Current Journal of Applied Science and Technology

40(11): 64-73, 2021; Article no.CJAST.66009
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Standardization of Starch Concentration for Saree Rolling at Domestic Usage

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Authors' contributions

This work was carried out in collaboration among all authors. Author LPS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors RNR and KS managed the analyses of the study. Authors KS and KP managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2021/v40i1131371
Editor(s):
(1) Dr. Chen Chin Chang, Hunan Women's University, China.
Reviewers:
(1) Wirongrong Tongdeesoontorn, Mae Fah Luang University, Thailand.
(2) Tiago Reis Dutra, Instituto Federal do Norte de Minas Gerais (IFNMG), Brazil.
Complete Peer review History: http://www.sdiarticle4.com/review-history/66009

Original Research Article

Received 25 January 2021
Accepted 30 March 2021
Published 27 May 2021

ABSTRACT

Starching is one of the most significant finish given to sarees. Apart from minimizing wrinkles, starch/sizing material protects fiber due to its polished appearance provided by adequate starch concentrations while finishing the textile material. Hence, the present study is conducted on standardization or optimization of selected starches (Mango kernel starch (MKS), Jack fruit seed (JFS) starch, Bhagavathi gum (BG)/synthetic gum, Maize starch (MS) and Revive liquid (RL)) for 1 and 3 percent concentrations as per the consumer requirement on cotton fabric. All the sized samples were tested for stiffness, crease recovery angle, and tear strength parameters assessing against control sample. Results showed that, for all the tested samples, the crease recovery angle of control sample is more in both ways and other treated samples have higher angle in warp ways than the weft ways. It was also observed, with an increase in concentration there was an increase in the angle. Similarly, the bending length and tear strength is more towards warp direction than weft direction in all the tested samples. Bending length is higher in 3 percent than 1 percent starch concentration for both warp. Amongst all the starched samples, MSK has good tear strength in both directions of the fabric. Based on the study it can be concluded that, depend on the type of the material one and three per cent of the starches from natural sources can be efficiently used at domestic level.

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Keywords: Starch; gum saree; rolling; textile analysis; mango starch; jackfruit starch.

1. INTRODUCTION

The saree, a 5½ to 9 meter length fabric, has a great significance in Indian culture. This traditional drape is one of the most graceful dresses that has replica at Indian heritage. Western wear has penetrated in the habitant indeed there is no match to this attire, hence, the zest is still persistent. Cotton, light weight silks, and linens are most comfortable for working professionals, which show crispy and fresh look when starched. So, women show keen interest in wearing them for its aesthetic appeal.

Starch is still well known and most widely used as finishing agent for cotton fabrics, particularly white cotton goods. In weaving, starching/sizing is beneficial in improving the efficiency of weaving. Sizing not only improves the texture but also enhances fineness and drape of the fabrics. Mostly starches are sourced from different parts of the plants in varying sizes and shapes. The important substances of starch granules in vegetable starches have combination of two matters viz. straight chain polymers (amylose molecule) and a branch chained polymer (amylopectin). According to Parv and Kalpana, 2018, the starchs from food wastes are utilized by food, pharmaceutical and textile sectors which not only drive for minimizing environmental effects but also gain economic benefits.

Starching has a long history, but it is unknown until 16th century. It is the time when Elizabethan high society raised the usage of lace and ruffle collars, in turn the demand for starch was at its summit in professionally-laundered clothing (https://brendid.com/3-ways-make-non-toxic-spray-starch/). Starching of costumes or materials improves crispiness and structure which further provides body to textiles especially natural fiber like cottons, linens and silks. Starching enables ease in ironing. Apart from resistance to wrinkle, it also resists soiling of materials, hence, keeps the fabric clean. Once the starched saree is used, it is further washed and re-starched. Owing to the continual process of saree finishing and lack of time and space, there is an ample of scope for the entrepreneur to make profit in saree rolling once achieved the breakeven point. Further, the income can be improved by utilizing natural resources for sizing of textile products. So, establishment of enterprise in such fields of homestead income generation avenues will outright income lacunas. Hence, in the present study, standardization of saree sizing with various available starches was done based on its performance. Thus, three plant source, one synthetic and one commercial sizing/stiffening agents were selected for the study.

2. MATERIALS AND METHODS

2.1 Starching Technique

Spray-dried starch technique was employed for the present research.

2.2 Selected Starches

Mango kernel starch,Jack fruit seed starch, Bhagavathi gum (synthetic gum), Maize starch, Liquid starch (commercial stiffening agent) were selected for the study.

2.3 Mango Kernel Starch

Mango is a commercial fruit and belongs to *Mangifera* genus of Anacardiaceae family [1]. According to Nawab et.al. [2], mango seeds contain 58% of starch.Locally, the raw mango was used for pickle making, whilst the kernel was disposed. Hence, this agro – waste can be utilized for textile application. Padma and Khateeja [3] has explored mango kernel starch for textiles application. The viscosity of the starch was found be having 1150 centipoise.

2.4 Jack Fruit Seed Starch

Jackfruit (*Artocarpus heterophyllus* Lam) is one of the popular fruit crops that is grown widely for consumption. Its seeds have high carbohydrate and protein contents [4,5]. In general, seeds are discarded or steamed and consumed as snack or used in some reciepies. Bobbio et al. [4] studied pasting characteristics of jackfruit seed starch. And according to Ocloo, et al. [6], the pasting characteristics of the jack fruit seed flour have moderate peak viscosity. Vanna *et. al.* [7] suggested having good paste stability during heating.

2.5 Bhagavathi Gum (Synthetic Gum)

Bhagavathi gum is a byproduct of guar gum.

2.6 Maize Starch

Maize starch is a naturally available indigenous substance which can be used as a substitute for synthetic starches [8]. Industrial Laundering Starching, Ideal Manufacturing Ltd, UK suggested maize starch have less filling effect with low gloss owing to its large grain size. Hence, this starch gives stiffer but less pliable finish that is most evidently suitable for white cotton coats and aprons. The organization also suggested its streaking effects on colored linens.

2.7 Liquid Starch (Commercial Stiffening Agent)

According to Industrial Laundering Starching, Ideal Manufacturing Ltd, UK textiles with manmade fibers have no response to conventional starching, hence commencement of synthetic liquid poly vinyl compounds were done as an alternative. These substances acts as glue which on ironing stiffen the fabric.

2.8 Selected Textile Material

Cotton material was selected for the research.

2.9 Starch Solution Preparation

Prepared starch solution with the selected starch powders except revive liquid. Two concentrations viz., 1 and 3% (w/v) were used for preparation of starch solution. Each starch concentration is mixed in 100 ml water and boiled at around 100°C. Let the starch be little cool and fill the starch solution in the spray jar.

2.10 Starch Application and Drying on Textile Material

Shake the jar before spraying on textile material to avoid clogging. Evenly spray the starch solution on the cotton fabric and in damp condition roll the fabric on the rollers for drying. The rollers were left for 24 hours to dry completely.

Note: Ironing can be avoided by use of rollers, as the fabric gets straightened while drying.

Successful starching occurs when starch grains embed into the hollow structure of cottons. to fulfill this, mechanical process is required at proper time, and starch concentration in low dip level and mechanical action is needed. Further, grain size also influences it penetration (Industrial Laundering Starching, Ideal Manufacturing Ltd, UK).

2.11 Textile Analysis

Crease recovery angle, stiffness (bending length, flexural rigidity and overall flexural rigidity) and tear strength tests were measured based on the consumer needs and usage of the starch treated materials.

2.12 Atmospheric Conditions for Testing

For testing of textile materials in the laboratory, standard atmosphere has to be maintained (Angappan, 1997). The samples to be tested were conditioned for 24 hrs at 65±2 %RH and 27±2°C prior to testing.

2.13 Preparation of Test Specimens

The test specimens were prepared by cutting the samples as per the templates and procedures of Bureau of Indian Standards (1968). Specimens cut in each direction were selected as far as possible so that no two warp way specimens contain the same set of warp yarns and no two weft way specimens contain the same set of weft yarns. It was ensured that the specimens represented adequately the fabric under test and excluded the areas within 10 cm of the selvedges and those with wrinkles or sharp folds.

2.14 Handle Properties

2.14.1 Crease recovery

Resistance to creasing is required, as a wrinkled fabric is aesthetically unappealing especially when it is made into apparel [9]. Crease recovery was measured quantitatively in terms of crease recovery angle.

Crease recovery of the test specimens was determined as per IS NO: 4681-1968 using SASMIRA crease recovery tester. From the test fabrics, five warp way and five weft way specimens were cut using a template. The specimen was creased carefully end to end and placed between two glass plates under a weight of 500 gm for five minutes. After five minutes, the specimen was carefully transferred to the fabric clamp on the instrument and allowed to recover for one minute. The dial of the instrument was rotated to bring the free edge of the sample in the line with the knife edge and recovery angle in degrees was noted from the engraved scale on the dial. Half the numbers of specimen of both warp and weft way were folded face to face and the other half back to back. Warp and weft crease recovery angles were recorded separately to the nearest degree from the mean values of the five replicates in each direction.

2.14.2 Stiffness

Fabric stiffness is the key factor in the study of handle and drape [9]. Bending length was determined by Shirley fabric stiffness tester and flexural rigidity was calculated from the bending length values. According to the test method IS 6490-1971, five warp way and weft way specimens from each test fabric were cut using template. The lengthwise direction of the warp specimen was parallel to the selvedge and crosswise direction for weft way specimens was perpendicular to selvedge. The sample was transferred to the platform along with the scale keeping the fabric underneath. The zero of the scale was coincided with the leading edge of the specimen and pushed forward until the tip of the specimen viewed in the mirror coincide both the index lines. The bending length was read from the scale. Four readings from each specimen with side up, first at one end then at the other end were noted. The mean bending length of each specimen was calculated.

From this bending length the flexural rigidity was calculated using the formula.

A) Bending length: $C = L/2$ cm
   L = the mean length of overhanging portion in centimeters

B) Flexural rigidity: $G = W \times (L/2)^3$ mg-cm
   W = weight per unit area of the fabric in milligrams per square centimeter

C) Overall flexural rigidity: G0: $\sqrt{Gw} \times Gf$
   Gw = warp way flexural rigidity
   Gf = weft way flexural rigidity

2.15 Mechanical Properties

2.15.1 Tear strength

Elmendorf tester was used to determine the tear strength of the fabric. The average force required to continue a tongue- type tear is determined by measuring the work done in tearing a fabric thorough a fixed distance [9]. The pendulum of the instrument was sector shaped with a clamp to hold the sample. The other clamp was fixed to the frame with the pendulum in raised position so that the two clamps were aligned.

According to IS 6489-1971 five test specimens each from warp and weft were cut using the template. The sample was held in the clamps tightly. On the sample a precut slit of 20 mm was made using a knife present on the frame. When the pendulum was released it moved along with the clamp away from the fixed clamp tearing the fabrics across its width. The arc of the movement related to the energy consumed by the tear was indicated as tearing force on the scale of the pendulum.

The scale reading in grams read the average tear strength from warp and weft way was calculated using the formula:

Tear strength = capacity of the instrument × pointer reading/100

The average tear strength in grams force (gf) was converted into Newton.

Chart 1. Sample coding

Sample no.	Sample name	Sample code
C	Control	C
7	1 % Mango kernel starch	1 % MKS
8	3 % Mango kernel starch	3 % MKS
9	1 % Jack fruit seed starch	1 % JFS
10	3 % Jack fruit seed starch	3 % JFS
11	1 % Bhagavathi gum/synthetic gum	1 % BG
12	3% Bhagavathi gum/synthetic gum	3 % BG
13	1 % Maize starch	1 % MS
14	3 % Maize starch	3 % MS
15	1 % Revive liquid	1 % RL
16	3 % Revive liquid	3 % RL

3. RESULTS AND DISCUSSION

3.1 Crease Recovery Angle (SASMIRA – Crease Recovery Tester)

The creasing of textile material is a complex effect involving tensile, flexing, compressive and torsional stresses. Creasing of a fabric results in the bending of constituent [9]. The data regarding to the wrinkle recovery of the tested samples is furnished in the Table 1.

Apart from control sample, the crease recovery angle at warp direction is more than the weft direction. Control sample for warp and weft ways have higher angle with 72.2 and 79.8 degrees than others which is followed by 3% BG with 71.25 and 58.50 that represents poor stiffness of the fabric. Among all the treated samples MKS samples have less crease recovery angle with around 41 and 40.5 degrees for 1% and 3% starch concentrations respectively, whereas, on weft way the angle is around 32 and 32.25 degrees for 1% and 3% starch concentrations, as shown in Table 1 and Fig. 1.

On warp ways, there was an increase in the crease recovery angle with the increase in the concentration from 1 to 3 3% for JFS (46.25 to 50.5), BG (57 to 71.25) and RL (49.5 to 61.5) finished samples. Similarly, on weft ways the crease recovery angle of the samples have increased for JFS (43.5 to 48) and BG (52 to 58.5) except for RL sample which showed decrease in angle from 47 to 37.75 for 1% to 3% sample. Likewise, with the increase in starch concentration,the crease recovery angle decreased for MS treated samples. This might be due to larger size of maize starch granules, as said by Laundering Starching, Ideal Manufacturing Ltd, UK.

Table 1. Crease recovery angle for the starch treated samples

Sample No.	Sample code	Warp (angle in degrees)	Weft (angle in degrees)
C	Control	72.20	79.80
7	1 % MKS	41.00	32.25
8	3 % MKS	40.50	32.00
9	1 % JFS	46.25	43.50
10	3 % JFS	50.50	48.00
11	1 % BG	57.00	52.00
12	3 % BG	71.25	58.50
13	1 % MS	52.75	44.50
14	3 % MS	49.75	39.75
15	1 % RL	49.50	47.00
16	3 % RL	61.50	37.75

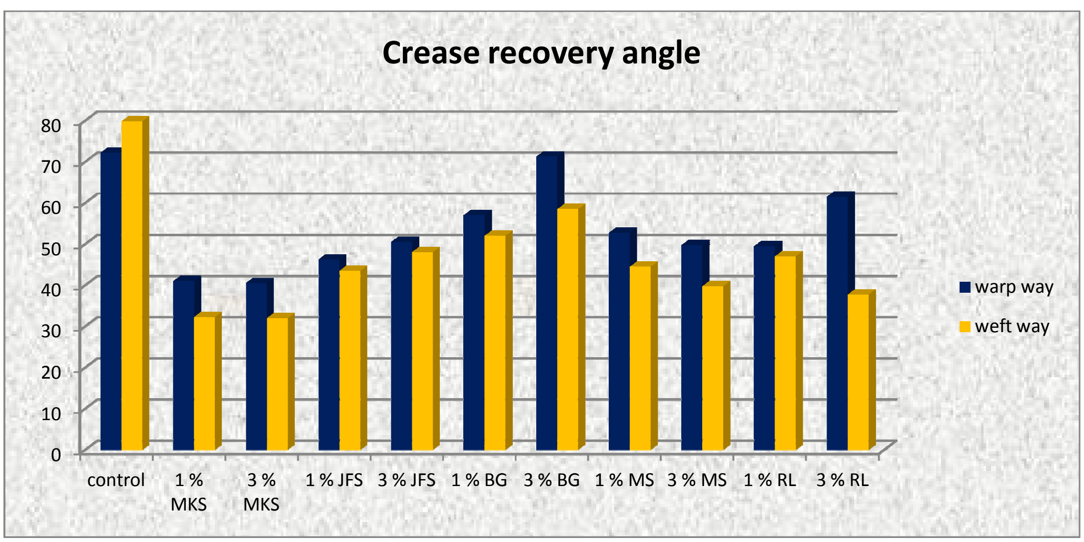

Fig. 1. Crease recovery angle of the starch treated samples

3.2 Fabric Stiffness (Eureka Stiffness Tester)

Stiffness is an important characteristic of a fabric. Stiffness is measured by bending length of the fabric. Bending length is the length of fabric that will bend under its own weight to a definite extent. Bending length determines the draping quality of a fabric.

As shown in Table 2 and figure, on warp ways, the bending length of the 3% MKS (1.95 cm) and 3% RL (1.9 cm); both percents of BG (1.77 cm for 1% and 1.92 cm for 3%) are high which suggests stiffer fabric. Followed by 3% MS, 1 % RL also have more bending length. The least bending length is found in 3% JFS starch treated sample is 1.15cm which is similar to that of control sample followed by 1% JFS, 1% MKS, 1% MS and 1% RL with bending length of 1.12 cm, 1.22 cm, 1.4 cm and 1.55 cm respectively. Except 1% JFS, in all the treated samples the bending length of warp ways is more that the weft ways.

From the Table 2 and Fig. 2 on weft direction 3% BG has more bending length with 1.525 cm followed by which 1% JFS and 1% BG are having bending length of 1.425cm. 3% MKS and 3% RL are having 1.3 cm and 1.35cm of bending length respectively. Amongst all samples in weft direction, 1% MKS and 3% JFS are having very less bending length of 1.05 cm and 1.025 which are lower than that of control sample (1.11 cm). where are 1% MS, 3% MS and 1% RL are having moderate bending lengths with 1.15 cm, 1.25 cm and 1.2cm respectively.

Table 2. Fabric stiffness results for the starch treated samples

Sample No.	Sample code	Warp			Weft			OFR
		A (cm)	B (cm)	FR (mg-cm)	A (cm)	B (cm)	FR (mg-cm)	
C	Control	2.30	1.15	0.0076	2.22	1.11	0.0068	0.00718
7	1 % MKS	2.45	1.225	0.0114	2.1	1.05	0.0072	0.009
8	3 % MKS	3.9	1.95	0.0556	2.6	1.3	0.0164	0.0301
9	1 % JFS	2.25	1.125	0.0071	1.85	1.425	0.0144	0.0101
10	3 % JFS	2.3	1.15	0.0095	2.05	1.025	0.0067	0.0079
11	1 % BG	3.55	1.775	0.0279	2.85	1.425	0.0144	0.02
12	3 % BG	3.85	1.925	0.0445	3.05	1.525	0.0221	0.0313
13	1 % MS	2.8	1.4	0.0171	2.3	1.15	0.0095	0.0127
14	3 % MS	3.3	1.65	0.0336	2.5	1.25	0.0146	0.0221
15	1 % RL	3.1	1.55	0.0186	2.4	1.2	0.0086	0.126
16	3 % RL	3.8	1.9	0.0428	2.7	1.35	0.0153	0.0255

A – Average readings, B - Bending Length, FR - Flexual Rigidity, OFR - Overall Flexual Rigidity

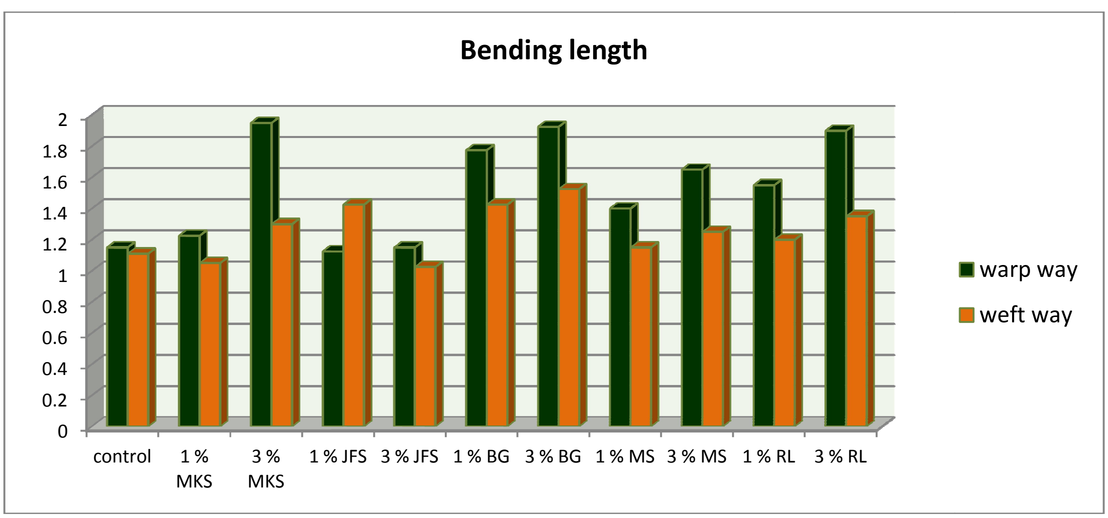

Fig. 2. Bending length of the starch treated samples for warp and weft ways

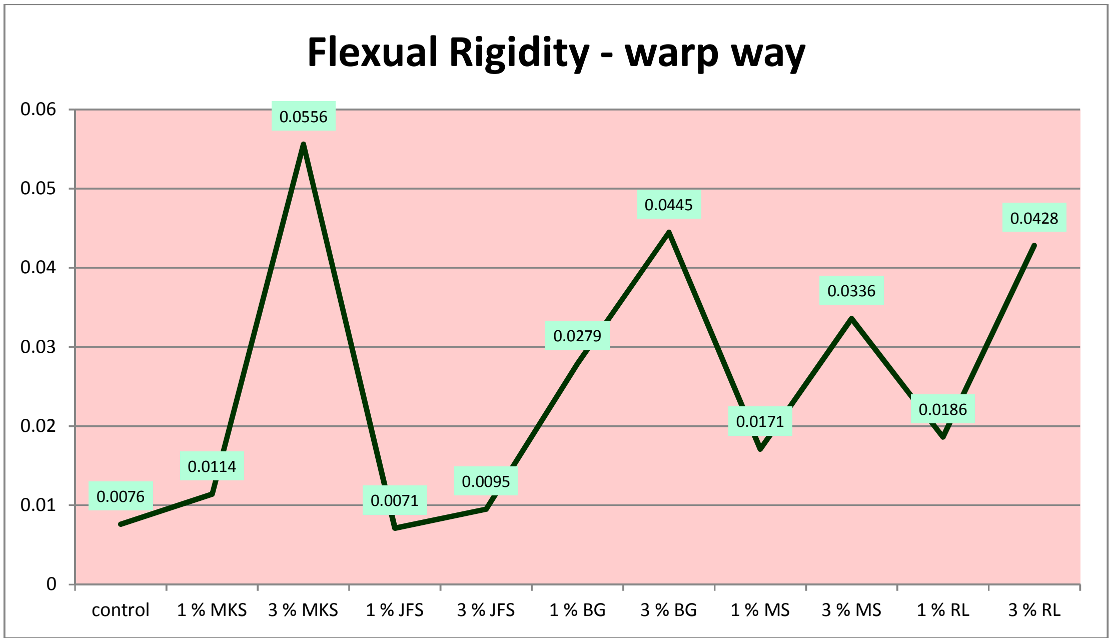

Fig. 3. Flexual rigidity (warp way) of the starch treated samples

It was clearly evident from Table 2 and Fig. 3 the flexural rigidity of the 3% MKS (0.055 mg-cm)in warp ways is more than other samples followed by 3% BG (0.0445 mg-cm), 3% RL (0.0428 mg-cm) and 3% MS (0.0336) are having good flexual rigidity. Compared to control sample 1% BG, 1%MS and 1% RL are having moderate values with 0.0279 mg-cm, 0.0171 mg-cm and 0.0186mg-cm respectively. Whereas, flexual rigidity of 1% MKS, 1% JFS, 3% JFS are having low values with 0.0114 mg-cm, 0.0071 and 0.0095 mg-cm respectively, which are on par with control sample (0.0076 mg-cm).

3% BG is having good flexual rigidity for the weft way when compared to other samples. Whilst, 3% MKS, 1% JFS, 1% BG, 3% MS and 3% RL are found to be having similar results for flexual rigidity with around 0.014 to 0.016. Whereas, 1% MKS, 3% JFS, 1% MS and 1% RL are having flexual rigidity on par with control sample with about 0.007, as shown in Table 2 and Fig. 4.

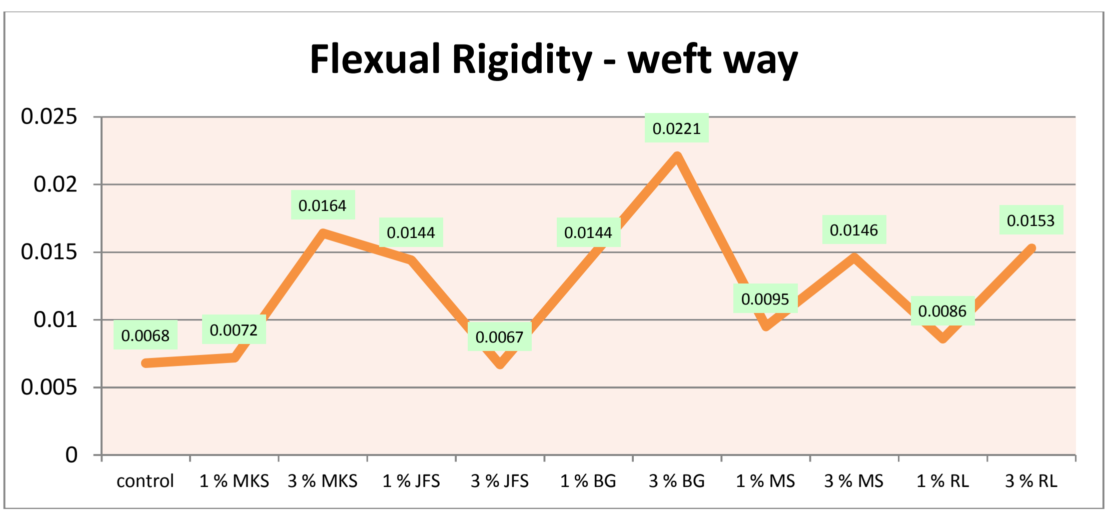

Fig. 4. Flexual rigidity (weft way) of the starch treated samples

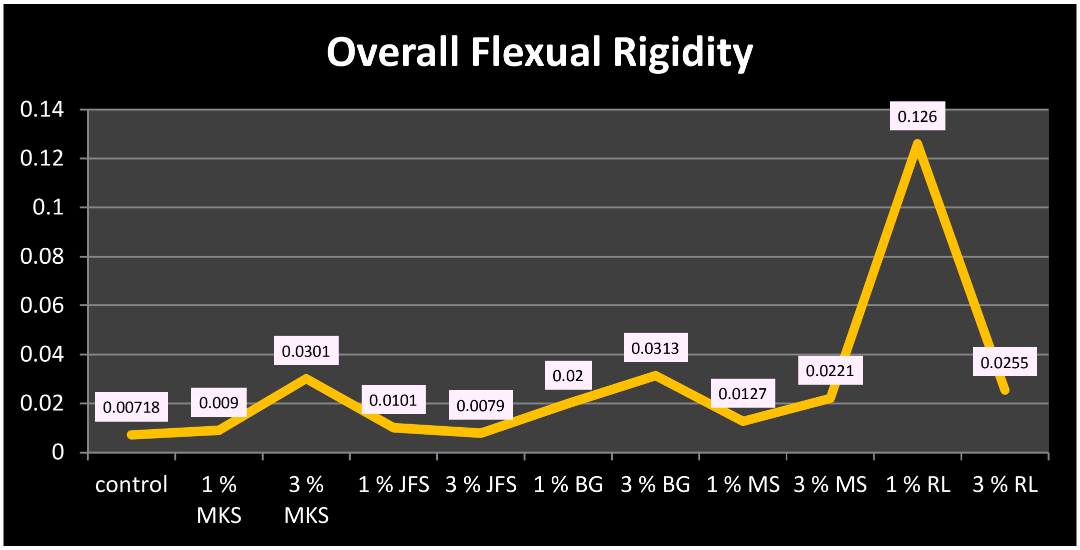

Fig. 5. Overall flexual rigidity of the starch treated samples

As given in Table 2 and Fig. 5, the overall flexual rigidity of the 1% RL sample is more than that of other counterparts. There is no significant difference was found for 3% MKS and 3% BG which are having 0.03 and 0.031 overall flexual rigidity respectively. Similarly, 3% BG and 3% RL are on par with each other with overall flexual rigidity of around 0.02. Likewise, 1% JFS and 1% MS are having similar results with about 0.01.

3.3 Tear Strength (MAG Tearing Tester)

Compared to weft, the tear strength of the warp is more for all the treated samples. Amongst all the warp starched samples, 1% MKS (1,324.8 kg) and 3% MKS (1,344 kg) are having more tear strength than their counterparts, but there was not much difference was found for tear strengthbetween control sample (1,1139.2 kg) and 1% JFS treated sample (1,1113.6 kg). Indeed, other starch treated samples like 3% JFS (985.6 kg), 1 & 3% BG (960 kg & 896 kg), 1 & 3% MS (921.6 kg & 793.6 kg) and 1 & 3% RL (960 kg & 921.6 kg) was found to be having low tear strength that the control sample, amongst which 3%MS was found to be lower tear strength with 793.6 kg (see Fig. 6).

Table 3. The tear strength is a measure of resistance to tearing of either the warp or weft series of yarns in a fabric.

Sample No.	Sample code	Warp			Weft		
		Average readings	Tear strength (kg)	Newton ($mN.m^2/g$)	Average readings	Tear strength (kg)	Newton ($mN.m^2/g$)
C	Control	17.8	1139.2	11.1717	9.6	614.4	6.025
7	1 % MKS	20.7	1,324.8	12.99	18.7	1,196.8	11.736
8	3 % MKS	21	1,344	13.18	18.4	1,177.6	11.548
9	1 % JFS	17.4	1,113.6	10.92	14.4	921.6	9.037
10	3 % JFS	15.4	985.6	9.66	11.4	729.6	7.154
11	1 % BG	15	960	9.41	10.4	665.6	6.527
12	3 % BG	14	896	8.786	10	640	6.276
13	1 % MS	14.4	921.6	9.037	11	704	6.903
14	3 % MS	12.4	793.6	7.78	10.4	665.6	6.527
15	1 % RL	15	960	9.41	10.4	665.6	6.527
16	3 % RL	14.4	921.6	9.037	8.7	556.8	5.46

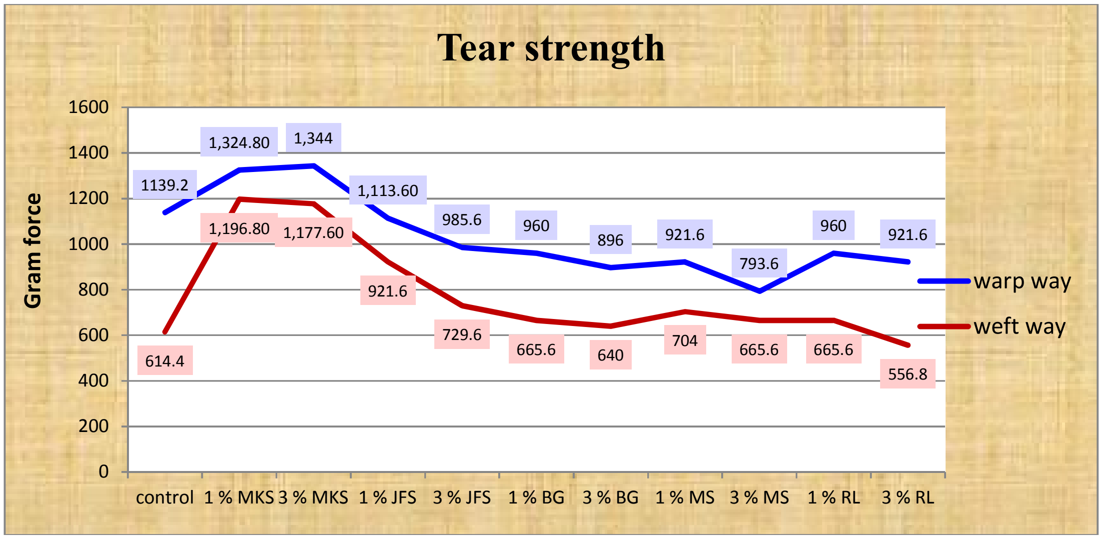

Fig. 6. Tear strength of the starch treated samples for warp and weft ways

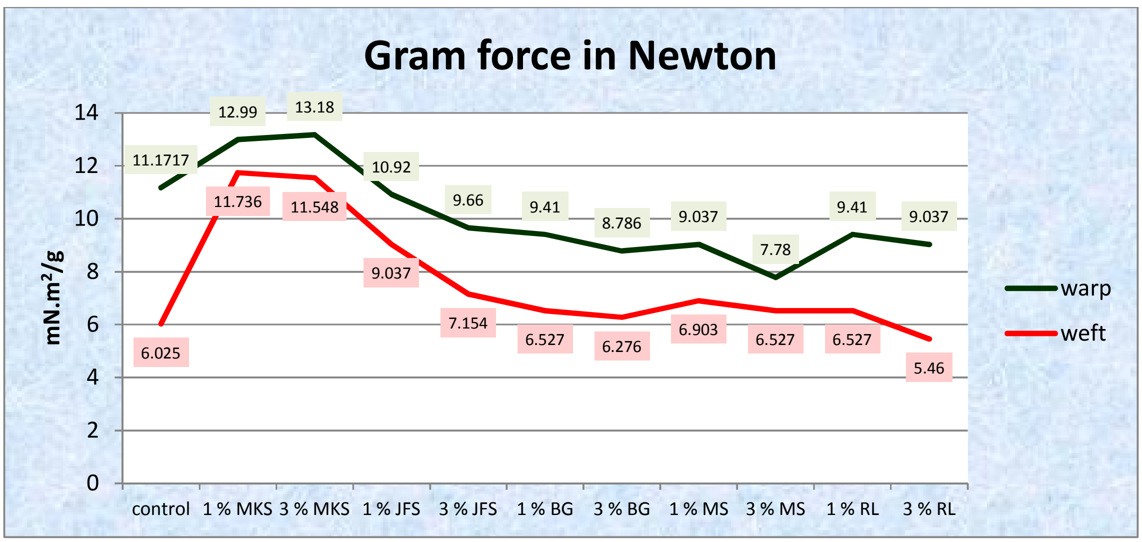

Fig. 7. Tear strength in Newton for the starch treated samples

From the Fig. 6, it was evident that similar to warp tear strength results, tear strength of 1% MKS and 3% MKS is more than their counterparts tested samples on weft ways with 1,196.8 kg and 1,177.6 kg respectively. Except 1% JFS treated samples all the other samples are on par with control sample which is having about 614.4 kg. Whereas, 1% JFS, 3% JFS, 3% BG and 1% MS is having tear strength of 921.6 kg, 729.6 kg, 64 Kg and 704 kg respectively. 1% BG, 3% MS and 1% RL are having same results with tear strength of 665.6 kg.Among all the tested samples 3%RL was found to be lowest tear strength with 556.8 kg. As per Mohammad Mobarak Hossain, et al. [10] stated that tear strength of the fabric depends on many parameters like yarn count, fabric structure, stiffness, etc.

The tear index of the tested samples was converted to Newton as shown in Fig. 7.

4. CONCLUSION

From the present investigation it can be concluded that the crease recovery angle of treated samples increased with an increase in starch concentration and the angle is comparatively more at warp direction than the weft direction, control sample being the highest angle. The bending length of 3% starch treated samples are more than the bending length of 1% treated starch. Except jack fruit starch treated with 1%, all the treated samples have more bending length in warp direction than weft one. Amongst all the samples tear strength of the MKS is highest and RL is lowest. Considering the consumer wear and tear parameters, it can be recapitulated that the natural starch products can be used as sizing agents.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors

ACKNOWLEDGEMENT

All the authors are sincerely thankful to the researchers quoted in reference, as their research publications helped us to finish this article.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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DOI:10.11648/j.sr.20160403.13

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/66009