for data listed and relationships between variables were obtained.

3.1 Effect of fibers raw material on fabricperformance:

3.1.1Effect of fibersraw material on fabric weight:

Results of the weight determination are listed in Table 2. The fabric which has bamboo in weft has recorded the less weight when it is compared with cotton and rayon fabrics. That due to the density of bamboois lessthan rayonand cotton respectively, where the density of bamboo is 0.8 and the density of rayon and cotton are 1.29 and 1.52.

Table (2) Samples specification and test results

No.	Fiber material	Weave structures	Picks density/cm	Weight (g/m2)	Relative water-vapor Permeability (%)	Air permeability (cm^3/ cm^2/sec)	Thermal conductivity (cal/s.cm.K)	Pilling resistance
1	Cotton	Plain	20	170	54.1	53.9	0.71	4
2	rayon viscose	Plain	20	170	52.26	53.6	0.62	4
3	Bamboo	Plain	16	132	56	82.1	0.89	4
4	Bamboo	Plain	20	165	55.72	90.2	0.92	4

IJARSE
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5	Bamboo	Plain	24	198	66.86	57.2	0.98	4
6	Bamboo	Basket 2/2	16	140	55.6	50.1	0.68	4
7	Bamboo	Basket 2/2	20	160	55.06	62.1	0.73	4
8	Bamboo	Basket 2/2	24	170	50.05	52.6	0.77	4
9	Bamboo	Satin 4	16	140	57.2	28.6	0.58	4
10	Bamboo	Satin 4	20	160	52,76	44.8	0.66	4
11	Bamboo	Satin 4	24	170	51.68	51.7	0.66	4

3.1.2Effect of fibers raw material on fabrics water vapor permeability

The results of water vapor permeability and air permeability are illustrated in Figures 1, 2;the water vapor permeability and air permeability of bamboo is higher than cotton and stable rayon viscoserespectively. This can be explained bymicro- gaps and micro- holes in bamboo fibers which lead to higher water vapor permeability compared to the other two materials.

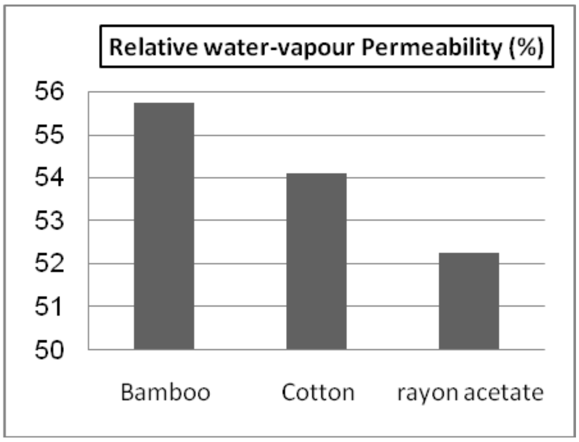


Fig. (1) Effect of raw material on water vaporpermeability

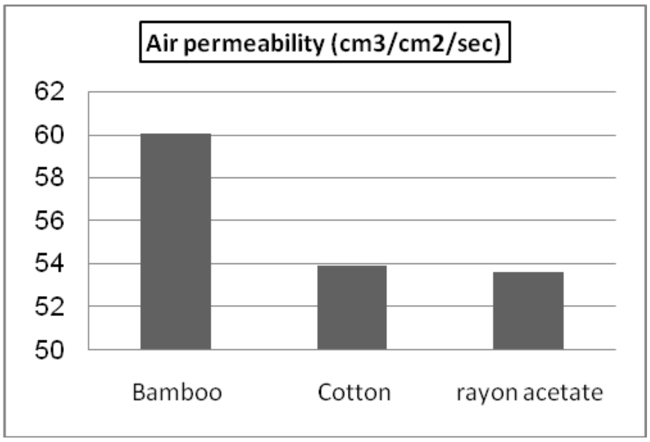
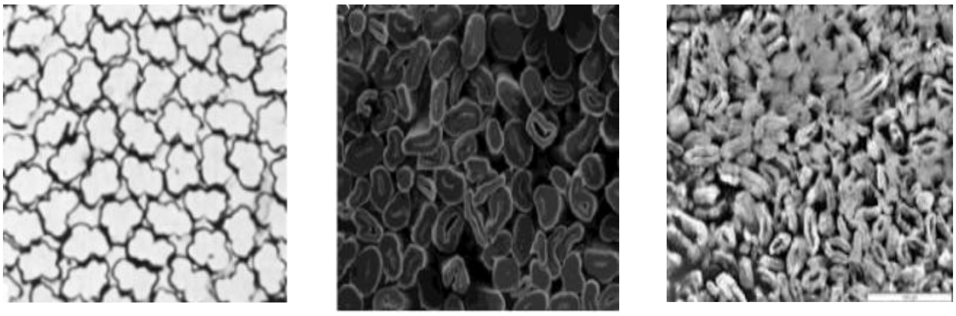


Fig. (2) Effect of textile material on air permeability(cm^3/cm^2/sec)



Rayon viscose **Cotton** **bamboo**

Fig. (3) cross sections of raw materials

IJARSE
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ISSN (P) 2319 - 8346

3.1. Effect of fibers raw material on fabric thermal conductivity

Table (2) and figure (4) Show that bamboo sample has thehighest thermal conductivity, followed by cotton and rayon viscose respectively.Thismay beattributed to the bamboo polymers which have amorphous semi-crystalline regions and thus its thermal conductivity is influenced by their molecular structure, density, crystallization level, crystal orientation angle and mobility of molecular chains in amorphous regions. The specific heat (heat capacity per unit mass) of cellulose is 1.25kJ/kg [18], but the morphology of cellulose fibers, either natural or regenerated is responsible for their thermal capacity and thermal conductivity.

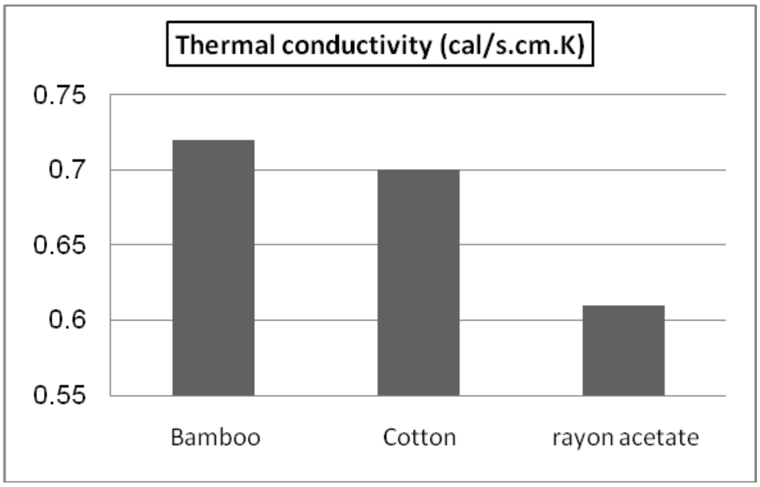

Fig. (4) Effect of textile material on thermal conductivity

3.1.5 Effect of fibers raw material on fabricspilling resistance

Table (2) and figure (5)Showthat all materials used have high resistance to the pilling. This may be attributed to the moderate tensile strength of natural raw materials natural (bamboo, cotton or rayon viscosefibers) which lead to good pilling resistance as fabrics which possess high tensile strength will retain the formed pills without the ability to shed off those pills leading to low pilling performance.

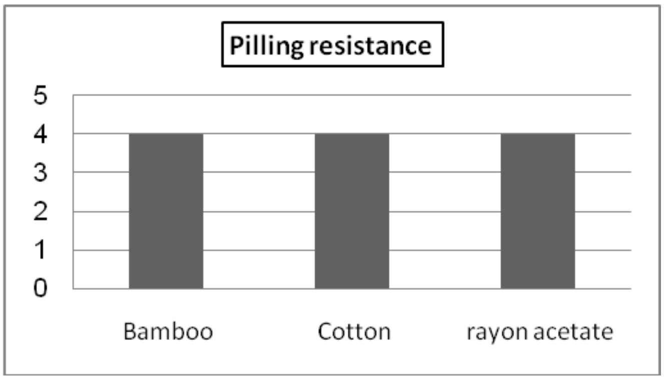

Fig. (5) Effect of textile material on pilling conductivity

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

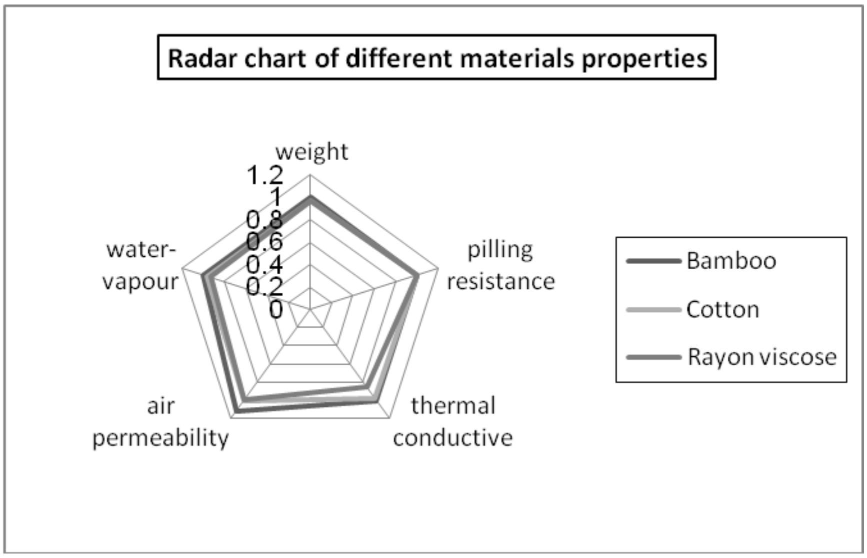

Fig.(6) Radar chart of different materials properties

It can be shown from figure (6) that bamboo fabrics achieved the best comfort properties namely water vapor, air permeability, and thermal conductivity and achieved the same performance on pilling resistance. (In addition to the aforementioned properties of bamboo fabrics, it exhibitshigh resistance to bacteria. Accordingly, Bamboo fabrics were the focus for more examination regarding the effect of fabric weave structure and weft density.

3.2 Effect of fabric weaves structure on bamboo fabric properties

3.2.1Effect of fabrics structure on water vapor permeability of bamboo fabrics

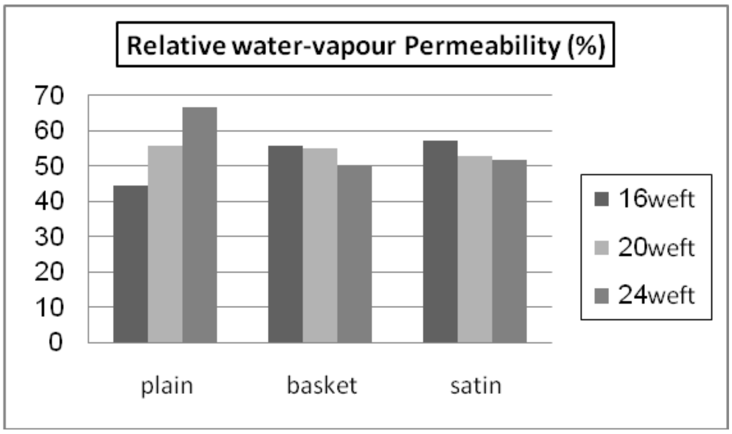

Fig.(7) Effect of weave structure on relative water vapor permeability (%) at three weft densities

It is clear fromTable (2) and figure (7) that the water vapor permeability**%** increases in case of plain 1/1, followed by basket and satin weave structures respectively. This can be explained by the fact that plain weave structures have the highest intersection points among the examined structures which in turn leads to more pores and accordingly higher water vapor permeability.

IJARSE
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ISSN (P) 2319 - 8346

3.2.2Effect of weave structure fabrics on air permeability of bamboo fabrics

It is clear from thetable (2) and figure (8) that theplain structure has achieved the highest air permeability as expected, because of the increase the ratios of spaces between the yarns, as mentioned earlier.

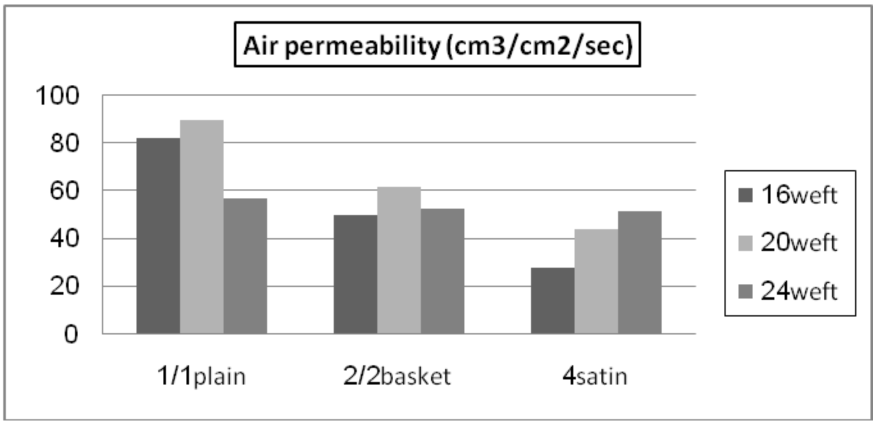

Fig. (8) Effect of structure on air permeability at permeability at three weft densities

3.2.3Effect of weave structure on thermal conductivity of bamboo fabrics

It is clear from the table (2) and figure (9) that theweave structure significantly influences the thermal conductivity of the woven fabrics. The highest thermal conductivity was achieved by plain fabrics followed by basket 2/2 and satin 4 weave structures respectively.

The better thermal conductivity of plain fabrics compared to basket and satin fabrics can be explained by the higher air permeability of plain fabrics as seen in Table (2) which lead to better thermal conductivity due to the increase of the heat convection effect.

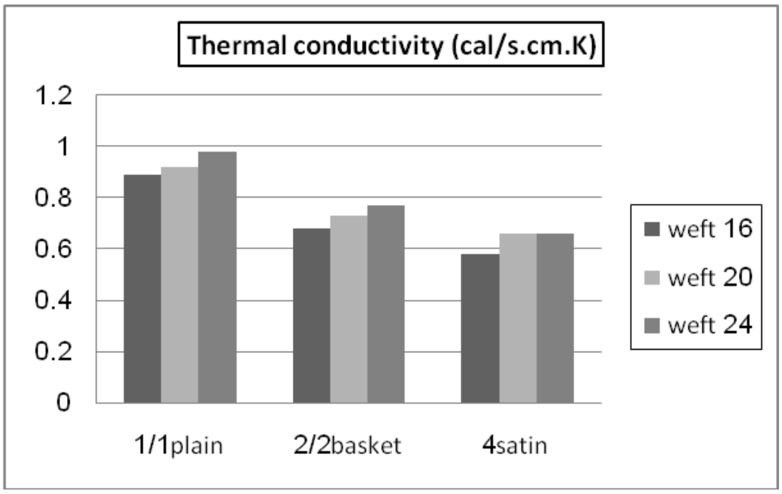

Fig. (9) Effect of structure on thermal conductivity at three weft densities

3.2.4.Effect of weave structure on pilling resistance of bamboo fabrics

Table (2) shows that weave structures do not have a significant effect on pilling.This may be attributed to the fact that pilling is affected more by raw material type than weave structure.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

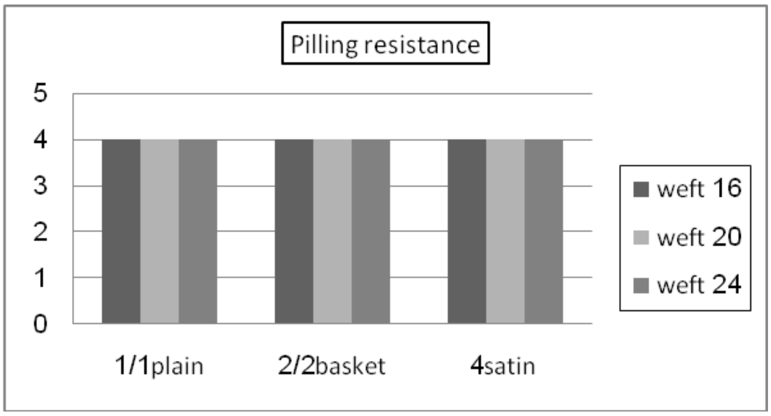

Fig. (10) Effect of structure on pilling resistance at three weft densities

3.3 Effect of fabric weave density on bamboo fabric properties

3.3.1Effect weft density of fabrics on water vapor permeability of bamboo fabrics

Tables (2 and 3) and figure (11) show that there is an inverse relationship between weft fabric density and water vapor permeability which translates to more water vapor permeability with the decrease with fabric weft density. This may be explained by the fact that with the increase of fabric weft density the spaces between the yarns decreases which translates in fewer voids for water vapor to pass through.

Table (3)Correlation coefficientfor the effect of fabricsweft densitieson water vapor permeability

Fabric structure	Correlation coefficient	Regression equation
Plain 1/1	0.816	y = 69.56 - 0.78 x
Basket 2/2	0.822	y = 67.45 - 0.69 x
Satin 4	0.879	y = 67.65 - 0.69 x

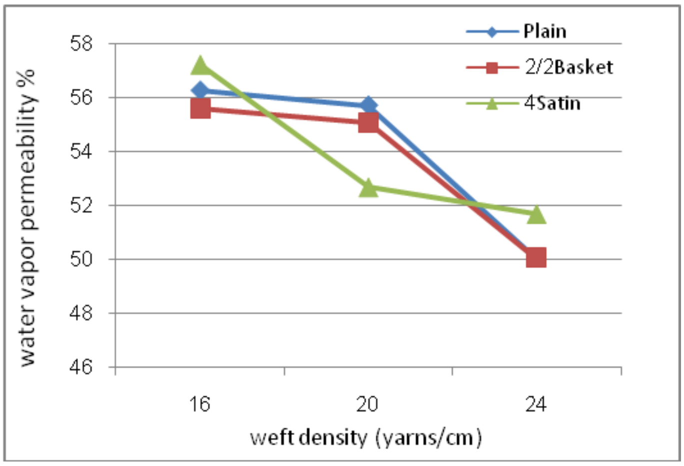

Fig. (11) Effect of weft density on water vapor permeability

IJARSE
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ISSN (P) 2319 - 8346

3.3.2Effectof weft density onthermal conductivity of bamboo fabrics

Tables (2 and 5) and figure (13) Show that there is**a** relationship between the weft densityof fabrics and the thermal conductivity. The strong correlation between the mass/sq^{2}m and thermal conductivity results from the fact

The better thermal conductivity of higher weft densities can be explained by the increased heat conduction caused by the dense weft threads which lead to higher thermal conduction when compared to the lower weft densities.

Table (5) Correlation coefficientfor the effectweft density of fabrics on thermal conductivity

Fabricsstructure	Correlation coefficient	Regressionequation
Plain 1/1	0.96	y = 0.705+ 0.0113 x
Basket 2/2	0.99	y = 0.5017+ 0.01125 x
Satin 4	0.75	y = 0.433 + 0.01 x

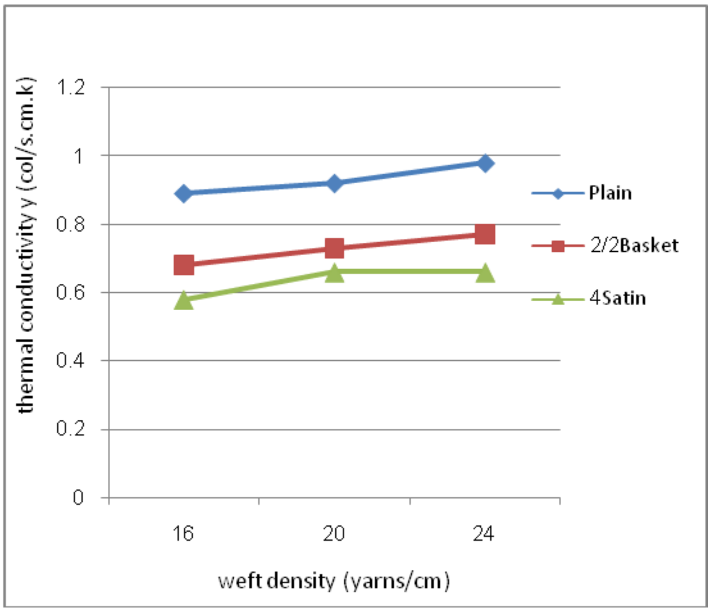

Fig.(13) Effect of weft density on thermal conductivity

3.3.3. Effectof weft density on pilling resistance of bamboo fabrics

Table (2) shows that weave structures do not have a significant effect on pilling.This may be attributed to the fact that pilling is affected more by raw material type than weave structure.

IV. CONCLUSION

It can be concluded that raw materials, weave structure, and weft density have an effect on comfort properties of samples under study which may lead to better control of bed sores. Moreover, it was found that bamboo fabrics have better comfort properties when compared to the widely used cotton and rayon viscose fabrics in the medical field if used as bed sheets. Plain structure gives the highest water vapor, highest air permeability, and highest thermal conductivity regardless of raw material type.

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