

## Effects of washing on performance attributes of fabrics for Basic School Uniforms

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### Abstract

The determination of the suitability of fabrics for specific end-uses requires the subjection of selected fabrics to conditions they would be exposed to during use and care such as washing. Three different brands of fabrics commonly used for Ghanaian basic school uniforms labelled A, B and C were evaluated after washing to suggest suitable fabric(s) to be used to achieve quality in uniforms. Specimens were subjected to three washing cycles and strength, elongation, dimensional stability and colourfastness tested. Data were analyzed, using the Predictive Analytical Software for windows version 22. Means of the performance characteristics of the fabrics were determined and hypotheses were tested, using analysis of variance at 0.05 alpha level. Washing had an effect on the parameters investigated. In all, fabric brand B performed best as throughout the wash cycles, its strength values were above the standard requirements set by the Ghana Standards Authority for uniform fabrics. Since the fabric brand B performed best with the parameters investigated, it is suggested for use as school uniform fabric. Further studies can be conducted on these same fabrics where other parameters such as absorbency and abrasion resistance can be evaluated.

**Keywords:** Washing, Strength, Shrinkage, Uniform fabrics, Ghanaian

**Running title:** Effects of Washing on Basic School Uniform Fabrics

### Introduction

The quality of school uniforms is an issue of concern in the educational sector. To achieve quality the conditions the garments would be subjected to during use have to be assessed to be able to select the best suited fabrics. Washing and dry-cleaning are care procedures that garments go through during use.[1] However, as far back as 1977 it was noted that as much as half of garment degradation happens in laundering.[2] It is noted that laundering of textile products is one of the most employed care procedures used in the evaluation of clothing items to establish suitability.[3] Washing and sunlight, for example, were found to cause the colour of Real Wax, Real Java, and Batik fabrics produced in Ghana, to fade [4] with laundered specimens losing more strength than unlaundered.[5] It was also observed that agitation during laundering caused 34% of changes in fabric attributes.[6] As school uniforms go through their cycle of use, they are exposed to washing which may influence their overall performance. Fabrics used for uniform production, therefore, have to be evaluated by subjecting them to conditions such as washing to determine their suitability.

In this study effects of washing on selected performance attributes of fabrics commonly used for the production of Ghanaian public basic school uniforms were investigated. The objective of the study was to determine whether there would be differences in the performance of the selected fabrics in terms of strength, colourfastness, elongation, weight and dimensional stability after three cycles of washing and to establish the most suited fabric(s) amongst the three to be used for school uniforms.

The following hypotheses were tested:

Ho<sub>1</sub>: There is no significant difference among the strengths and elongations of three different brands of fabrics used for Ghanaian public basic school uniforms and the number of times of washing.

H<sub>0</sub>: There is no significant difference among the weights and shrinkage of three different brands of fabrics used for Ghanaian public basic school uniforms and the number of times of washing.

## **Materials And Methods**

### **Materials**

#### ***Fabric Samples***

Three different brands of fabrics (labelled A, B, C) used for producing public basic school uniforms in Ghana were selected for the study. Each brand was in two colours. Therefore, the samples were further labelled A1, A2; B1, B2 and C1, C2. A1, B1 and C1 were chocolate 4/saddle brown colours used for skirts, pinafore or a pair of shorts. A2, B2 and C2 were sandy brown colours used for shirts and blouses. For this study, 3.5 metres of each of the colours of fabrics from the three brands were selected making a total of 6 different fabrics which were assessed.

#### ***Soap Used for Washing Tests***

Key bar soap, produced by Uniliver, Ghana Limited, was purchased for the washing tests. The choice of the soap was influenced by the popularity of it among Ghanaians [7] and the fact that it is used by Ghanaians for washing coloured clothes.[5]

### **Methods**

The Ghana Standards Authority's (GSA) textile laboratory test methods were used in carrying out all the investigations. The specimens were conditioned for 24 hours in a relaxed state at a relative humidity of  $65 \pm 2\%$  and a temperature of  $21^\circ \pm 1^\circ\text{C}$  before data collection.[8] The following attributes were determined:

#### ***Woven Fabric Yarn Count***

Three specimens each measuring 2.5cm in both warp and weft directions were cut from each brand of uniform fabric.[9] The number of yarns in the warp and weft directions of the specimens were counted 5 times with the aid of a magnifying glass and each recorded. An average warp and weft count was, then, calculated for each fabric.

#### ***Weight of Fabric***

Five specimens each with the area of 0.015m<sup>2</sup> were cut using a sample cutter from each fabric. Each specimen was weighed, using Adam's equipment weighing balance, Model No. B215846278. The average weight of the five specimens was calculated and indicated in grams per square meter.

#### ***Colourfastness to Washing***

Two specimens measuring 10cm×4cm were cut from each brand of fabric and a multi-fibre fabric of same measurement was attached to each specimen. The specimens were washed, using the Standard Launder-Ometer (Gyrowash 315) and dried at room temperature. Colourfastness assessment was carried out, using the International Organisation for Standardisation (ISO) Grey Scale for colour change and staining.[10] Five readings were recorded in the visual inspection of the specimens for colour change and staining for each fabric in a well-lighted colour assessment chamber. Readings were recorded and averages calculated.

#### ***Dimensional Stability (Shrinkage) to Washing***

Two specimens, 15cm×15cm were cut from each fabric such that the yarns in both directions (warp and weft) were parallel to the edges. Four lines of 10cm apart and 2.5cm from the specimen edges were marked on each specimen. The specimens were washed with the Standard Launder-Ometer (Gyrowash 315) and dried at room temperature. The distance between the marked lines (10cm×10cm) was, then, re-measured for each direction (warp and weft) of the specimen with the aid of a tape measure and recorded. This was carried out to determine if any change in the original length (10cm×10cm) occurred. Percentage dimensional change (shrinkage) was calculated with formula 1.[11]

**Formula 1:** Dimensional Change =  $(\Delta L/L) \times 100$ .

#### ***Fabric Strength and Elongation***

Following ISO 13934-1 [12], the fabrics' strengths and elongations were tested using the tensile testing machine (Mark-10 Force Gauge Model M5-500). Forty specimens (20 from the warp and 20 from the weft), measuring 15cm×5cm were cut from each fabric. The lengthwise directions of each specimen were frayed to achieve 15cm×3cm specimen size for testing. The tensile testing machine's gauge length was 100mm with the rate of extension or the speed of 20mm/minute. Readings for the force (strength) at break and elongation (extension) at break were taken for each specimen in both the warp and weft directions for unwashed and washed specimens after each wash cycle. Maximum forces at rupture were recorded in Newton (N) and elongation in millimetres. The rate of extension was then calculated using formula 2:

**Formula 2:**  $\epsilon = (\Delta L/L) \times 100$

**Washing Procedures**

A stock solution, made up of 33 grams of key bar soap and 6.6L of water was used for washing the specimens. The Standard Launder-Ometer (Gyrowash 315) was used in washing the specimens with the solution prepared from the key bar soap at 60°C temperature for 30 minutes. The specimens were rinsed and dried at room temperature and tested for the various attributes identified without ironing.

**Data Analysis**

The data were analysed, using the Predictive Analytic Software (SPSS) for windows, version 22. Means and standard deviations of the fabrics performance characteristics such as yarn count, weight, strength and elongation were determined. Analysis of Variance at 0.05 alpha level was employed to test the hypotheses.

**RESULTS**

The investigated fabrics were all plain woven in 1×1 repeats. In terms of yarn count, fabrics C (1 and 2) had the highest number of yarns in the warp direction and A (1 and 2) had the lowest. In the weft direction, fabric C (1 and 2) again had the highest count and fabrics B (1 and 2) had the least numbers of yarns. Their weight values ranged between 107g/m<sup>2</sup> to 175g/m<sup>2</sup> with fabrics A (1 and 2) recording the highest weight values followed by B (1 and 2) and C (1 and 2) had the lowest weight values (Table 1).

**Table 1:** Mean yarn count and weight of the sampled fabrics

Fabric type	Parameter		Mean Weight (g/m <sup>2</sup> )
	Warp	Weft	
A1	56	50	174
A2	57	52	175
B1	61	45	138
B2	62	46	138
C1	81	68	121
C2	79	66	107

A1, B1, C1= the Chocolate 4/saddle brown colours of fabric brands A, B and C, A2, B2, C2=the sandy brown colours of fabric brands A, B and C

**Hypothesis 1**

A significant difference existed between number of times of washing and strength in the weft ( $F=4.175$ ,  $df=3$ ,  $p=0.008$ ), but not in the warp ( $F=2.779$ ,  $df=3$ ,  $p=0.041$ ) directions of the fabrics. The mean strength values indicate that, in the weft direction, unwashed specimens ( $M=348N$ ) had the highest strength while 3rd wash specimens ( $M=314N$ ) had the least strength (Table 2). In the warp direction, 2nd wash specimens had the highest strength ( $M=421N$ ) while unwashed specimens ( $M=381N$ ) had the least strength. A post hoc analysis performed revealed that in the weft direction, differences were significant between unwashed and 3rd wash specimens. There were trends of increase or decrease in the strength of each fabric brand as washing progressed (Table 3). For fabric A1, strength in the warp direction decreased after 1<sup>st</sup> wash, increased after the 2nd wash and decreased after the 3rd wash. This same trend was noted in fabrics A2 and B2 in their weft directions (Table 3). Fabrics A2, B1 and C1 had a trend of increased strength after 1st and 2nd washes and decreased strength after the 3<sup>rd</sup> wash in their warp directions. For fabric B1, in the weft direction, a trend of decrease in strength after the 1st, 2nd and 3rd washes was observed (Table 3).

**Table 2:** ANOVA results for fabrics strengths, elongation, weights, and shrinkage by wash

cycles

Parameter	Wash Cycle	Unwashed		1st Wash		2nd Wash		3rd Wash		MS	df	F	p-value
		M	SD	M	SD	M	SD	M	SD				
<b>Strength (Newton)</b>													
Warp		381	66.59	411	55.46	421	46.18	400	54.39	8749.469	3	2.779	0.041
Weft		348	49.93	322	39.10	342	45.60	314	38.84	7943.319	3	4.175	0.008*
<b>Elongation (%)</b>													
Warp		27	3.38	31	5.14	28	4.18	32	9.09	166.129	3	4.822	0.004*
Weft		37	6.38	38	5.91	35	5.48	36	3.29	57.351	3	1.969	0.146
<b>Weight (g/m<sup>2</sup>)</b>													
Warp		142	25.67	142	25.55	142	24.64	141	23.80	5.895	3	0.009	0.999
<b>Shrinkage (%)</b>													
Warp		-	-	2	0.80	1	0.91	1	0.96	0.700	2	0.821	0.443
Weft				2	0.78	2	0.89	2	1.04	0.744	2	0.902	0.337

\*Significant  $p < 0.05$ , M= Mean, SD= Standard Deviation, MS= Mean Square

For elongation, significant differences existed between the number of times of washing in the warp ( $F=4.822$ ,  $df=3$ ,  $p=0.004$ ), but not in the weft ( $F=1.969$ ,  $df=3$ ,  $p=0.146$ ) directions (Table 2). The mean elongation values show that, in the weft direction, elongation increased after the first wash ( $M=38\%$ ), decreased after the second wash ( $M=35\%$ ) and increased after the third wash ( $M=36\%$ ). The same trend was established with the warp direction as well. A post hoc analysis conducted for the warp direction showed that differences were significant between 3rd Wash  $\times$  Unwashed and 3rd Wash  $\times$  2nd wash specimens.

### Hypothesis 2

No significant difference between the number of times of washing and weight of the fabrics was observed. The mean weight values, however, showed a slight decrease in weight of the fabrics after the third wash ( $M=141\text{g/m}^2$ ) (Table 2).

For shrinkage, no significant difference existed between the number of times of washing and both in the warp ( $F=0.821$ ,  $df=2$ ,  $p=0.443$ ) and weft ( $F=0.902$ ,  $df=2$ ,  $p=0.337$ ) directions. The mean scores from the warp direction, however, indicate that shrinkage reduced after the second and third washes (Table 2).

**Table 3:** Mean values for fabric strength, elongation, shrinkage and weight for three wash cycles

Parameter	Wash Cycle	Unwashed		1st Wash		2nd Wash		3rd Wash		GSA Standard Requirement		
		P	T	P	T	P	T	P	T	P min.	T min.	
<b>Strength (Newton)</b>	A1	379	368	372	280	418	382	367	293	P min. T min.	<140g/m <sup>2</sup> 200 140g/m <sup>2</sup> to 189g/m <sup>2</sup> 700	<140g/m <sup>2</sup> 200 140g/m <sup>2</sup> to 189g/m <sup>2</sup> 400
	A2	461	382	465	356	467	380	461	343			
	B1	359	347	408	324	425	312	354	301			
	B2	401	372	370	352	428	360	422	330			
	C1	341	318	401	336	406	338	403	319			
	C2	354	279	351	287	385	283	388	297			
<b>Elongation (%)</b>	A1	27	36	26	38	28	35	26	35	-		
	A2	27	40	36	43	26	40	25	35			
	B1	29	35	35	40	28	35	26	38			
	B2	31	44	32	43	31	40	31	40			
	C1	27	39	30	25	29	31	32	45			
	C2	24	31	27	38	24	33	28	35			
<b>Shrinkage (%)</b>	A1	-	-	1	2	1	3	2	3	Max for warp and weft $\pm 2$		
	A2	-	-	2	2	2	3	2	3			
	B1	-	-	2	1	2	1	2	1			
	B2	-	-	1	2	1	1	1	1			
	C1	-	-	1	2	1	3	1	1			

	C2	-	-	2	2	1	1	3	1	
<b>Weight (g/m<sup>2</sup>)</b>	A1	174		173		173		169		<140 - >280
	A2	175		175		174		173		
	B1	138		138		139		138		
	B2	138		139		138		139		
	C1	121		121		122		121		
	C2	107		107		108		108		

*P=warp, T=weft, A1, B1, C1= the Chocolate 4/saddle brown colours of fabric brands A, B and C, A2, B2, C2=the sandy brown colours of fabric brands A, B and C*

### Colourfastness to Washing

After the first wash, no change in colour was observed in fabrics A1, A2, B2, C1 and C2 with average values of 5 on the grey scale (Table 4). Surprisingly, all the fabrics obtained the same average value of 4-5 on the grey scale after the second wash indicating that wash cycle had a slight influence on colour change (Table 4). With regard to third wash, fabrics A2, B2, C1 and C2 had same average values of 4-5 on the grey scale as obtained after the second wash. Fabrics A1 and B1 also obtained same average values of 4 (Table 4).

**Table 4:** Average colour change values for fabric specimens

Fabric Brand	Average colour change values		
	1st Wash	2nd Wash	3rd Wash
A1	5	4-5	4
A2	5	4-5	4-5
B1	4-5	4-5	4
B2	5	4-5	4-5
C1	5	4-5	4-5
C2	5	4-5	4-5

With regard to fastness to staining, after the third wash, almost all the multi-fibre fabric specimens had grey-scale values of 5 for staining indicating no contrast. However, among the fabrics studied, C1 and C2 did not perform very well with regard to staining on nylon and acetate after the first wash as C1 and C2 had values of 3 each on acetate. In terms of staining on nylon after the first wash, C2 had a value of 3, but C1 had a value of 3-4 (Table 5). Fabrics A1 and A2 also had an average value of 3-4 for staining on acetate after the first wash (Table 5).

**Table 5:** Average grey scale values for staining

Staining Fabrics		Wool	Acrylic	Polyester	Nylon	Cotton	Acetate
<b>A1</b>	<b>1st wash</b>	5	5	5	4-5	4-5	3-4
	<b>2nd wash</b>	5	5	4-5	4-5	4-5	4-5
	<b>3rd wash</b>	5	5	5	5	5	5
<b>A2</b>	<b>1st wash</b>	4-5	5	4-5	4-5	4	3-4
	<b>2nd wash</b>	5	5	5	4-5	4-5	4-5
	<b>3rd wash</b>	5	5	5	5	5	5
<b>B1</b>	<b>1st wash</b>	4-5	4-5	4	4-5	4	4
	<b>2nd wash</b>	5	4-5	5	5	5	4-5
	<b>3rd wash</b>	5	5	5	5	5	5
<b>B2</b>	<b>1st wash</b>	4-5	4-5	5	4-5	4	4
	<b>2nd wash</b>	5	5	5	4-5	4-5	4
	<b>3rd wash</b>	4-5	5	5	5	5	5

<b>C1</b>	<b>1st wash</b>	4-5	5	4	3-4	4-5	3
	<b>2nd wash</b>	5	4-5	5	4-5	4-5	4-5
	<b>3rd wash</b>	5	5	5	5	5	5
<b>C2</b>	<b>1st wash</b>	4-5	4-5	4	3	4-5	3
	<b>2nd wash</b>	4-5	5	4-5	4-5	4-5	4-5
	<b>3rd wash</b>	5	5	5	5	5	5

## Discussion

The analysis of variance results in Table 2 indicate significant differences between the number of times of washing and the fabrics strengths. This proves that washing has effect on the strengths of fabrics. Although fabric B in the weft direction experienced decrease in strength with increase in the number of times of washing where the least strength occurred after third washing, it still met the standard requirement for strength indicated in GS 970.[13] For fabric A its strength could not even meet the requirement based on its weight value even before washing (Table 3). The observation made in this current study is similar to what was reported by.[5] Significant differences existed between the number of times of washing and fabrics elongation in the warp direction, but not the weft. In addition, the mean values in Table 3 show differences in elongation with respect to wash cycles indicating washing had effect on the elongation of the fabrics. Generally, the fabric brand B performed best in terms of elongation (Table 3).

In terms of differences between the number of times of washing and the fabrics' weights, no significant difference was found. Research works on the effect of washing cycles on the elongations as well as weights of fabrics seem non-existent so no comparison could be made. However, as evident from this study (Table 3), washing slightly affected the weights of the fabrics as there was a margin of increase and decrease in the weight of the samples as washing progressed with fabric B maintaining a generally stable weight.

With regard to differences between the number of times of washing and shrinkage (Table 2), no significant differences were found. The finding is, however, contrary to [14], who found that repeated laundering affected shrinkage regardless of the detergent and grade of cotton fabric. The differences in their findings and that of the current study may be due to the variation in the structure of fabrics used. The current study used woven fabric structures, but in they used knitted fabrics. In addition, changes were observed in the dimensions of fabrics due to laundering [6], which is also at variance with what is found in this study. It must however be noted that even though differences observed in the mean values presented in Table 3 were not statistically significant, fabric brand B consistently maintained its dimension of 1% - 2% throughout the wash cycles.

With regard to colour change of the fabrics, in general, it was observed that minimal differences existed between the number of times of washing. This finding is similar to [15] who found marginal differences between wash and light fastness of the fabrics they studied. The grey scale values obtained by the fabrics in the current study in all the wash cycles, however, are acceptable and indicate that all the fabrics would perform well in terms of colourfastness during use. The finding is similar to a study which found excellent colourfastness to washing for knitted fabrics.[14]

For the staining properties of the fabric samples, there was a minimal amount of staining on the undyed multi-fibre fabric attached to the specimens before washing. However, generally, not much difference existed between the number of times of washing and the staining properties of the fabrics. All the fabrics had acceptable staining values on the fibres indicated on the multi-fibre fabrics, showing they would perform satisfactorily in terms of staining during use. This outcome is similar to what was noted by [16], that staining properties of the uniform fabrics they studied were very good.

## Conclusion And Recommendations

Washing has effect on the fabric samples and the degree of effect varied base on the attribute investigated as well as the fabric brand. However, from the results of all the parameters studied, the fabric brand B was noted to perform best among the three samples investigated. For instance, throughout the wash cycles, the strength values of brand B were above the standard requirements set in the GS 970 [13] of the Ghana Standards Authority.

Since washing has effects on the fabric samples performance attributes, consumers should pay attention to the care requirements of fabrics during selection for specific end-use. The fabric brand B is suggested for

use as school uniform fabric. School uniforms go through a number of washes during use and require the application of strong fabrics that are able to maintain their weights and dimensions. Further studies can be conducted on these same fabrics where the number of washes can be increased to establish a better performance and parameters such as absorbency and abrasion resistance can be evaluated as well.

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