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Effect of laundering on physical parameters of sized materials

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ABSTRACT : Starch is added in the resin cycle of laundering, the last stage before drying. It helps to make the clothes stiff and keep the clothes clean for a longer time by holding down the fibres surfaces which catch dust and dirt. The white muslin having cloth count of 70 ends x 60 picks per inch, 34.80 GSM was selected in the present study and sized separately with 10 per cent each arrowroot and revive at 1:1 and 1:2 dilution levels. The sized samples were assessed for the various structural performances, durable and comfort properties before and after laundering where in laundering of sized samples an important aspect of the present investigation was. Nevertheless, the sized samples were subjected for a hand wash by kneading and squeezing method. On laundering the sized samples demonstrated a trend of decrease in structural properties like cloth count, GSM, thickness, bending length, crease recovery, as well as performance properties like drape, abrasion resistance, tensile strength and air permeability. This change in structural and performance was due to gradual softness and pliability induced on partial desizing. It is evident that single hand wash will not completely desize the cotton fabric thus, such partially desized cotton garments can be used/worn as 'soft-sized' materials. The sized clothes when used after one wash, indicates a way to 'cutting cost' of starching the clothes.

KEY WORDS : Muslin, Sizing, Laundering

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A laundry starch is the solutions that penetrates into the fibre but leaves it pliable and gives a smooth glossy finish that resist dirt. Thus, starching is a process of adding stiffness to the cotton fabric and tends to make subsequent washing easier as soil clings to starch rather than the fabric (Dantyagi, 1974). Clothing or laundry starch is a liquid that prepared by mixing a vegetable starch in water and is used in the laundering of clothes. Starch was widely used in Europe in the 16th and 17th centuries to stiffen the wide collars and ruffles of fine linen which surrounded the necks of the well-to-do. During the 19th century and early 20th century, it was stylish to stiffen the collars and sleeves of men's shirts and the ruffles of girls' petticoats by applying starch to them as, these clean clothes were being ironed. Aside from the smooth, crisp edges it gave to clothing, sizing did serve several practical purposes as well. Dirt and sweat from a person's neck and wrists would stick to the starch rather than to the fibres of the clothing, and would easily wash away along with the starch. After each laundering, the starch would be reapplied.

Hence, the present study was conducted to examine the effect of hand washing on the structural, performance, durable and comfort properties of sized samples was carried out.

RESEARCH METHODS

The sample selected for the present study was cotton kora muslin (gray), specially hand woven having cloth count of 70 ends x 60 picks per inch, 34.80 GSM without any finish applied on to it. The fabric sample was starched separately with 10 per cent each arrowroot and revived with 1:1 and 1:2 dilution levels. In all, the test sample was subjected for 2 types of starches one being natural and the other instant at two levels of dilution totaling to 4 treatments. The sized samples were subjected for one hand washing and the main aim of the study is to assess the percentage change in the basic characteristics of the sized fabric on washing; to find out whether complete desizing is possible in single hand washing;

if not whether the partially desized cotton is fit to use after one hand wash where a great deal of money could be saved.

For all practical purposes, the sized samples were laundered by kneading and squeezing method. Each sized sample was washed separately using 5gpl soap, rinsed twice in clear water, shade dried and ironed.

Soap concentration : 5 gpl
Soaking time : 15 min
Type of cleaning agent : Detergent powder

After hand washing, the test samples were assessed for structural properties *viz.*, cloth count, cloth thickness and GSM; performance properties – cloth bending length, cloth crease recovery and drapability; durable properties - cloth abrasion and cloth tensile strength & elongation; and comfort parameters i.e. cloth air permeability tests and these values were compared with the control as well as the sized samples.

Percentages and completely randomized design in three factorial format was used to find out the effect of independent variables *viz.*, two sizing materials (arrowroot, revive), dilutions (1:1 and 1:2) and yarn directions (warp and weftways) on dependent variable *viz.*, cloth count, cloth thickness, cloth crease recovery of the test samples.

Hypothesis:

The hypothesis set for the present study is home washing does not affect the structural, performance, durable and comfort properties of the sized samples.

■ RESEARCH FINDINGS AND DISCUSSION

The findings obtained from the present study have been discussed under the following sub-heads:

Effect of hand washing on structural properties of sized samples:

The cloth count, thickness and GSM are the basic yet foundation parameters under the umbrella of structural properties (Table 1and Fig. 1).

Effect of hand washing on cloth count (threads per inch) of sized samples:

Cloth count of the woven textile is the number of ends and picks per unit length and was calculated while the fabric is under zero tension and free from folds and wrinkles. Cloth count is influenced by the respective yarn density and fabric set.

The effect of washing on the structural properties of sized sample is presented in Table 1. It is clear that there was increase in threads per unit area of the test samples sized with arrowroot and revive at the dilution levels, 1:1 and 1:2. The observations indicated that the percentage increase in pick per inch is greater than the corresponding ends per inch; maximum yarn consolidation in weft direction is observed with revive (16.67%) and arrowroot (13.33%) at 1:2 dilution compared to 1:1 dilution (10.00% and 06.66% arrowroot). Whereas, the percentage increase in ends per inch was same at 1:1 and 1:2 dilutions, when starched with selected agents.

Among the structural properties the most focal features is threads per unit area synonymously referred to cloth count, comprises of ends and pick per inch. In fact cloth count greatly contributed to cloth GSM and thickness. It is noted that consolidation of picks is greater than corresponding ends because the density of pick/inch is lower than ends/inch at control, giving sufficient space for the picks to relax and consolidate on wet treatment. In other words since ends/inch is relatively higher, there is less space for the existing yarns to move closer. It is clear that the percentage increase in cloth count is greater in 1:2 dilution than 1:1, which may be due to higher deposition of sizing material in dilution level within the pores that restricted the yarn relaxation.

The effect of washing on the structural properties of sized sample is also presented in Table 1. It is clear from this Table that there is meager increase in ends/inch at 1:2 dilution of arrowroot and revive similarly picks/inch of arrowroot sized

Table 1 : Effect of hand washing on cloth count (thread per inch), cloth thickness (mm) and cloth weight (GSM) of sized samples

Sr. No.	Characteristics	Direction	Control sample	Starched samples							
				Arrowroot (10%)				Revive (10%)			
				Dilution				Dilution			
				1:1		1:2		1:1		1:2	
				Sized	Washed	Sized	Washed	Sized	Washed	Sized	Washed
Structural properties											
1.	Cloth count (thread per inch)	Warp	70	72 (02.86)	72 (02.86)	74 (05.71)	76 (08.51)	72 (02.86)	72 (02.86)	74 (05.71)	76 (08.51)
		Weft	60	64 (06.66)	66 (10.00)	68 (13.33)	70 (16.67)	66 (10.00)	66 (10.00)	70 (16.67)	70 (16.67)
2.	Cloth thickness (mm)	-	0.212	0.302 (42.00)	0.288 (35.84)	0.284 (35.85)	0.250 (17.92)	0.296 (39.62)	0.264 (24.52)	0.288 (35.85)	0.252 (18.88)
3.	Cloth weight (GSM)	-	34.8	44.8 (28.73)	42.5 (22.13)	41.2 (18.39)	38.8 (11.49)	44.4 (27.58)	42.3 (21.55)	41.00 (17.81)	38.2 (09.78)

Figures in parenthesis indicate percentage

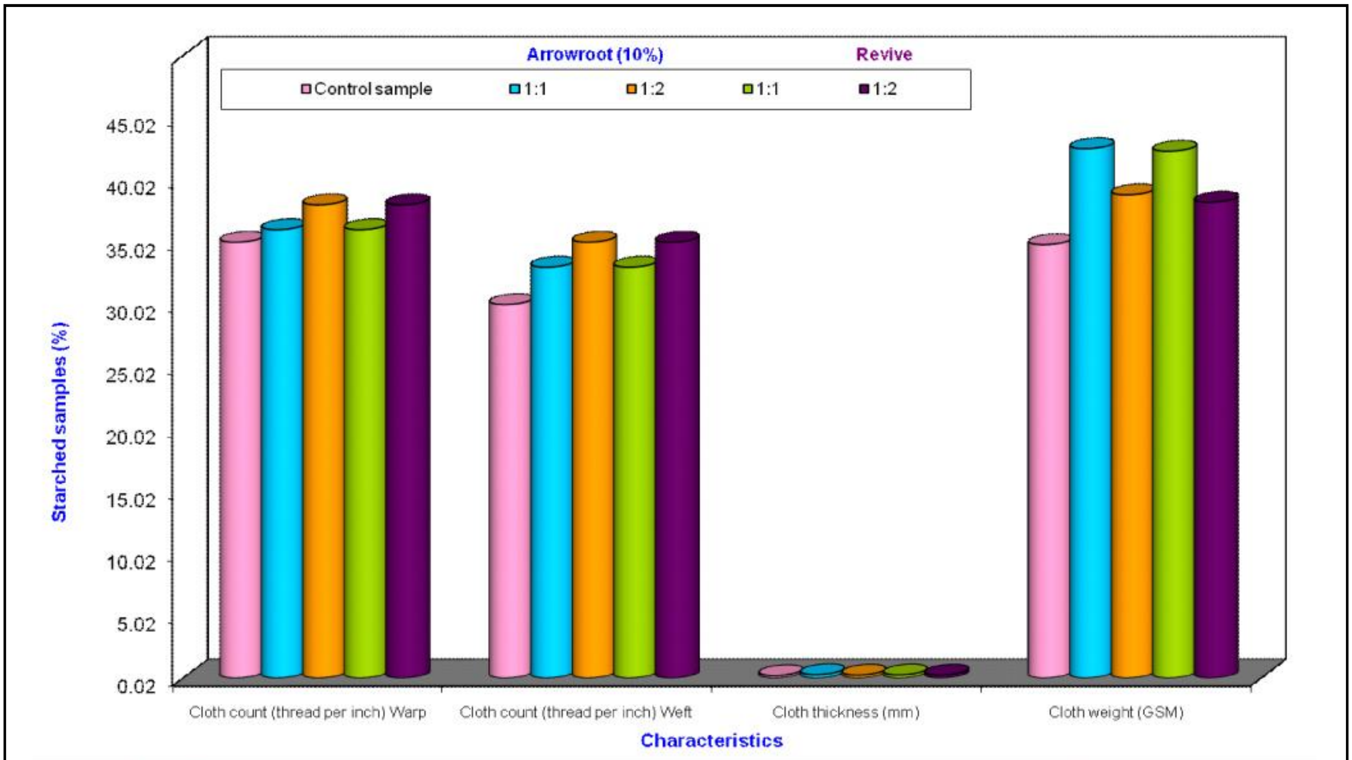

Fig. 1 : Effect of hand writing washing on cloth count (thread per inch), cloth thickness (mm) and cloth weight (GSM) of sized samples

sample at 1:1 and 1:2 dilutions. The increase in warp count from sized sample to that of washed sample is 05.71 to 08.51 per cent at 1:2 dilution and that of weft at 1:1 dilution is from 06.66 to 10.00 per cent for arrowroot and at 1:2 dilution is from 13.33 per cent to 16.67 per cent, irrespective of the sizing materials.

On washing there is an increase in the threads/unit area which is due to further consolidations of yarns. This yarn consolidations was mainly due to desizing of the micro molecules of starching material, mechanically (temporarily) held on the yarn as well in between the yarns.

From ANOVA, it is found that the sizing materials, dilutions, and their interactions have influenced the cloth count of sized samples after first wash and were found to be highly significant (Table 2).

Effect of hand washing on cloth thickness (mm) of sized samples:

Cloth thickness is the distance between one surface to its opposite. In textiles, it is the distance between upper and lower surface of the material, measured under the specified pressure.

Table 1 indicates that there is increase in the cloth thickness on sizing and maximum thickness is observed with samples sized with arrowroot at 1:1 dilution followed by revive 1:1 (39.62%) and at 1:2 dilution level the cloth thickness was

Table 2 : ANOVA for assessment of cloth count (thread per unit) of sized samples after wash

Source of variable	Degree of freedom	Starched samples		
		MSS	F	SEM
Sizing materials (S)	2	11.317	10.527**	0.231
Dilution (D_1)	1	8.817	8.202**	0.189
S x D_1	1	183.750	170.930**	0.327
Direction (D_2)	2	2.817	2.620	0.189
S x D_2	2	1.950	1.814	0.327
D_1x D_2	1	2.017	1.876	0.327
S x D_1 x D_2	2	8.317	7.736**	0.463
Error	48	1.075	-	-

** indicates significance of value at P=0.01

maximum with arrowroot (35.85%) followed by revive (33.96%) *i.e.*, the cloth thickness was relatively greater when starched with arrowroot compared to revive at both the levels of dilution.

The increase in thickness is directly proportional to dilution level *i.e.*, lower the dilution level higher the thickness percentage is, this is mainly therefore of deposition of sizing materials on the substrate surface. After washing the sized sample, it is observed that there is decrease in the cloth thickness (mm) when compared to the thickness values of sized sample. However, the cloth thickness values after wash are higher than the corresponding control sample. Maximum reduction in thickness is observed among arrowroot sample (17.92%) compared to revive (18.88%) at 1:2 dilution.

From ANOVA it is indicated that the influence of sizing materials and dilutions on cloth thickness of sized samples after first wash was found to be highly significant and significant respectively (Table 3).

The fabric heavily sized showed a significant decrease in thickness and mass per area after desizing. The stiffness could be correlated with physical parameter *viz.*, tensile strength, drape and thickness of the fabric using effective Young's modulus as indicated by Rayachaudhuri and Das (2001), in a study on Physical testing and mathematical modeling for stiffness characteristics of fabrics using polyester cotton blends'

Effect of hand washing on cloth weight (GSM) of sized samples:

Cloth weight of the fabric depends on the fibre composition, yarn type, yarn twist, threads density, method of fabric construction and finish applied.

It is evident from Table 1 that in general there is increase in the GSM on starching. Greater increase in GSM is observed among the samples sized with 1:1 dilution than that of 1:2. Among all the four treated samples maximum gain in GSM is observed at 1:1 dilution when starched with arrowroot (28.73%) followed by revive 1:1 (27.58%) and at1:2 dilution, with arrowroot (18.39) and revive (17.81%).

As there is increase in the yarn density as well as cloth thickness on sizing, the GSM of the test sample automatically got elevated. GSM at control increased remarkably after sizing and is mainly due to increase in yarn density and deposition of starching material on the cloth surface.

It is evident that GSM is one of the important structural properties that greatly influence the performance properties, especially the drape of the sari. There was reduction in the GSM of starched sample after the first wash, eventually because of partial desizing. Desizing is partial because it is obvious from Table 1 where the GSM of control sample is at least 10-20 per cent lesser than the washed sample. Moreover, the GSM at 1:1 dilution is about 10 per cent greater than at 1:2 level.

The reduction in cloth thickness directly indicates the loss in GSM after hand wash. There was increase in cloth thickness after sizing mainly due to deposition of sizing material and this deposition is temporary. Much of the starch particles were washed off during washing not only reduced the thickness but also brought down the GSM.

However these results are in line with the study conducted by Joshua (1998) where the loss in mass of both selected fabric samples was accompanied by the changes in other properties like thickness and stiffness. However, mass per square meter and thickness showed a consistent decrease with increasing wear.

The study conducted by Naik and Kulloli (2003) on 'A comparative study of sizing agents on the physical parameter of unbleached cotton material' did support the results by indicating that sample sized with natural sizing material showed gain in cloth weight as well shrinkage percentage;

Table 3 : ANOVA for assessment of cloth thickness (mm) of sized samples after wash

Source of variable	Degree of freedom	Starched samples		
		MSS	F	SEM
Sizing materials (S)	2	0.010	42.392**	0.000
Dilution (D_1)	1	0.001	6.168*	0.000
S x D_1	2	0.001	2.392	0.000
Error	24	0.000	-	-

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 4 : ANOVA for assessment of cloth weight (GSM) of sized samples after wash

Source of variable	Degree of freedom	Starched samples		
		MSS	F	SEM
Sizing materials (S)	2	0.000	222.994**	0.527
Dilution (D_1)	1	0.000	97.200**	0.527
S x D_1	2	5.712	25.706**	0.745
Error	18	2.222	-	-

** indicates significance of value at P=0.01

shrinkage is nothing but progressive consolidation of yarns in the woven cloth. Higher cloth density was observed when sized with arrowroot.

Hence, the null hypothesis that, hand washing does not alter the structural properties of size sample is rejected, *i.e.* hand washing did alter threads per unit area, cloth thickness and cloth weight of the sized sample.

Effect of hand washing on performance properties of sized samples:

Every fabric manufactured has definite end use, thus has all intrinsic qualities or characteristics to perform better as per the specification. Therefore, several varieties and qualities of fabrics are produced and made available in the market for the consumers to select wisely for clothing, bed linen furnishing and industrial purposes.

Cotton cloth is produced in varied GSM that helps the people to select material for variegated end uses. There are several parameters of a cloth that determine its performance *viz.*, bending path, crease recovery and drape co-efficient. Hence, an effort was made to assess the impact of sizing on these parameters and evaluate its performance. The result of performance properties of sized sample after hand wash is presented in Table 5 and Fig. 2.

Effect of hand washing on bending path (cm) of sized samples:

The bending length (cm) of the cloth on sizing increased in both the directions *i.e.*, warpway end weftway. However, warpway bending path was higher than the respective weftway. It is interesting to note from Table 5 that the warpway bending length of fabric sized with arrowroot and revive at 1:1 dilution was same (4.8 cm) whereas that of revive was higher (4.4 cm) compared to arrowroot (4.28 cm) at 1:2 dilution. A similar trend was observed in weftway too *i.e.*, bending length was 4.7 cm and 4.75 cm, respectively when sized with arrowroot and revive at 1:1 level. However weftway bending length was relatively small when measured at 1:2 dilution *i.e.*, 4.18 cm and 4.32 cm for arrowroot and revive respectively.

Table 5 further depicted that on washing there was gradual decrease in bending length compared to sized sample but this bending path was greater than its corresponding control values. In general there was not much variation in warpway and weftway bending length of arrowroot and revive samples at 1:1 and 1:2 dilution levels. In fact the warpway bending path of all the treated samples was very closer to their corresponding weftway bending length. However, the bending length was longer at 1:1 dilution to that of 1:2 dilution. This clearly indicates that the viscosity of 1:1 dilution was higher than 1:2 level and partial desizing of superficially deposited starching material brought a change in the fabric texture *i.e.* softness and limpness due to which the bending length was longer.

A study entitled 'Effect of laundering on crease recovery and stiffness of P/C blended uniform fabric' was carried out by Bhavani and Shailaja (1996) inferred that as the number of washes increased there was reduction in the crease recovery property as well as stiffness. Reduction in bending length values indicates the fabric gradually becoming soft, pliable and flexible on laundering; a supportive reference.

The bending length of cent per cent cotton fabric was found to be higher in both warp and weft directions at used condition (after washes) compared to brand new condition. It was attributed to the decrease in load on the strip after washing as confirmed in a study conducted by Rayachaudhuri and Das (2001), which favours the results of the present study.

Further ANOVA indicated that influence of sizing materials, dilutions, their interactions and yarn directions were found to be highly significant but the interaction of sizing materials and yarn direction was found to be significant (Table 6).

Table 5 : Effect of hand washing on cloth bending length (cm), cloth crease recovery (angle) and cloth drape coefficient (%) of sized samples

Sr. No.	Characteristics	Direction	Control sample	Starched samples							
				Arrowroot (10%)				Revive (10%)			
				Dilution				Dilution			
				1:1		1:2		1:1		1:2	
				Sized	Washed	Sized	Washed	Sized	Washed	Sized	Washed
Performance properties											
1	Cloth bending length (cm)	Warp	1.7	4.8 (182.33)	3.9 (129.41)	4.28 (151.76)	3.00 (76.47)	4.8 (182.35)	3.9 (129.41)	4.4 (158.82)	3.57 (110.00)
		Weft	1.4	4.7 (235.71)	3.9 (178.57)	4.18 (198.57)	2.9 (107.47)	4.75 (239.28)	3.8 (171.42)	4.32 (208.57)	3.4 (142.85)
2	Cloth crease recovery (angle)	Warp	80.8°	84.4^{0} (04.45)	83.2° (02.97)	81.2^{0} (0.49)	80.5° (00.37)	84.4^{0} (04.45)	82.4° (01.87)	83.8^{0} (03.71)	81.6° (00.99)
		Weft	78.6°	82.2^{0} (04.58)	80.4° (02.29)	80.0^{0} (01.82)	79.0° (00.50)	83.4^{0} (06.10)	81.9° (04.19)	83^{0} (05.59)	81.4° (03.81)
3	Cloth drape coefficient (%)	-	37.6	93.7 (149.20)	88 (134.04)	86.0 (131.11)	73.0 (94.14)	93.9 (149.73)	87.4 (132.44)	88 (135.63)	71.6 (90.42)

Figures in parenthesis indicate percentage

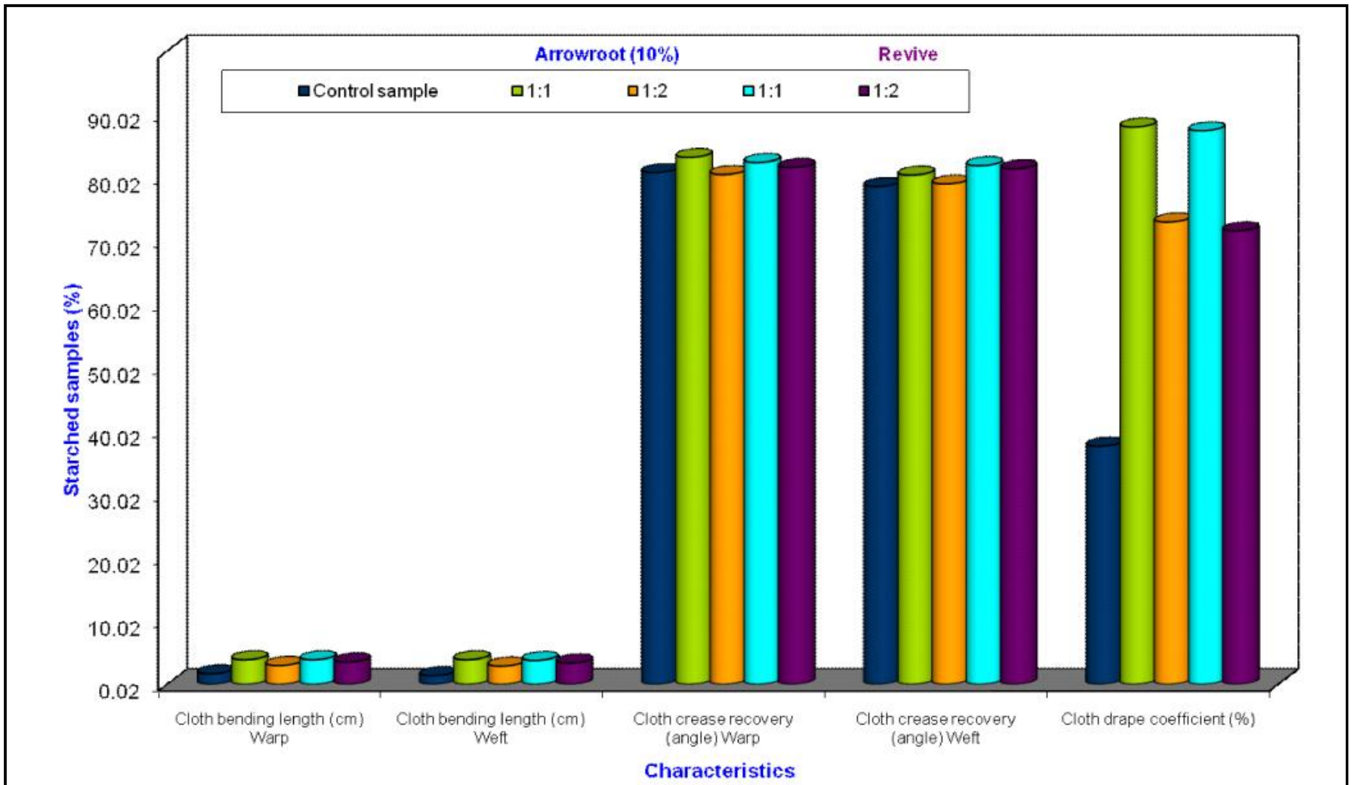

Fig. 2 : Effect of hand writing washing on cloth count bending length (cm), cloth crease recovery (angle) and cloth drape coefficient (%) of sized materials

Table 6 : ANOVA for assessment of cloth bending (cm) on after wash

Source of variable	Degree of freedom	Starched samples		
		MSS	F	SEM
Sizing materials (S)	2	21.638	1.212**	0.033
Dilution (D_1)	1	2.297	128.696**	0.027
S x D_1	1	0.285	15.981**	0.047
Direction (D_2)	2	0.891	49.903**	0.027
S x D_2	2	0.071	4.004*	0.047
D_1x D_2	1	0.010	0.572	0.047
S x D_1 x D_2	2	0.003	0.152	0.067
Error	36	0.018	-	-

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Effect of hand washing on cloth crease recovery (angle) of sized samples:

Crease recovery angle is one of the performance properties directly supports the bending length of that fabric. Cloth crease recovery is the angle of recovery indicates the soft and pliability of a fabric. Greater the recovery angle, stiffer the fabric is. In general the warpway recovery is greater than its corresponding weftway recovery; and higher the dilution level, lower the recovery angle is. It is evident from Table 5 that irrespective of sizing materials the warpway recovery angle was 84.4° (increased by 04.45% over control) in contrast to its corresponding weftway recovery angles *i.e.*, 82.2° (arrowroot) and 83.4° (revive) at 1:1 dilution level. However, the warpway crease recovery angle at 1:2 dilution level was lower (81.2° arrowroot and 83.8°, revive) than 1:1 dilution. On the other hand the weftway recovery angle at 1:1 dilution is higher in revive (83.4°) compared to arrowroot (82.2°) and that of 1:2 dilution are 83.0° and 80.0°, respectively.

Cloth crease recovery is complimentary to cloth bending length *i.e.*, longer the bending path greater the recovery angle and this formula indicates stiffness of the fabric. The warp and weft crease recovery angle at control is relatively lower than at 1:1 and 1:2 dilution levels. Though the recovery angle at 1:2 is lower than 1:1 level, these values are higher than that of control. The test samples exhibited higher warpway crease recovery when sized with both arrowroot and revive than its corresponding weftway recovery, which indicated that the sample is stiffer in warp direction than weft. These results are supportive to the corresponding values of cloth bending length.

Impact of hand washing on crease recovery of sized samples was determined and recorded in Table 5. It is seen that from this table that after washing, the cloth crease recovery of the sized sample was decreased, in general, but this recovery angle was greater than its control values. The warpway recovery angle was relatively greater than the weft way recovery irrespective of dilution levels. However, at 1:1 dilution the warp way recovery was 83.2^0 and 82.3^0 (arrowroot and revive) and that of 1:2 dilution was 80.5^0 and 81.6^0, respectively. The weft way recovery at 1:1 dilution ranged from 80.4^0 to 81.9^0 and that of 1:2 dilution ranged from 79^0 to 81.4^0.

It is true that there was change in the structural characteristics of the test sample on washing, which had direct impact on the performance properties. This is mainly due to superficially deposited starching material was partially removed on washing and thus making the fabric relatively soft and resilient. These results are in line with the study conducted by Bhavani and Shailaja (1996). Mean while Mishra *et al.* (2007) concluded that the MLR and concentration of stiffening agent made a significant difference in air permeability, bending length, crease recovery and drapability of white cotton fabric stiffened with arrowroot powder.

From ANOVA it is pointed out that the sizing materials and dilutions have influenced the cloth crease recovery of sized samples after first wash and were found to be highly significant. But the influence of yarn direction was found to be significant (Table 7).

Effect of hand washing on cloth drape co-efficient (%) of sized samples:

The total impact of cloth thickness, GSM, bending length and crease recovery of the fabric is depicted in its drape quality. The drapeability of fabric may be expressed in terms of drape co-efficient (%) or number of nodes on draping. Higher the drape co-efficient stiffer the fabric is. From Table 5 it is clear that there is increase in the drape co-efficient values on sizing and invariably it is higher at 1:1 dilution than 1:2 dilution. However, there was not much difference or variation in the drape co-efficient values when starched with arrowroot (93.7 and 86.0) and revive (93.9 and 83.0) at 1:1 and 1:2 levels of dilutions.

Drape quality of a fabric is determined by the interaction of both ends and picks when hung freely on its own weight. Drape of a fabric does generate information on its stiffness and expresses whether the fabric is stiff and hard or soft and limp. From the results presented in Table 5 it is clear that there is not much variation in drape quality of the test samples when sized with either arrowroot or revive.

Further it is learnt from this Table that the sized sample on washing lead to modification bending path and crease recovery angle that in turn has influenced the drapeability. There was reduction in the drape co-efficient values of the test samples on washing. The drape co-efficients at 1:1 level of dilution was greater (88.00 and 87.40%) for arrowroot and revive, respectively, in contrast to 1:2 level (73.00 and 71.60%). This may be due to washing off the sized sample that was held mechanically and temporally on fabric surface. However, drape co-efficient of washed sample was higher than its control values, which indicate that the sample has not attained the soft and pliable texture as that of control.

These results are in line with the findings of Mishra *et al.* (2007) who indicated that the material to liquor ratio and concentration of stiffener made a significant difference in air permeability, bending length, crease recovery and drapability of white cotton fabric stiffened with arrowroot powder. Sizing not only improves the appearance of cottons but also keep clothes clean for longer time, helps in stain removal, a valuable task of day to day use of cotton fabric.

High cloth cover significantly leads to high shear stiffness, high bending rigidity and poor drape quality. The use of coarser cotton leads to lower fabric bending stiffness and better drapability, is the inference made by Sheela *et al.*, 1997 as well mentioned that drape co-efficient in cotton fabrics is related only to the fabric cover.

Table 7 : ANOVA for assessment of cloth crease recovery (angle) on after wash

Source of variable	Degree of freedom	Starched samples		
		MSS	F	SEM
Sizing materials (S)	2	22.650	15.802**	0.267
Dilution (D_1)	1	10.417	7.267**	0.218
S x D_1	1	46.817	32.663	0.378
Direction (D_2)	2	2.917	2.035*	0.218
S x D_2	2	3.517	2.453	0.378
D_1x D_2	1	0.817	0.570	0.378
S x D_1 x D_2	1	0.317	0.221	0.535
Error	48	1.433	-	-

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Hence, the null hypothesis that hand washing does not alter the performance of the size sample is rejected, *i.e.* on hand washing there was variation in the performance of cloth bending length, crease recovery and drape co-efficients of the sized sample.

Effect of hand washing on durable properties of sized samples:

'Wear' is net result of a number of agencies which reduce the serviceability of an article. Some of the important agencies are bending, stretching, tearing, abrasion, laundering and cleansing. The laboratory approach to assess the durability of the test samples in this study are abrasion resistance, tensile strength and its corresponding elongation. The durability of the fabric in the present study was evaluated on the assessment of abrasion resistance and tensile properties and impact of washing on these two characteristics are presented in Table 8.

Effect of hand washing on cloth abrasion resistance (cycles) of sized samples:

Cloth abrasion resistance is the wearing off of any part of material by rubbing against another surface. The abrasion resistance (cycle) of the test sample on sizing is presented in Table 8. It is evident from this Table that, maximum resistance for abrasion (cycle) is found in test sample when sized with arrowroot (260) followed by revive (243) at 1:1 level of dilution compared to 203 and 193 cycles (arrowroot and revive) at 1:2 dilution. It clearly indicates that the abrasion resistance is better when the sizing concentration is higher.

This is mainly due to the higher concentration rather viscosity of the sizing material at 1:1 dilution, and this formed relatively a thicken layer on the fabric surface, thus giving better resistance to abrasion than 1:2 dilution. The viscous stiffening agent coated the fabric surface, in fact a protective layer for the cotton fabric. The sizing solution when diluted, naturally the viscosity get diluted and on application to fabric, form remarkably a thin layer compared to 1:1 dilution, thus giving resistance to abrasion not as much as that of 1:1 concentration.

Table 8 clearly indicate that the abrasion resistance of the fabric increased on sizing but was reduced on washing it. However, the abrasion resistance at 1:1 level was higher than 1:2 level and arrowroot showed better resistance at both levels of dilutions compared to revive sample. The decreasing order of abrasion resistance was 55.71 and 39.28 per cent (1:1 and 1:2 arrowroot), 30.71 and 25.71 per cent (1:1 and 1:2 revive). Though there was reduction in the abrasion resistance, the washed sample exhibited better abrasion resistance to its corresponding control.

The abrasion resistance of sized sample on washing gradually reduced as compared to its resistance when sized. This invariably indicated that resistance to abrasion was mainly due to a temporary coating formed by the nano starch particles. The release of these particles on washing did reduce the abrasion resistance because the starch layer formed a coating that protected the fabric from wear test. Starching indeed acts as a durable coating but is a temporary one.

Effect of hand washing on cloth tensile strength (g) and elongation (%) of sized samples:

Tensile strength is the ability of the material to resist strain or rupture induced by external force. It is expressed as

Table 8 : Effect of hand washing on cloth abrasion resistance (cycles), cloth tensile strength (g) elongation (%) and cloth air permeability (m^3/cm^2/min of sized samples

Sr. No.	Characteristics	Direction	Control sample	Starched samples							
				Arrowroot (10%)				Revive (10%)			
				Dilution				Dilution			
				1:1		1:2		1:1		1:2	
				Sized	Washed	Sized	Washed	Sized	Washed	Sized	Washed
Durable properties											
1.	Cloth abrasion resistance (cycles)		140	260 (85.71)	218 (55.71)	203 (40.00)	195 (39.28)	243 (73.57)	183 (30.71)	193 (37.85)	176 (25.71)
2.	Tensile strength a) Breaking load (N)	Warp	87.2	153.6 (76.14)	132.1 (51.49)	138.00 (58.25)	113.2 (29.81)	154.0 (76.60)	148.0 (69.72)	135.9 (55.84)	130.1 (49.08)
		Weft	80	144.0 (79.55)	118.2 (47.75)	121.7 (52.12)	115.5 (44.38)	143.6 (78.75)	131.2 (64.00)	118.0 (47.50)	106.2 (32.75)
	b) Elongation (%)	Warp	5.2	6.40 (23.07)	8.5 (63.46)	6.90 (32.69)	7.1 (36.54)	6.60 (26.92)	6.7 (28.85)	6.10 (17.30)	5.3 (01.92)
		Weft	4.5	5.70 (48.87)	8.4 (86.67)	5.40 (66.67)	7.5 (66.67)	5.50 (17.78)	6.2 (37.78)	5.30 (31.11)	6.1 (35.56)
Comfort properties											
3.	Cloth air permeability (m^3/cm^2/min)	-	554.1	399.6 (27.88)	467.40 (15.64)	434.0 (21.67)	473.3 (14.58)	416.40 (24.85)	472.5 (14.73)	458.80 (17.20)	485.8 (12.32)

Figures in parenthesis indicate percentage

force/unit on cross- sectional area of the specimen at the time of maximum load.

Table 8 does depict the results of tensile strength of control and sized test sample. In general there is remarkable increase in the tensile strength on sizing; however, the warpway strength is higher than its corresponding weftway strength at 1:1 and 1:2 levels of dilution. The descending order of warpway tensile strength on sizing with arrowroot is 153.60 g and 138.00 g at 1:1 and 1:2 levels of dilution respectively, similarly that of revive is 154.00 g and 135.90 g. The weft way breaking load is found to be higher in arrowroot *i.e*., 144.00 g (80.00%) followed by 143.60 g (78.75%) at 1:1 dilution and that of 1:2 dilution is 121.70 g (52.12%) and 118.0 g (47.50%) for arrowroot and revive, respectively.

Similarly, the percentage warpway elongations at 1:1 dilutions is found to be almost same when starched with arrowroot and revive so also at 1:2 dilution (6.90 and 6.10%); whereas the weftway elongation ranged from 5.30 per cent (revive, 1:2) to 5.40 per cent (arrowroot, 1:2). In other words the greater per cent elongation is observed when sized with higher concentration (1:1) than that of lower (1:2).

Hand washing on tensile strength and elongation of sized samples is depicted in Table 8. This table revealed that the tensile strength of the fabric reduced on washing when compared to sized sample. The reduction in tensile strength was relatively low in warpway compared to weftway for arrowroot and revives samples at 1:1 and 1:2 dilutions. In other words the tensile strength of wash sample was higher when compared to control. The decrease in warpway tensile strength at 1:1 dilution for arrowroot and revive was 51.49 per cent and 69.72 per cent and that of 1:2 dilution was 29.81 per cent 49.08 per cent, respectively; and that of weftway tensile strength was 47.75 and 64.00 per cent for arrowroot and revive, respectively at 1:1 level and that of 1:2 dilution was 36.54 per cent and 28.85 per cent.

The main reason for decrease in the tensile strength is the withdrawal of binding support of nano starch particles on washing. Due to release of the sizing particles, the yarns became softer, pliable and free, which could be broken at a lower load. In other words, the fabric acquires temporary strength by the starch particles as long as it is held on the fabric surface.

The outcome of the study is favoured with results revealed in a study conducted by Bhavani and Shailaja (1997) where there was a gradual reduction in the tear strength of fabric with increase in the number of launderings may be because of the fact that tear strength of fabric is largely affected by the mobility of yarns within the fabrics during laundering and constructional features.

It is further noticed that percentage of elongation was inversely proportional to the corresponding tensile strength of the test sample on washing *i.e.* a trend of increase in elongation (%) was observed on washing, which was relatively higher than the elongation at break of sized sample. However, much variation in elongation was not observed between the corresponding warpway and weftway samples.

Hence, the null hypothesis that hand washing does not alter the durability of the sized sample is rejected, *i.e.* on hand washing there was variation in the abrasion resistance, tensile strength and elongation of the sized sample.

Effect of hand washing on comfort properties of sized samples:

The comfort properties are influenced by the structural properties, performance characteristics and durability features to some extent. Among several comfort properties air permeability is one of them. The fabric must allow air to pass through but at the same time prevent the passage of dust and dirt. There is a relation on the effect of yarn density and fabric count. Sometimes the finish given to a fabric has considerable effect on permeability, even though the porosity may remain the same.

Effect of hand washing on cloth air permeability ($m^3/cm^2/min$) of sized samples

From Table 8 it is clear that the air permeability decreased on sizing, in general compared to control. From the results it is evident that air permeability is higher when sized with revive and arrowroot at 1:2 dilution compared to 1:1. The ascending order of increase in air permeability over to control is 399.60 (27.88% arrowroot 1:1), 416.40 (24.85% revive 1:1), 434.0 (21.67%, arrowroot, 1:2) and 458.80 (17.20% revive, 1:2).

The air permeability of the fabric is reduced on sizing due to closure of fabric pores. In fact the porosity is reduced due to deposition of the sizing agent on the fabric surface. However, the air permeability is directly proportional to air porosity and air porosity in turn directly proportional to dilution levels as well as size of the sizing particles. The air permeability though in higher at 1:2 dilution level but is relatively more with revive than arrowroot which may be due to larger particles of arrowroot that covered the pores more densely than that of revive. In other words the revive nano particles are much finer than its counter reagent, thus its slimy and gelatinized structure is simpler than arrowroot. However, at 1:1 dilution the air porosity is higher because of the consistency, its level of spreading and deposition on the fabric surface.

From the same Table 8 it is clear that the cloth air permeability is increased on washing due to washing off of the starch. The air permeability at 1:1 dilution for arrowroot and revive (15.64 and 14.73%, respectively) is relatively lower than at 1:2 dilution (14.58 and 12.32%, respectively), which clearly indicates that at 1:2 level of dilution the permeability is higher than at 1:1 dilution.

Washing ultimately improved the air permeability of the fabric. The air permeability at 1:2 dilution was better than 1:1 level on washing, since and the consistency and concentration of starch at 1:1 dilution is higher and amount of starch deposition is relatively more than at 1:2 level. It is but natural that the percentage of starch particles in 1:2 dilution is much lower and possibly these particles are released from fabric and moved to liquid media during washing.

However, it may be stated that higher the starch concentration, greater the deposition on fabric surface and lower the impact of washing on it release. Further the type of sizing materials did not show much impact on the air permeability at both 1:1 and 1:2 dilutions, after hand wash. Mishra *et al.* (2007) made observations on standardization stiffening procedure for white cotton fabric, while Kade (2010) made some observations on the aspects related to the household practices of stiffening clothes.

Hence, the null hypothesis that, hand washing does not alter the comfort property of the sized sample is rejected, *i.e.* on hand washing there was change in air permeability of the test sample.

Conclusion:

From the study it can be concluded that after laundering, the sized samples showed reduction in cloth count, GSM, thickness, bending length, crease recovery, drapability, abrasion resistance, tensile strength and air permeability. This change in structural and performance was due to gradual softness and pliability imparted on partial desizing. It is evident that single hand wash will not completely desize the cotton fabric. Such cotton garments / saris can be used at least for 2-3 times without starching; since some percent of size in these materials facilitate the individual to it as 'soft – sized' fabrics. The sized clothes can be used after one wash, definitely a means to 'cutting cost' on starching the clothes. It is also observed that sizing materials, dilution levels and yarn directions made a significant difference in cloth count, GSM, thickness, bending length, crease recovery, drapeability, abrasion resistance, air permeability, tensile strength and elongation of muslin cloth. In fact the viscosity of the starch produced by hot process is higher than cold process; nevertheless the consumer has a choice to select the sizing material, dilution level, MLR, and method of starching.

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■ REFERENCES

Bhavani, K. and Naik, S.D. (1996). Effect of laundering on crease recovery and stiffness of P/c blended uniform fabric. *Tex. Dyer & Printer*, **29**(14): 15-16.

Bhavani, K. and Naik, S.D. (1997). Laundry effect on P/C uniform fabric: Tensile and tear strength. *The Indian Tex. J.,* **107**(4): 24-25.

Dantyagi, S. (1974). *Fundamental of textiles and their care*. Orient Longman Ltd. New Delhi, pp. 222-228.

Das, J., Kalita, B. and Gogoi, N. (2011). Jackfruit seeds - A source of natural sizing agent. *The Tex. Trends,* **24**(4): 36-40.

Joshua, O.U. (1994). Bending properties on wet abraded woven fabrics. *Indian J. Fibre & Tex. Res.,* **19**(4): 229-239.

Joshua, O.U. (1998). The assessment of fabric wear and handle caused by increments of accelerator abrasion in dry conditions. *The J. Tex. Institute,* **79**(4): 568-579.

Kale, S. (2010). Aspects related to household practices of stiffening clothes. *Asian J. Home Sci.,* **5**(1): 1-5.

Mishra, N., Singh, A. and Shweta (2007). Standardization of stiffening procedure for white cotton fabric. *The Tex. Industry & Trade J.,* **45**(7-10): 21-24.

Naik, S.D. and Kulloni, S. (2003). A comparative study of sizing agents on the physical parameters of unbleached cotton material. *The Tex. Industry & Trade J.,* **41**(3-4): 21-23.

Rayachaudhuri, B. and Das, S.P. (2001). Physical testing and mathematical modeling for stiffness characteristics of fabrics using cotton polyester blends. *Man-Made Tex. India,* **43**(9): 427-430.

Sheela, R., Vivekanandan, V. M., Sreenivasan, S. and Krishna, K.R. (1997). Shear stiffness and drapability. *The Indian Tex. J.,* **108**(2): 18-25.

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