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Performance Evaluation of Cotton Yarn Sized With Natural Starches Produced From Native Corn, Cassava and Potato Starches

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Abstract

In this study three starches viz, potato, corn and cassava have been comparatively studied for their performance on sized 34 Nm Ring spun yarn. The properties of the constructed fabric in terms of tensile strength and elongation, abrasion resistance, stiffness character, fabric thickness, size removal percentage after desizing and End breakage rate on the loom was observed to check the weaving efficiency. From the test analysis, it was clear that the cassava starch was showing overall better performance followed by potato and corn starches.

Keyword: Corn starch; Cassava starch; Potato starch; Sizing; Viscosity

Introduction

The objective of warp sizing is to improve the weave-ability of yarns by applying a uniform coating on the yarn surface so that protruding hairs are laid on the yarn surface and fabric quality with an optimal cost of the sizing operation. Progress in the sizing process enables the achievement of this goal with relatively strong yarn. Unfortunately, sizing is even one of the major pollutants of wastewater in the textile industry due to the utilization of synthetic sizing agents, often because of inadequate or no facilities for wastewater treatment [1-7]. Sizing is a procedure where the film forming polymer is used to offer temporary protection to the warp yarns from abrasive and other types of stresses generated on the weaving machine in order to bring down the warp breakages. Sizing help in forming coating which encapsulates the yarn embeds the protruding fibers and also do some inter fiber binding by penetration [8].

The carrying out of warp yarn largely depends on the nature of protective covering applied and its interaction with fiber substrate [9]. With the advent of synthetic sizes, their application quickly came into usage and completely excluded natural sizes. Their advantage was not solely in getting more serious performances of yarn, but also more comfortable and faster preparation of the size, mass, as well as easy removal from the base in chemical finishing, lower consumption of sizes and the possibility of recycling. The negative impact of synthetic sizes has a bad outcome on human health (respiratory tract, allergic effects, harder preparation, etc.), and it damages parts of the size box (bearings, pumps, dipping and squeezing rollers). Even so it was not possible to halt their use in sizing.

Further, Modified natural size pastes were given up because of their bad viscous properties, removal in the procedure of weaving (formation of debris), greater and longer removed from the ground, which regarded the cost of de-sizing, and the character of the final framework. Despite the fact that they were more inexpensive, more approachable, and environmentally favorable and did not adversely affect human health, they did not do any damage by destroying contact parts in the bed sizing; however, they have failed to be held back in the diligence. This report will explore the negative sides that will accompany natural modified size pastes compared to the synthetic ones today, with the possibility of improving the properties of natural modified size resources as easily as their combination with synthetic sizes for twisted yarns that require less size pick-up [10-13]. Likewise, in the weaving process, the warp yarns on a loom undergo extremely harsh mechanical actions of repeated stresses and stresses as well as substantial abrasion due to friction [14].

Many efforts have been pulled in to measure the variables that affect size, performance without expensive full-scale sizing and weaving trials. During desizing of cotton yarn, aqueous sizing agent dissolves in water with elimination from the yarn and it is presumed that the yarn will behave in the standardized style after the weaving [15]. Few researchers investigated the role of both synthetic and natural modified corn starch in yarn sizing. From the results, they indicated that there is no much difference between the size with modified starch and synthetic sizing agents [6].

The natural starch and its derivatives constitute almost share of 75% of sizing agents used. Many efforts have been pulled in to measure the variables that affect size, performance without expensive full-scale sizing and weaving trials [16]. Hence, the present investigation is a kind of tool to explore the suitability of different experimental approaches at evaluating the performances of starches and sized yarn properties. In this setting, we have compared three kinds of natural starch viz., cassava, potato and corn, for their various attributes and operation analysis.

Experimental Part

This research was possible and reproducible on laboratory sizing machines under customized manufacturing conditions. For comparison of three forms of natural starches, the most important properties of yarn were examined, including the breaking strength, extension at break, work to rupture, strength, unevenness, hairiness, resistance to abrasion as well as size pick-up.

Materials and methods

The trials were conducted on cotton ring spun yarn count of 34 NM, twist level 789 TPM and weft yarn of 34 NM count ring spun yarn

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with potato starch, maize starch, cassava starch, water. Standardized methods were used for examination of the yarn. For sizing of the yarns the conventional cylinder sizing machine with 9 drying cylinders was used and machine setting used was speed (30-40 m/min), pressure-2 kg/cm^2, yarn stretch % (1-1.2) and number of ends (used was 2706. Size solution preparation and cooking is given in Table 1.

Further, the performance analysis was performed Tensile behavior of strength of yarns was tested using ASTM D2256 on Autodyne 300 single strength tester with test speed of 1000 mm/min and pretension-450 gram.

The percentage increase in the sized yarn strength is measured by using the following formulae.

$$Percentage\ Increase\ in\ Strength = \frac{(Ss - Su)}{Su}\ X\ 100$$

Where, S*s*: Sized yarn strength; S*u*: Unsized yarn Strength

Fabric Abrasion Testing was carried using (American Society for Testing and Materials) ASTM D 4966 measured on the Martindale fabric abrasion tester. During this test, First one is finding an endpoint which counts the number of cycles until the fabric ruptures, two or more yarns have broken or a hole appears, according to fabric type; for woven structure abrading is continued until two threads are broken. The end point is the different Stiffness behavior was analyzed using ASTM D 1388 on the Shirley fabric stiffness tester. The thickness of fabric samples is tested using ASTMD1777 on the fabric thickness gauge tester. Size removal percentage of the samples were calculated after desizing the samples using enzymatic desizing at MLR 1:20, using biolase enzyme 6%w/w, NaCl 5%, and temperature 60°C, time 1 hr, and wetting agent-1.5 g/l.

Plain fabric with 22 x 20 EPC and PPC was constructed on rapier loom. A weft and warp yarn of count 34 Nm was used. The fabric had a width of 150 cm with warp and weft crimp of 5% and 4%. All other machine parameters were kept constant and end breakage rate was attended for two hours and finally breaks/105 ends/104 picks were calculated. The size pick-up in relation to the sized yarn was determined according to the equation:

$$Sp = \frac{m2 - m1}{m2}$$

Sp – size pick-up in%, m^2 – mass of dry sized yarn in g, m^1 – mass of dry unsized yarn in g.

Result and Discussion

Yarn tensile results

Following Table 2 shows Tensile and elongation tests were performed in the unsized and sized ring spun carded yarn of 34 Nm.

It is clear from the above table (Figures 1 and 2) we could understand that there is a great enhancement on the tensile strength of yarn sized with the three starches. When we compare each of the starches in terms of their contribution to the tensile strength of yarn, potato starch shows a better improvement on the tensile strength of the sized yarn. The strength gain percentage has been calculated for the three starches sized yarn. The calculated values for the gain in strength for the three starches sized yarns was potato starch sized yarn 32.05%, corn starch sized yarn 21.06%, cassava starch sized yarn 27.73%. Strength gain for sized yarns as per BITRA standard should be greater than 25%. Test of significance level was analyzed at 99% and 95% confidence interval and it was clear that, there is a greater impact of the natural starch which was chosen for analysis. It can be seen that elongation at break was better on sized yarn than the unsized yarn which is expected [17]. There was good elongation at break for cassava starch sized yarns followed by potato starch and Corn Starch.

Starch type			
Parameter	**Potato**	**Corn**	**Cassava**
MLR	1:13.5	1:11	1:13.5
Cooking Time	30 min	30 min	30 min
Cooking Temp	90°c	90°c	90°c
Size Box Temp	83°c	83°c	83°c

Table 1: Size solution preparation and cooking for the three starches.

Fabric test result

Sized yarn of same beam is used to produce a plain weave structured fabric as per the methodology. Samples from the constructed fabric were taken randomly and tested for different fabric characteristics. The Table 3 and Figure 3 clearly show that, corn starch treated samples were exhibiting lower strength when compared with cassava and potato starch treated samples. This reason is due to the percentage of molecular cohesion towards the cotton yarn.

Further, it is also confirmed that there is significant impact by the starch particle on the tensile strengths of the yarn.

Abrasion resistance test

Abrasion is wearing a way of any part of material by rubbing against another surface. Abrasion cycle is one complete movement

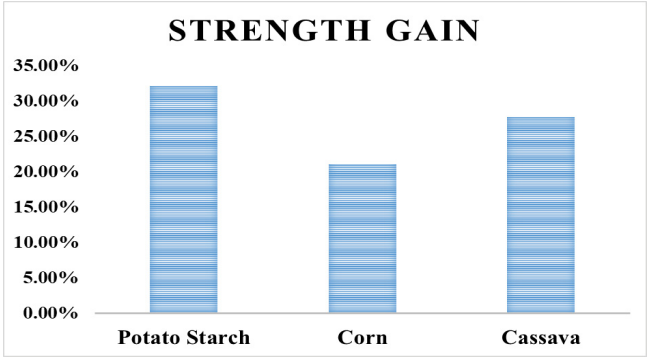

Figure 1: Sized yarn Strength compared to Unsized yarn.

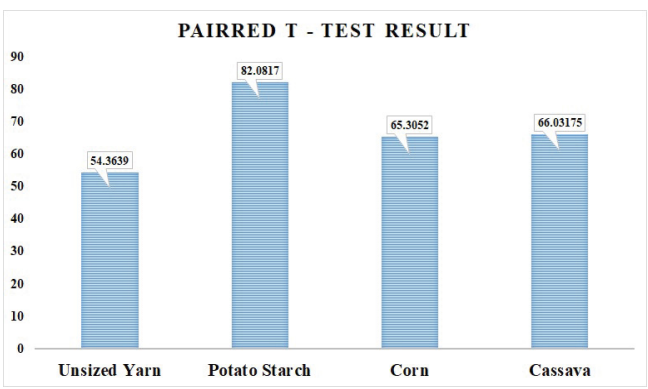

Figure 2: Pairred T- Test Result of Confirmation.

Sample No.	Unsized Yarn		Potato Starch		Corn		Cassava	
	T	E	T	E	T	E	T	E
1	17.94	6.22	22.22	6.26	20.17	6.06	19.21	5.67
2	17.17	6.10	22.64	6.26	19.80	5.60	20.45	5.86
3	15.37	5.65	21.29	5.93	20.73	5.58	21.56	6.80
4	15.30	5.43	20.59	5.73	19.86	5.93	21.14	6.80
5	15.86	5.06	21.01	5.73	20.39	5.86	20.53	5.88
6	16.88	5.69	21.28	5.93	20.49	5.73	20.31	6.46
7	16.79	6.03	21.28	5.93	19.66	5.93	21.56	6.26
8	16.15	5.52	23.22	6.33	18.84	5.93	22.11	6.33
9	16.75	5.29	22.05	6.01	18.98	5.80	21.17	6.20
10	16.41	5.62	21.54	5.80	19.92	5.66	21.58	6.06
Avg	**16.46**	**5.66**	**21.712**	**5.991**	**19.852**	**5.808**	**20.962**	**6.232**
SD	0.8198	0.3685	0.8055	0.2221	0.6419	0.1613	0.8455	0.3824
St. Error	0.2592	0.1165	0.2547	0.0702	0.2140	0.0510	0.2674	0.1209
95%	0.5865	0.2636	0.5763	0.1589	0.4934	0.1154	0.6048	0.2736
99%	0.8426	0.3787	0.8279	0.2283	0.7180	0.1658	0.8690	0.3931
Paired T Test	T value:54.363 P value: 0.000 Degrees of Freedom: 9		T value:82.081 P value: 0.000 Degrees of Freedom:9		T value 65.305 P value 0.000 Degrees of Freedom:9		T value: 66.031 P value: 0.000 Degrees of Freedom:9	
			T value -14.4367383293 P value 0.0000000 Degrees of Freedom 18		T value -10.5594988022 P value 0.0000000038 Degrees of Freedom 18		T value -12.0756169648 P value 0.0000000005 Degrees of Freedom 18	
Strength Gain	--		32.0535693%		21.0608052%		27.736681%	

Note : *T-Tenacity (cN/tex) ; E - Extension (%)*

Table 2: Tensile Results of Unsized and Sized yarns.

Sample No.	Corn	Cassava	Potato
	Max force(N)	Max force (N)	Max force (N)
1	284	292	329
2	252	272	307
3	332	348	321
4	329	383	332
5	255	351	354
6	341	374	318
7	287	346	280
8	311	328	344
9	306	306	335
10	329	307	360
Avg	302.6000	330.7000	328.0000
SD	32.0250	36.0218	23.3714
St. Error	10.1272	11.3911	7.3907
95%	22.9098	25.7690	16.7193
99%	32.9147	37.0225	24.0207

Table 3: Tensile results sized fabrics.

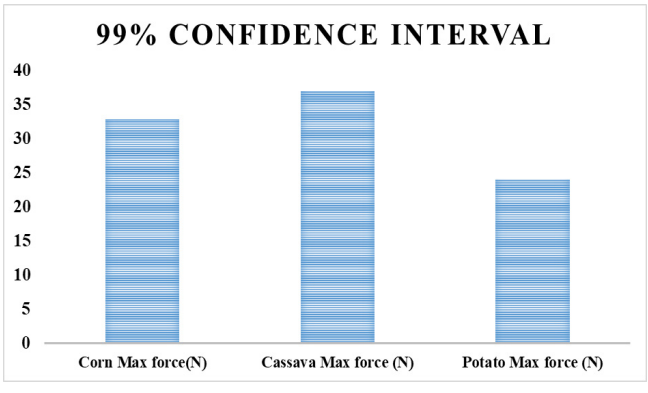

Figure 3: Fabric tensile behaviour improvement.

of abrading across the surface of material being abraded. Complete movement of abrasion cycle depends on the action of abrasion machine and test methods used. As the number of abrasive cycles increase the performance of sized yarn on the loom will be high. Fabric abrasion resistance is directly related to yarn abrasion resistance [18-23]. The test result of average abrasion cycles of fabrics constructed from yarns sized with the three starches was potato starch samples 15000 cycles, corn starch samples 13500 cycles and cassava starch samples 14000 cycles as shown in Table 4 and Figure 4. It is seen that abrasion resistance value of potato starch is the highest and corn exhibited the least abrasion resistance value. The high abrasion resistance of potato starches may

Fabric sample	No. of Cycles till Two Ends Breaks
Cassava	14000
Potato	15000
Corn	13500

Table 4: Abrasion test result.

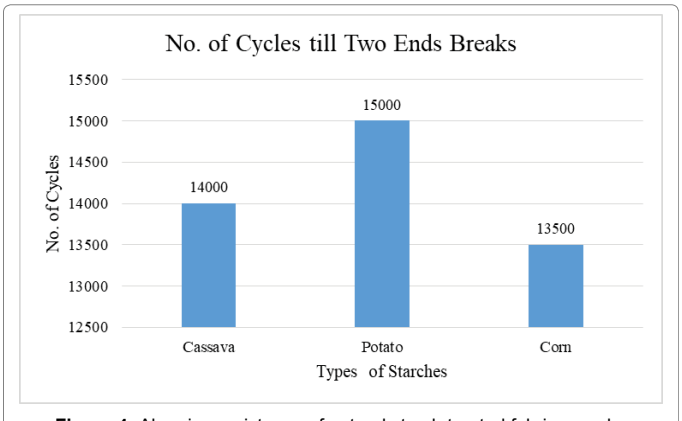

Figure 4: Abrasion resistance of natural starch treated fabric sample.

Sample number	Stiffness Test Results Bending length(cm)			Fabric Weight (GSM			Fabric Thickness (mm)		
	Cassava	Potato	Corn	Cassava	Potato	Corn	Cassava	Potato	Corn
1	1.70	1.75	1.55	1.45	1.41	1.38	0.70	0.66	0.70
2	1.60	1.52	1.70	1.42	1.42	1.43	0.70	0.63	0.67
3	1.75	1.42	1.87	1.40	1.43	1.41	0.71	0.69	0.82
4	1.70	1.67	1.75	1.43	1.39	1.43	0.60	0.67	0.71
5	1.72	1.50	1.60	1.44	1.40	1.42	0.63	0.71	0.73
6	1.92	1.72	1.75	1.43	1.41	1.41	0.72	0.62	0.79
7	1.62	1.02	1.60	1.44	1.41	1.39	0.70	0.65	0.70
8	1.80	1.55	1.50	1.42	1.42	1.43	0.69	0.59	0.71
9	1.85	1.60	1.43	1.44	1.41	1.42	0.60	0.74	0.7
10	1.75	1.65	1.75	1.43	1.40	1.41	0.68	0.67	0.71
Mean	**1.74**	**1.54**	**1.65**	**1.43**	**1.41**	**1.41**	**0.67**	**0.66**	**0.72**
Std. Dev.	**0.0979**	**0.208**	**0.137**	**0.014**	**0.012**	**0.017**	**0.046**	**0.044**	**0.046**
Std. Err	**0.0310**	**0.0660**	**0.044**	**4.47e-3**	**3.65e-3**	**5.38e-3**	**0.0144**	**0.0139**	**0.0145**
95% confidence Interval	**0.0701**	**0.1494**	**0.098**	**0.0101**	**8.26e-3**	**0.0122**	**0.0325**	**0.0315**	**0.0327**
99% confidence interval	**0.1007**	**0.2147**	**0.142**	**0.0145**	**0.0119**	**0.0175**	**0.0467**	**0.0452**	**0.0470**

Table 5: Stiffness, GSM and thickness test results of sized fabrics.

Fabric sample	Breaks/loom/hr
Cassava	1.68
Potato	1.68
Corn	2.2

Table 6: End breakage test results for the three samples.

Fabric sample	Size removal (%)
Cassava	5.37
Potato	5.0
Corn	4.7

Table 7: Size removal percentage test result.

be due good adhesion between yarns and the starch because of its relatively large amylose content. Low abrasion character of the corn is related to low adhesion where the size will be on the surface of yarn without penetration [24].

Other common test results

The stiffness of fabric is defined as resistance to bending. The degree of fabric stiffness is related to its properties such as fiber material, yarn and fabric structure [18]. As yarn diameters and fabric modulus increase, the stiffness of the fabric also increases. There is a direct relationship between warp diameter and fabric stiffness [19]. Yarn (or fiber) diameter is the most important structural property of a fabric to affect its stiffness. Different varieties of starch may show different stiffening properties [20]. The following Table 5 shows that, the stiffness of cassava starch used fabric sample was higher than the others and potato shows the least stiffness which support [21]. One of the researcher comparing wheat, rice, and potato on the stiffness of fabric found that the wheat produced the stiffest fabric and potato produce the least stiff. Significance test has been done to compare the mean stiffness value for the three starches sized yarn fabrics and it shows that there was a significant difference in the mean stiffness value between cassava and potato [21].

When the analysis performed with respect to the weight of the fabric the naturally sized higher weight was observed in cassava starch treated fabric followed by other fabrics. This shows that there was a significant difference of weight only between cassava and corn and there was no significant weight difference between the others.

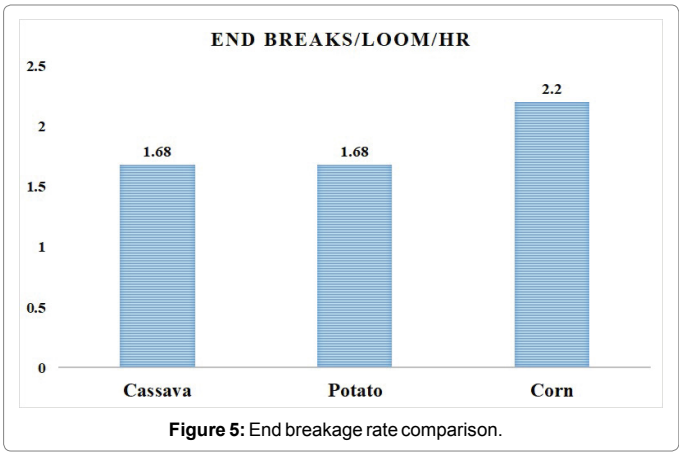

Figure 5: End breakage rate comparison.

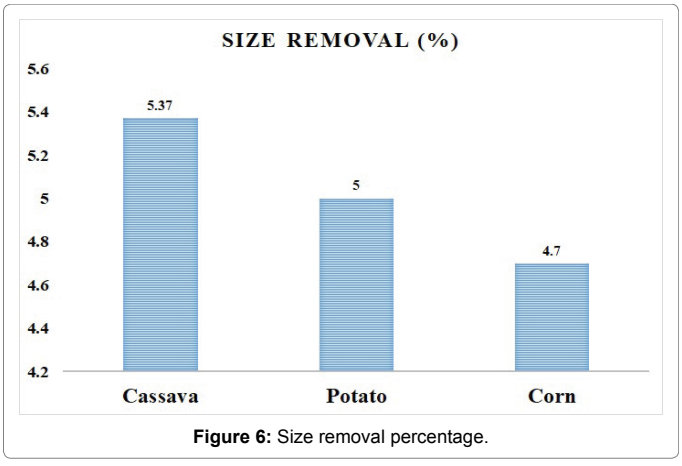

Figure 6: Size removal percentage.

In case of Fabric thickness the results show that highest fabric thickness was observed in case of cassava sized samples. This may be due to its good adhesion and cohesion property with fibers. Corn starch sized sample fabrics had a relatively larger thickness than potato which may be due strong brittle film forming character of these starches having good surface cohesion for fibers.

End breakage test on loom

Plain fabric was constructed on Dornier rapier loom and an end breakage was observed for two hours. The total warp breaks within two hours were recorded and finally the end breakage rate was calculated. The calculated end breakage for the three samples is shown in Table 4.

It is observed from the Table 6 and Figure 5, the end breakage rate for the three samples is far from the standard. But this result is acceptable as per the company specification which is 1.5 breaks per loom/hr. So when we compare the three samples corn starch sample has the highest end breakage rate, which can affect the loom efficiency indicating poor performance this starch on sized yarns.

Size removal percentage

Water soluble size may simply be washed out, whereas water insoluble size must first be subjected to chemical or enzymatic degradation. Easy desizability is one of the greatest requirements of sizing agent. The higher the water solubility of sizing agents, lesser will be the energy consumption. This leads to more economic process [4]. Desizability of sizing agents depends on factors like the viscosity of size paste, moisture regain of size film, and solubility of size film in water. All these factors are directly or indirectly dependent on the chemical structure of the size material [4]. Size removal percentage has been calculated by enzymatic desizing of the fabric samples and weight loss calculation.

Amylase enzyme 6% owf, sodium chloride 5% owf and wetting agent 1.5 g/l at an MLR ratio of 1:20 were used for desizing solution preparation. All the three fabric samples of equal weight were immersed into the solution and boiled at for one hour at 60°C.

The Table 7 and Figure 6 give the clear idea that high size removal percentage was obtained in the case of cassava starch, which shows the easy solubility of this starch and its cost effectiveness. Corn starch shows the least size removal percentage which may be due to the highest degree of association between molecules in its structure which lowers the solubility of these starches in the water.

Conclusion

During the Study the following conclusions were drawn and recommended the Kombolcha Textile Share Company for minimizing the cost. The study shows that tensile strength and abrasion resistance characteristic of yarns sized with potato starches has high value which indicates good performance of these yarns on loom.

Cassava starch shows high results on elongation at break, low stiffness characteristics, good fabric thickness, which indicates a good diameter increment on yarn and high size removal percentage which makes it cost effective. The tensile strength and abrasion resistance characteristic of yarns sized with potato and cassava are not very far and as per paired sample T-test significance test result, there is no significant difference on the tensile strength value due to starch type which confirms that these two starches have comparable performance in terms of their tensile strength and abrasion resistance characteristics on yarn.

Corn starch sized sample fabrics had a relatively larger thickness than potato which may be due strong brittle film forming character. Cassava starch, which shows easy solubility, hence it has greater size removal percentage. When we compare the End Breakage rate of three samples, the corn sample shows the greater end breakage rate followed by cassava and potato.

Generally cassava starch sized yarns have good performance in overall properties and also its size removal percentage is higher as compared to the others which make this starch preferable and cost effective over the others. Native corn starch has poor performance in overall properties and its size removal percentage is low as compared to the others which make it costly and not preferable.

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