Volume 5, Issue 5, 2022 ISSN: 2617-9938
DOI: https://doi.org/10.31058/j.ad.2022.55001

ITS

Washing Cycles of GTP and ATL Wax Prints (Indigo) With Detergents in Ghana: Appraisal of Tensile Strength

Grace Commey[1*], Mavis Koranteng[2], Victoria Doris Amankrah[1]

[1] Department of Technical and Vocational Education and Training, Komenda College of Education, Komenda, Ghana
[2] Department of Technical and Vocational Education and Training, Our Lady of Apostles College of Education, Cape Coast, Ghana

Email Address

bordohlity@yahoo.co.uk (Grace Commey)
*Correspondence: bordohlity@yahoo.co.uk

Received: 9 April 2022**; Accepted:** 8 July 2022**; Published:** 14 August 2022

Abstract:

The study examined the tensile and colour strength of GTP and ATL wax prints (Indigo) after washing with the selected detergents. Ghana Text style Print (GTP) and Akosombo Textile Limited (ATL) fabrics were selected on the basis that both are real wax products and are produced using wax printing techniques. Purposive and random sampling techniques were employed for the study. Purposive sampling procedure was used in selecting the detergents and fabrics for the study. A total of 146 specimens were cut randomly from along the warp and weft direction of the grain of GTP and ATL cotton fabrics selected. The data for the study were collected through the use of laboratory experiment. Weighing scale T*L/A12/WGS/ (Adam equipment) was used to weigh specimens and detergents before washing because the weights of the fabric determine the amount of soap solution to put into each canister before washing. Microsoft Excel (2007) version and one-way analysis of variance (ANOVA) were used to analyse the study. The was used to guide the study. The study concluded that, Noncompliance with the standardisation of detergents cause excessive colour bleeding and loss of tensile strength as fabrics are subjected to washing. It is recommended that the Ghana Standards Authority should ensure that detergents on the local market meet the standard chemical specifications of washing detergents. This will help to protect consumers by reducing the degrading effect of the detergents on their wax prints, as well as increasing the durability of their fabrics. It is also recommended that the Ghana Standards Authority could also publish the names of detergents which do not meet their chemical specifications to deter people from patronising their products.

Keywords:

Washing Cycles, Detergents, Tensile Strength, Wax Prints

1. Introduction

Enzymes are catalysts which speed up chemical reactions without themselves becoming consumed in the process. Enzymes have played an important role in many aspects of life since the dawn of time. In fact, they are vitally important to the existence of life itself. Modernization has used enzymes for thousands of years without understanding what they were or how they work. Over the past several generations, science has unlocked the mystery of enzymes and has applied this knowledge to make better use of these amazing substances in an ever-growing number of applications [1]. Enzymes play crucial roles in producing the food we eat, the clothes we wear, even in producing fuel for our automobiles. Enzymes are also important in reducing both energy consumption and environmental pollution.

Laundry detergents contain enzymes. Certain molecules of the stain latch onto the active site of an enzyme as the molecule into smaller sections that may be more easily dissolved [2]. Enzymes as proteins that act as biological catalyst and are involved in virtually all reaction taking place in living cells. Each enzyme has a specific role to play, and its structure reflects the way in which it must interact with the substrate [3]. The original idea of using enzyme as detergents was described in 1913 by Dr. Otto Rohm, who patented the use of crude pancreatic extracts in laundry pre-soak compositions to improve the removal of biological stains. In the same year, the first enzymatic detergent named Burnus was launched, but was not popular because of its own limitations. Subsequently, Bio 40 - a detergent containing a bacterial protease was produced in Switzerland, and this was launched in the market in 1959 and it gradually became popular [3]. Enzyme applications in detergents began in the early 1930s with the use of pancreatic enzymes in presoak solutions [4].

In the period from 1965 to 1970, the use and sale of detergent enzymes grew very fast. In 1970, the use was distorted due to dust production by formulations, leading to allergies to some workers. This problem was overcome in 1975 by encapsulating the granules of enzymes. Between 1980s and 1990s, several changes took place in the detergents and these include development of softening through the wash, development of concentrated heavy-duty power detergents, development of concentrated or structured or non-aqueous liquid detergent [1]. Enzymes have been used to improve the cleaning efficiency of detergents for more than 35 years, and are now well accepted as ingredients in powder and liquid detergents, stain removers'/laundry pre-spotters, automatic dishwashing detergents and industrial/institutional cleaning products. Detergent enzymes account for about 30 percent of the total worldwide enzyme production and represent one of the largest and most successful applications of modern industrial biotechnology. The largest segment within the global industrial enzyme market is the market for technical enzymes, estimated at around US 980 million dollars in 2002. In the technical enzymes category, detergents additives make up for nearly two-thirds of the market population. These enzymes are used as functional ingredients in laundry detergents and automated dishwashing detergents [5].

Enzymes can perform two main roles in a laundry detergent. They make effective stain removal, and provide colour and fabric care [6]. Enzymes break down large molecules such as proteins, carbohydrates and fats into smaller segments. These smaller segments are either water-soluble or are of size and polarity compatible with surfactants, meaning that they can be suspended in solution. So, only a small amount of an enzyme is required in the laundry detergent formulation because the enzyme can work over and over again. However, this does not mean that the same detergent solution can be used again and again for many washes [7].

Although enzymes may remain active, the finite amounts of other key ingredients limit the amount of soil that can be suspended in solution by each detergent dose.

Different enzymes are able to break down different types of stains. Some enzymes degrade protein stains (such as blood, dairy products, eggs, meat, mud, and grass) into smaller units called "peptides". Other enzymes degrade carbohydrates (such as potato, pasta and rice) into smaller molecules called "oligosaccharides" or "monosaccharides". Others degrade fats (or "lipids") such as butter and oil. Whatever the type of stain, after its enzymatic breakdown, surfactants suspend the resulting fragments in solution. Some enzymes act to smoothen cotton fabrics by cleaving fibres that protrude from the surface. A smoother cotton surface means that soils are less readily taken up by fibres, and are more easily liberated. Enzymes can also help remove fuzz and pills and can assist colour protection of fabrics. The most commonly used enzymes are proteases (break down protein), amylases (break down starch - a type of carbohydrate) and lipases (break down fats). Enzymes are used in cleaning products as cleaning and fabric care agents. Most of the used enzyme types break down large, water-insoluble soils and stains which are attached to fabrics into smaller, more water-soluble pieces. Subsequently, the smaller molecules are removed from the fabric by the mechanical action of the washing machine, or by the interaction of other detergent ingredients. The enzyme does not lose its functionality after having worked on one stain and continues to work on the next one.

Some enzymes also deliver fabric care benefits, for example, better maintaining whiteness or keeping colours bright. The most important reasons to use enzymes in detergents are:

a. A very small quantity of inexhaustible bio-catalysts can replace very large quantity of man-made chemicals.

b. Enzymes work at very low temperature at which traditional chemistry quite often is no longer effective and they are fully biodegradable.

All these characteristics make enzymes environmentally friendly ingredients on top of their high efficiency.

Tensile strength is the greatest longitudinal stress a fabric can bear without tearing. A high tensile strength is essential for durable, reliable and safe press fabric operation on the paper machine [8]. Tensile strength determines the breaking strength and elongation of textile fabrics and is usually expressed as force per unit cross-sectional area. Tensile strength is a basic indicator of relative strength. It is fundamental for architectural fabrics that function primarily in tension.

Tear strength is important in that if a fabric ruptures in place, it generally will do so by tearing. This can occur when a local stress concentration or local damage results in the failure of one yarn, which thereby increases the stress on remaining yarns. Adhesion strength is a measure of the strength of the bond between the base material and coating or film laminate that protects it. It is useful for evaluating the strength of welded joints for connecting strips of fabric into fabricated assembly [9]. Complex actions of laundering are expected to cause degradation of fabric performance and changes in tensile strength which is a good indicator of degradation [10]. The tenacity of all fabrics becomes lower, especially in the warp direction of the crease resistant treated fabric, as the number of laundering cycles increase. The warp direction exhibits higher strength than the weft direction. This is usually the case for most fabrics as the warp yarns are required to be stronger. Therefore, tensile strength is a measurement of the ability of a yarn to resist breakage under the action of an applied force [11].

Cotton is the most widely used fibre as it is excellent for a multitude of purposes. Cotton fabrics may be inexpensive as the fibre is comparatively low in price. It offers good wearing qualities and has universal consumer acceptance [12]. The Ghanaian ATL and GTP wax cotton printed fabrics have universal acceptance among Ghanaian, for the very fact that they are made from cotton fabrics, and cotton does well in the Ghanaian weather condition. Consumers wash their garments often because of sweat combined with dirt from the atmosphere [13]. The periodic washing of fabrics calls for the use of detergent. A study into the effect of thread type, stitch density and washing cycle on seam strength, efficiency and elongation of Ghanaian real wax cotton printed fabric and concluded that the overall performance of a seam direction in the fabric depended on its stitch density and the number of washes the garment will receive [14].

A study on Physical Properties of Fabrics: Chemical Compositions of Selected Detergents on Colourfastness of GTP Wax Print and ATL Wax Print (Indigo) in Ghana published in Journal of Art and Design revealed that the two wax prints performed better with Omo multiactive than with Ariel enzymax. This was attributed to the differences in the chemical compositions of the two detergents. The implication is that similarities in the physical properties of fabrics are more likely to result in similar degrading effect when they are subjected to same or similar stress [15]. The study examined the tensile strength of GTP and ATL wax prints (Indigo) after washing with the selected detergents as well as comparing the effects of the selected washing detergents on GTP and ATL wax prints in terms of colour strength.

2. Theoretical Framework

The study adopted the failure theories of materials which are made up of the following, tresca or maximum shear stress theories, maximum normal stress theory, and maximum strain-energy theory. All he theories indicate that when a material is subjected to increasing loads, it eventually fails. The failure theory is the science of predicting the conditions under which materials fail under the action of external loads. Material failure is the loss of load-carrying capacity of a material unit. However, the failure of the materials depends on conditions such as temperature, state of stress, and loading rate. The failure theories are made up of four different theories which are presented as follows:

Tresca or Maximum Shear Stress Theory of material failure: The theory was propounded by Tresca in 1868 and states that failure occurs when the maximum shear stress in the component being designed equals the maximum shear stress in a uniaxial tensile test at the yield stress [16]. The theory assumes that a portion of material subjected to any combination of loads will fail by yielding or fracturing whenever the maximum shear stress exceeds a critical value. Yielding will occur when the maximum shear stress reaches that which caused yielding in a simple tension test.

Maximum Normal Stress Theory: This theory states that failure will occur in materials if the maximum normal stress exceeds the normal strength of the material as determined by tensile testing. This is the most commonly used of the strength equations. Failure will occur when the magnitude of the major principal stress reaches that which caused fracture in a simple tension test. The theory states that a material will fail when the maximum principal stress exceeds some value, independent of whether other components of the stress tensor are present. Experiments in uniaxial tension and torsion have corroborated this assumption [17]

Maximum Strain-Energy Theory: the theory indicates that material failure will occur when the total strain energy in a glioeven volume is greater than, or exceeds the strain energy in the same volume corresponding to the yield strength in tension.

3. Methods

Ghana Text style Print (GTP) and Akosombo Textile Limited (ATL) fabrics were selected on the basis that both are real wax products and are produced using wax printing techniques. Purposive and random sampling techniques were employed for the study. Purposive sampling procedure was used in selecting the detergents and fabrics for the study. A total of 146 specimens were cut randomly from along the warp and weft direction of the grain of GTP and ATL cotton fabrics selected. The data for the study were collected through the use of laboratory experiment. Weighing scale T*L/A12/WGS/ (Adam equipment) was used to weigh specimens and detergents before washing because the weights of the fabric determine the amount of soap solution to put into each canister before washing.

The specimens were washed in a standardised detergent solution explained earlier. This measurement was used for all the detergents and for all the washing cycles. The detergents solutions were pre-heated in a water bath to adjust the temperatures to within + 2°C of the specified temperature and also to aid the dissolution of the detergents particles uniformly in the water. The launderometer was pre-heated 30 minutes before each washing began to set the launderometer to the right temperature. The specimens were put in the canister (3 specimens to 1 canister) and 400L of detergent solution was poured into each canister containing three specimens, as used by Ghana Standards Authority. The container was closed and the launderometer was operated under temperature for different specified time (that is, 30, 60 and 90 minutes.) The specimens were removed at the end of each washing cycle, rinsed in 2 litre of ISO Grade 3 water for one minute and again, in running cold water for one minute, to remove any traces of the wash liquor, and to ensure equal treatment of the pieces. Excess water was squeezed out of the specimens and dried indoors at temperature not exceeding 60°C. For colourfastness, all excess water was extracted from the composite specimen.

The breaking strength of each of the washed specimen was tested according to GS ISO 13934-1 (current standard used by Ghana Standards Authority) using the strip method. The instrument used was the Universal Tensile Testing machine (Hounsfield H5K-S). With this method, the full length of the test specimen was clamped centrally so that its longitudinal centre-line passed through the central point of the jaws of the tensile testing machine securely. This machine had a means of indicating and recording the force applied to the test specimen. The movable clamp was switched in motion and extended to the point of rupture of the test specimen, and the maximum force was recorded at rupture. The tensile strength was measured in kilogram per force (kgf) with a gauge length of 200mm at a speed of 100mm per minute. The results for test specimen which ruptured in the jaws (jaw breaks) of the tensile testing machine were indicated and recorded as error which was not included in the analysis because it recorded a very low figure.

The ISO Grey Scale was used to establish colour change as a result of the washing. This test was implemented by visually rating the contrast between the unwashed and washed specimens (after each washing cycle) using the rating established by the ISO Grey Scale. This scale consists of paired chips varying from light to dark grey that represent a progressive difference in colour. Treated and untreated (control) specimens were placed side by side. Afterwards, the grey mask was placed over the specimens to prevent any influences. To ascertain the validity of the result, four observers compared the visual colour change between the treated and untreated (control) specimens with the colour changes represented by the Grey Scale. A grade of 3/4, 4, 4/5, 5 represents no perceived colour change while a grade of 1, 1/2, represents the most colour changes. The grades were recorded by the researcher for statistical analysis. The result of each treated specimen observed was compared to the standards (GS 126) set by Ghana Standards Authority for cycle of washing.

In determining the weight, count and weave of the fabrics, each fabric was folded into two equal parts and weighed separately on the weighing scale. The result recorded was multiplied by the area of the specimen (0.015m2). GTP weighed 114g/M2 against 128g/M2 for ATL. Ten specimens, five each for ATL and GTP, were used. Two specimens were needed for the yarn count, (one each for both fabrics). This was determined by two methods. The first method was done by counting frayed yarns to determine the number of warp yarns and filling yarns in a square inche of fabric. For validity, the second method which is by the use of pick glass was employed. A quarter inche square was mounted on a small stand with a square opening in its base. Through the opening of a magnifying glass, warp and filling yarns were counted. The number of yarns counted for each direction was multiplied by 4, which gave the number of yarns in 1 inch square of the fabric. GTP warp threads were 81 with 63 weft threads while ATL had 82 warp and weft of 64.

It was established that both specimens had plain weave (calico/tabby weave). Plain weave is the simplest of all weaves in which the filling threads pass over and under successive warp threads and repeat the same pattern with alternate threads in the following row, producing a chequered surface. Two specimens were used for each fabric in determining the weave. Microsoft Excel (2007) version was used to analyse the results. The one-way analysis of variance (ANOVA) was used to guide the study. ANOVA was used because the study tested for significant differences among three variables (three washing cycles) with Ariel enzymax.

4. Results and Discussions

4.1. Effect of Ariel Enzymax on the Colourfastness of GTP and ATL Wax Prints

This section focuses on the effect of the second detergent, Ariel enzymax, on the colourfastness of GTP and ATL wax prints after undergoing three washing cycles. The results are presented in Table 1.

Table 1. *Effect of Ariel Enzymax on the Colourfastness of GTP and ATL Wax Prints.*

	Mean Colourfastness of wax prints after three washing cycle Control			
Wax Prints	30 minutes	60 minutes	90 minutes	
GTP	4-5	4	4	4-5
ATL	4	4	3-4	4-5

Source: Laboratory results, 2011

An examination of the data in Table 1 shows that GTP maintained its original colourfastness of 4-5 after the first washing cycle with Ariel enzymax. This implies that the colourfastness of the GTP wax prints was reduced between the first and second washing cycle and the mean colourfastness of the GTP wax prints after the 90 minutes of washing with Ariel enzymax was 4. Therefore, GTP wax prints maintained their colourfastness between the second and third washing cycles with Ariel enzymax.

The ATL wax prints maintained their colourfastness between the first and second washing cycles of 4 on the Grey Scale and that of the ATL wax prints was 3-4 on the Grey Scale, which shows a reduction in colour. The mean colourfastness of the ATL fabrics measured 4 on the Grey Scale after the second washing cycle with Ariel enzymax.

The mean colourfastness of both GTP and ATL wax prints was 4. The results show that the colourfastness of both GTP and ATL wax prints reduces as they undergo more and more washing with Ariel enzymax. This agrees with previous study that as materials are subjected to more and more strain and stress, their qualities and performance begin to fail [17].

Table 1 shows that both GTP and ATL wax prints passed the colourfastness test as they both had the minimum test of 3-4 on the Grey Scale after the three washing cycles with Ariel enzymax. The results also show that there were no marked differences in colourfastness between GTP and ATL wax prints after undergoing three washing cycles with Ariel enzyme. This may, again, be attributed to the similar characteristics of the two wax prints in terms of their cotton properties, weave types, yarn counts and dye types.

ANOVA was, again, used to assess whether there was not statistically significant difference between the recorded colourfastness of GTP and ATL wax prints after undergoing three washing cycles with Ariel enzymax. According to the results, a p-value of 0.35 means that there was no significant difference between the colourfastness of GTP and ATL wax prints after undergoing three washing cycles with Ariel enzymax at an alpha value of 0.05. The meaning is that the mean colourfastness of the GTP wax prints after the three washing cycles was not significantly different from that of the ATL wax prints after undergoing three washing cycles with Ariel enzymax. This may be attributed to the little difference in the physical properties of the two wax prints in terms of their thread count at the warp and weft directions. It was expected that a significant difference should exist in the physical properties between the two fabrics before significant differences could be established between the colourfastness after undergoing the failure test. This means that Ariel enzymax detergent has similar effect on both GTP and ATL wax prints during washing.

4.2. Comparison between Ariel Enzymax and Omo Multiactive on their Effect on the Colourfastness of GTP and ATL

This section compares the effect of Ariel Enzymax with Omo multiactive on the colourfastness of GTP and ATL fabrics. The aim was to find out which of the detergents had more abrasive effect on the wax prints. The results are presented in Table 2.

From Table 2, even though both fabrics passed the colourfastness test after undergoing three washing cycles with each detergent, Omo multiactive had more abrasive effect on the fabrics than Ariel enzymax. Thus, the fabrics lost more colour undergoing washing with Omo than Ariel. This is shown after GTP underwent the third washing cycle with both detergents. After the third washing cycle, GTP recorded a mean coloufastness score of 3-4 units on the Grey scale with Omo multiactive, and 4 units on the Grey scale with Ariel enzymax.

Table 2. *Comparison between Omo Multiactive and Ariel Enzymax on their effect on the Colourfastness of GTP and ATL.*

Detergent	Wax Prints	Mean Colourfastness of wax prints after Control three washing cycles Prints			
		30 minutes	60 minutes	90 minutes	
	GTP	4-5	4	3-4	4-5
Omo	ATL	4	4	3-4	4-5
	GTP	4-5	4	4	4-5
Ariel	ATL	4	4	3-4	4-5

Source: Laboratory Results, 2011

However, the colourfastness scores of the two fabrics were the same for both detergents in all the other washing cycles.

4.3. Effect of Detergents on the Tensile Strength of GTP and ATL Wax Prints after Washing

Researchers argued that laundering is expected to reduce the performance of textile fabrics and cause changes in their tensile strength [10]. Tensile strength is the greatest longitudinal stress a fabric can bear without tearing [8]. A high tensile strength of a fabric is an indication of its durability, reliability and its relative strength. Again, it determines the breaking strength and elongation of textile fabrics. This implies that the tensile strength of textile fabrics is critical in determining their quality. It is therefore critical that these qualities are factored into the manufacturing process of textile fabrics. This section assesses the effect of detergents (Omo multiactive and Ariel enzymax) on the tensile strength of GTP and ATL wax prints after three washing cycles. The results are presented in Table 3.

Table 3. *Effect of Omo Multiactive on the Tensile Strength of GTP and ATL Wax Prints.*

Wax print	Yarn direction	Mean tensile strength of wax prints over the Control three washing cycles			
		30 minutes	60 minutes	90 minutes	
GTP	Warp	41.9	37.9	35.7	44.8
	Weft	33.8	26.8	26.8	34.3
ATL	Warp	49.6	45.4	34.4	50.7
	Weft	33.4	29.9	26.2	37.5

Source: Laboratory Results, 2011

Table 3 depicts the mean tensile strength of GTP wax prints at the warp direction before washing was 44.8 (control) whereas that of the weft yarn direction was 34.3. The control represents the untreated specimen. After the first washing cycles with Omo multiactive, the tensile strength of GTP at the warp direction reduced to 41.9, whereas that of the weft direction reduced to 33.8. The mean tensile strength of the GTP wax prints at the warp yarn direction after 60 minutes of washing with Omo multiactive was 37.9, and that of the weft yarn direction was 26.8. After washing the GTP wax prints for 90 minutes, the mean tensile strength at the warp yarn direction was 35.7, and that of the weft yarn direction was 26.8. The mean tensile strength at the weft yarn direction of the GTP wax prints between the second and third washing cycles were the same. However, the trend in the warp yarn direction of the GTP wax prints conforms to the failure theory that as materials are subjected to more and more strain and stress, their qualities and performance begin to fail [17].

Table 3 again reveals that the mean tensile strength of the ATL wax prints at the warp yarn direction before washing was 50.7, whilst that of the weft yarn direction was 37.5. This confirms to the assertion by Joseph (1986) that the warp yarn direction of textile fabrics is the strongest part. However, after washing the ATL wax prints with Omo multiactive for 30 minutes, the mean tensile strength at the warp yarn direction reduced from 50.7 to 49.6, whereas that of the weft yarn direction reduced from 37.5 to 33.4. The mean tensile strength of the ATL wax prints at the warp yarn direction reduced to 45.4, whereas that of the weft yarn direction reduced to 29.9 after 60 minutes of washing with Omo multiactive. After the third washing cycle with Omo multiactive, the mean tensile strength of the ATL wax prints at the warp yarn direction was 34.4, and that of the weft yarn direction was 26.2.

Further examination of the data in Table 2 indicates that the mean tensile strength of the original ATL wax prints at both the warp and weft directions was higher than that of the original GTP wax prints. The data in Table 2 imply that the original strength of the ATL wax prints was greater than that of the GTP wax prints. The results deviate from the failure theory which states that as a material is subjected to more and more strain and stress, its tensile strength reduces. This could be attributed to the non-treatment of the edges of the specimen's prints after cutting. In other words, where the yarns at the edges of a particular fabric are loose due to the non-treatment, their tensile strength is likely to be low. Conditions at the edges of the tested specimen are therefore critical in uniaxial testing.

Figure 1 shows the extent of tensile strengh in the two wax prints at the various washing cycles with Omo multiactive.

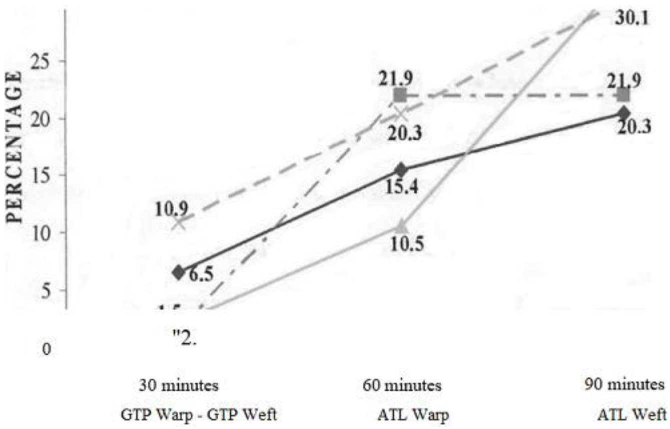

Figure 1. *Loss of strength in wax prints over three washing cycles with Omo multiactive.*

Source: Laboratory Results, 2011

From Figure 1, it can be observed that there was a 6.5 percent loss of strength in GTP warp yarns after washing with Omo multiactive for 30 minutes, whereas that of the ATL was 2.2 percent. On the other hand, there was a 1.5 percent loss of the strength in GTP weft yarns after washing with Omo multiactive for 30 minutes, whilst that of the ATL was 10.9 percent. This implies that there was a greater loss of strength in the GTP warp yarns at the first washing cycle than it was in the ATL warp yarns. However, there was a greater loss of strength in the ATL weft yarns than that of the GTP weft yarns for the same washing cycle, and this can be attributed to fabric unbalance. After the second washing cycle with Omo multiactive, there was a 15.4 percent loss of strength in the GTP warp yarns, whilst there was a 10.5 percent loss of strength in the ATL warp yarns. In addition, the weft yarns of GTP lost an average of

21.9 percent tensile strength after undergoing washing with Omo multiactive for 60 minutes, whereas the ATL weft yarns lost an average of 20.3 percent. These imply that the warp directions of both wax prints performed better than the weft directions. Thus, there was less loss of strength at the warp direction in both wax prints than at the weft direction. This finding agrees with previous study that the warp yarns of fabrics are the strongest part, owing to the greater number of thread counts at the warp yarn direction than that of the weft yarn direction [12]. Balance is the ration of warp yarns to filling in threads in a fabric. Therefore, when the ration is not even, then the fabric is said to be unbalanced. When any yarn ravels during washing, it can affect the balance of that fabric in terms of warp/weft. Again, during washing, some of the yarns/threads in the fabric can be removed, which can reduce the breaking strength of fabric [18].

Similarly, there was greater loss of strength in the GTP wax prints at both warp and weft yarn directions than in the ATL wax prints at the second washing cycle. This could be attributed to the differences in the physical properties of the two wax prints [9]. The average weight and thread count (in both warp and weft yarns) of the ATL wax prints were higher than those of the GTP. Thus, the greater the number of thread counts or weight of a particular fabric, the more it can resist any external force to increase its tensile strength and vice versa [10].

After washing both wax prints with Omo multiactive for 90 minutes, there was a 20.3 percent loss of strength in the GTP warp yarns, whereas those of the ATL warp yarns was 32.2 percent. On the other hand, the GTP weft yarns lost an average of 21.9 percent, while the ATL weft yarns lost an average tensile strength of 30.1 percent after the third washing cycle with Omo multiactive. The results imply that there was a mixed performance between the warp and weft yarns of the two wax prints. Thus, after washing both wax prints for 90 minutes with Omo multiactive, the warp yarns of GTP lost less tensile strength than the weft yarns. However, the warp yarns of ATL lost greater tensile strength than the weft yarns. This could be attributed to the non-treatment of the edges of the specimens and fraying of specimens during washing. In addition, the GTP wax prints performed better in terms of resisting tensional stretch than the ATL wax prints after undergoing washing with Omo multiactive for 90 minutes. Thus, there was a smaller loss of strength in both the warp and weft yarns of GTP than that of the ATL wax prints. This contradicts the assertion of previous study that the greater the number of thread counts and the weight, the better the performance of the fabric, and vice versa [9].

4.4. Testing Significance Difference in Tensile Strength (warp) between GTP and ATL Wax Prints after Three Washing Cycles with Omo Multiactive

This section assesses whether there was a significant difference in the tensile strength between GTP wax print and ATL wax print in the warp yarn direction after undergoing three washing cycles with Omo multiactive. Thus, the section examines whether the recorded differences between GTP and ATL were statistically significant. The results are presented in Table 4.

The result represents a p-value of 0.4 which implies that the observed differences between GTP wax print and ATL wax print at the warp direction were not statistically significant at an alpha value of 0.05. The implication is that Omo multiactive detergent has a similar effect on the tensile strength at the warp direction of the two wax prints. This could be attributed to the fact that there was little difference in the physical properties between the two wax prints, an example is it absorbency.

Table 4. *A One-way Analysis of Variance in Tensile Strength (warp) between GTP and ATL Wax Washing Cycles with Omo Multiactive.*

Source of Variation	Sum of squares	Df	Mean of squares	F	P-value	F crit
Between Groups	32.2	1	32.2	0.9	0.4	7.71
Within Groups	143	4	35.8			
TOTAL	**175.2**	**5**				

Source: Laboratory Results, 2011

4.5. Testing Significance Difference in Tensile Strength (weft) between GTP and ATL Wax Prints after Three Washing Cycles with Omo Multiactive

This section assesses whether there was a significant difference in the tensile strength between the weft yarns of GTP and that of the ATL after undergoing three washing cycles with Omo multiactive detergent. Table 5 presents the results.

Table 5. *A One-way Analysis of Variance in Tensile Strength (weft) between GTP and ATL Wax Prints after Undergoing Three Washing Cycles with Omo Multiactive.*

Source of Variation	Sum of Squares	df	Mean of squares	F	P-value	F crit
Between Groups	0.74	1	0.7	0.05	0.83	7.7
Within Groups	58.6	4	14.7			
TOTAL	**59.3**	**5**	**15.4**	**0.05**	**0.83**	**7.7**

From Table 5 a p-value of 0.83 implies that there was no significant difference in the tensile strength at the weft yarn direction between GTP and ATL wax prints. This implies that the observed differences between GTP and ATL at the weft yarn direction were not statistically significant. The implication is that Omo multiactive detergent has similar effects on the weft yarns on the two wax prints. This could be attributed to the similar physical characteristics (in terms of the thread count, weight and weave type) of the two wax prints. The implication is that there should be a significant difference in the physical properties between the two fabrics before significant differences could be established between their tensile strength after undergoing the failure test. Therefore, the FL hypothesis is accepted.

4.6 Effect of Ariel Enzymax on the Tensile Strength of GTP and ATL Wax Prints after Three Washing Cycles

This section assesses the effect of Ariel enzymax on the tensile strength of GTP and ATL wax prints after three washing cycles. It includes the effect at both the warp and weft yarn directions of the two wax prints. The results are presented in Table 6.

Table 6. *Effect of Ariel Enzymax on the Tensile Strength of GTP and ATL.*

Wax print	Yarn	Mean tensile strength of wax prints over the Control			
		30 minutes	60 minutes	90 minutes	
GTP	Warp	40	35.2	27.7	44.8
	Weft	28.3	25.8	23.4	34.3
ATL	Warp	42.4	35.8	28.7	50.7
	Weft	27.5	26.2	22.8	37.5

Source: Laboratory Results, 2011

From Table 6, it can be observed that the tensile strength of the GTP wax prints in the warp yarn direction reduced from 44.8 to 40 after 30 minutes of washing with Ariel enzymax detergent and that of weft direction reduced from to 28.3. After washing GTP wax prints with Ariel enzymax for 60 minutes, the tensile strength at the warp yarn direction was 35.2. After the third washing cycle, the mean tensile strength of GTP wax prints at the weft yarn direction was 35.2. The mean tensile strength of GTP in the weft direction was after undergoing washing for 90 minutes with Ariel enzymax,

The tensile strength of ATL wax prints reduced from 37.5 to 27.5 in the weft direction during the 30 minutes of washing with Ariel enzymax detergent while the 60 minutes wash reduced the tensile strength from 37.5 to 26.2. A 90 minute wash with Ariel enzymax also recorded 22.8 in the weft direction and 28.7 in the warp direction of the ATL wax prints. This shows a reduction from 50.7 in the unwashed wax print. ATL wax prints reduced from 50.7 to 42.4 in the warp direction during the 30 minute of washing whereas the 60 minute of washing of ATL wax prints recorded a reduction to 35.8. The tensile strength of GTP wax prints at the warp yarn direction was 27.7, whilst that of the ATL wax prints was 28.7. The trend in the reduction of tensile strength at the warp yarn direction for both the GTP and ATL wax prints conforms to the failure theory that as a material is subjected to more and more strain or stress, its performance in terms of resistance to external forces reduces gradually [19]. In a similar study the strength of fabric tested using key soap revealed that after three washing cycles fabric strength was greater than a majority of stitched seams. Again, the result shows that the warp direction of the fabric had greater strength and linear density as compared to the weft. The mean of squares for warp was 82.458 and that of weft was 1.232. Therefore, based on the two findings, it can be concluded that the warp direction continues to be stronger than that of weft when they are subjected to the same chemical treatment [14].

Trends in the weft directions of both GTP and ATL wax prints conform to the failure theory that as a material is subjected to more and more strain and stress, its resistance reduces gradually until it reaches a breaking point.

Figure 2 shows the loss in tensile strength of both the GTP and ATL wax prints over three washing cycles with Ariel enzymax.

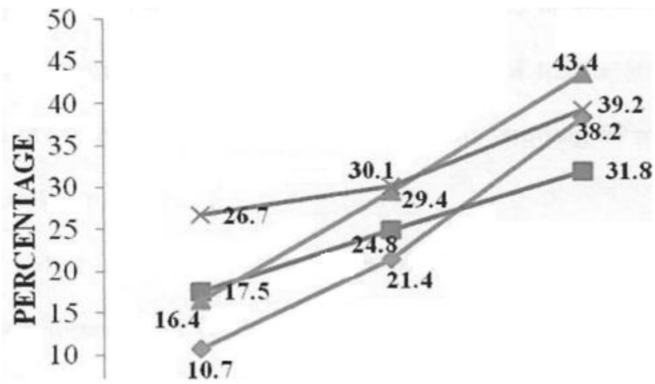

Figure 2. *oss of strength in wax prints over three washing cycles with Ariel.*

Source: Laboratory Results, 2011

From Figure 2, the warp yarns of GTP lost 10.7 percent of their tensile strength after undergoing washing for 30 minutes with Ariel enzymax, while the warp yarns of the ATL wax prints lost 16.4 percent of their tensile strength. On the other hand, the weft yarns of the GTP wax prints lost 17.5 percent of their tensile strength, whereas those of the ATL wax prints lost 26.7 percent of their tensile strength. This implies that there was a greater loss of tensile strength in ATL at both the warp and weft yarn directions than in the GTP wax prints after undergoing 30 minutes of washing with Ariel enzymax.

The tensile strength of GTP wax print in the warp yarn direction was reduced by 21.4 percent, while that of the ATL wax print was reduced by 29.4 percent after undergoing 60-minute washing with Ariel enzymax. Similarly, the tensile strength in the weft yarn direction of GTP wax print was reduced by 24.8 percent, whereas the tensile strength in the ATL wax print weft yarns reduced by 30.1 percent after undergoing 60 minutes of washing with Ariel enzymax. This implies that there was a greater loss of tensile strength in the ATL wax prints than in the GTP wax prints after undergoing 60 minutes of washing with Ariel enzymax.

After undergoing 90 minutes of washing, the tensile strength at the warp yarn direction of GTP wax print reduced by 38.2 percent, whereas that of the ATL wax print reduced by 43.4 percent. On the other hand, the tensile strength in the weft yarns of GTP wax print reduced by 31.8 percent, whereas that of ATL reduced by 39.2 percent. This implies that ATL fabrics lost more tensile strength than GTP fabrics after undergoing 90 minutes of washing with Ariel enzymax.

The above analyses show that GTP fabrics performed better in both the warp and weft yarn directions at all the three washing cycles after undergoing washing with Ariel enzymax. These analyses contradict the assertion that the greater the number of thread counts and the weight, the better the performance of the fabric, and vice versa. The differences may partly be due to the insignificant differences in the physical properties between the two wax prints. The difference again, may also be due to the yarn type used to manufacture each of the wax prints, since different sources of fabric yarns have different qualities and performances [9]. This assertion is supported by earlier study that Yarns may be classified according to length (staple, filament), twist, size, regularity or irregularity along its length and Yarns with high twist create the texture in true crepe apparel and furnishing fabrics, and more importantly enhancing good fibre [18].

4.7. Difference in Tensile Strength (warp) between GTP and ATL Wax Prints after Three Washing Cycles with Ariel Enzymax

In this section an assessment of whether there was a significant difference in the tensile strength between the warp yarns of GTP and that of the ATL after undergoing three washing cycles with Ariel enzymax are presented in Table 7 below.

Table 7. *A One-way Analysis of Variance in Tensile Strength (warp) between GTP and ATL Wax Print after Undergoing Three Washing Cycles with Ariel Enzymax.*

Source of Variation	Sum of squares	Df	Mean of Squares	F	P-value	F crit
Between Groups	2.67	1	2.67	0.06	0.82	7.71
Within Groups	170.75	4	42.69			
TOTAL	**173.41**	**5**	**45.36**	**0.06**	**0.82**	**7.71**

Source: Laboratory Results, 2011

The result indicates a p-value of 0.82 which implies that there was no significant difference in the tensile strength at the warp yarn direction between GTP wax print and ATL wax print after undergoing three washing cycles with Ariel enzymax. The implication is that the observed differences between GTP and ATL wax print at the warp yarn direction were not statistically significant, hence the Ho hypothesis is accepted. In other words, Ariel enzymax has similar effects on the two wax prints. This could be attributed to their similar physical characteristics in terms of their weight, weave type and thread count. This implies that there should be a significant difference in the physical properties between the two fabrics before significant differences could be established between their tensile strength after undergoing failure test.

4.8. Difference in Tensile Strength (weft) between GTP and ATL Wax Prints after Three Washing Cycles with Ariel Enzymax

This section examines whether there was a significant difference in the tensile strength between the warp yarns of GTP and that of the ATL wax prints after undergoing three washing cycles with Ariel enzymax.

Table 8. *A One-way Analysis of Variance in Tensile Strength (weft) between GTP and ATL Wax Prints after Undergoing Three Washing Cycles with Ariel Enzy.*

Source of Variation	Sum of squares	Df	Mean of squares	F	**P**-value
Between Groups	0.17	1	0.17	0.03	0.88
Within Groups	23.79	4	5.95		
TOTAL	**23.95**	**5**	**6.12**	**0.03**	**0.88**

The results in Table 8 indicate a p-value of 0.88 that shows that there was no significant difference in the tensile strength (at the weft direction) between the two wax prints after undergoing three washing cycles with Ariel enzymax at an alpha value of 0.05. This implies that the observed differences between the two wax prints were not statistically significant.

4.9. Comparison between Ariel Enzymax and Omo Multiactive on their Effect on the Tensile Strength of GTP and ATL

This section compares the effect of the two detergents on the colour and tensile strength of the two wax prints. This was aimed at assessing which of the detergents has more degrading effect on any of the two wax prints. Table 9 presents the results.

Table 9. *Comparison between Omo Multiactive and Ariel Enzymax on their Effect in the Loss of Tensile Strength on GTP and ATL.*

			Direction the three washing cycles		
	Wax Prints		30 minutes (%)	60 minutes (%)	90 minutes (%)
		Warp	6.5	15.4	20.3
	GTP	Weft	1.5	21.9	21.9
Omo		Warp	2.2	10.5	32.2
	ATL	Weft	10.9	20.3	30.1
		Warp	10.7	21.4	38.2
	GTP	Weft	17.5	24.8	31.8
Ariel		Warp	16.4	29.4	43.4
	ATL	Weft	26.7	30.1	39.2

Table 9 shows that Ariel enzymax had greater effect on the tensile strength of the two wax prints than Omo multiactive. In other words, the two wax prints performed better in terms of their tensile strength with Omo multiactive than with Ariel enzymax. The implication is that Ariel enzymax had a more degrading effect on the tensile strength of the two wax prints than Omo multiactive. Some of the components of

Ariel enzymax are enzymes, Surfactant Peroxide, Sodium Carbonate and many others, thereby improving the potency of the detergent.

After washing GTP with Omo multiactive for 30 minutes, there was a 6.5 percent and 1.5 percent loss in tensile strength at the warp and weft yarn directions, respectively. Similarly, the ATL wax prints lost 2.2 percent and 10.9 percent of tensile strength in the warp and weft yarn directions, respectively, after undergoing 30 minutes of washing with Omo multiactive. On the other hand, GTP lost 10.7 percent and 17.5 percent in tensile strength at the warp and weft yarn directions, respectively, after undergoing 30 minutes of washing with Ariel enzymax. Furthermore, there were 16.4 percent and 26.7 percent loss of tensile strength in the warp and weft yarn directions of ATL, respectively, after undergoing 30 minutes of washing with Ariel enzymax.

After the second washing cycle with Omo multiactive, there was a 15.4 percent and 21.9 percent loss in tensile strength at the warp and weft yarn directions, respectively, in the GTP wax prints. In addition, the ATL wax prints lost 10.5 percent and 20.3 percent of tensile strength in the warp and weft yarn directions, respectively, after the second washing cycle with Omo multiactive. However, GTP lost 21.4 percent and 24.8 percent in tensile strength at the warp and weft yarn directions, respectively, after the second washing cycle with Ariel enzymax. ATL lost 29.4 percent tensile strength in the warp yarns and 30.1 percent in the weft yarns after undergoing the second washing cycle with Ariel enzymax.

GTP lost an average of 20.3 percent in tensile strength at the warp yarn direction and 21.9 percent at the weft yarn direction after undergoing 90 minutes of washing with Omo multiactive. The ATL wax prints lost an average of 32.2 percent in tensile strength at the warp yarn direction and 30.1 percent at the weft yarn direction after undergoing 90 minutes of washing with Omo multiactive. On the other hand, the GTP wax prints lost an average of 38.2 percent in tensile strength at the warp yarn direction and 31.8 percent at the weft yarn direction after undergoing 90 minutes of washing with Ariel enzymax. After undergoing 90 minutes of washing with Ariel enzymax, the ATL wax prints lost an average of 43.4 percent in tensile strength at the warp yarn direction and 39.2 percent at the weft yarn direction.

The differences between the effect of Omo multiactive and Ariel enzymax on GTP and ATL wax prints after three washing cycles could be attributed to the differences in their chemical compositions. This agrees with previous study that differences in the chemical properties of detergents largely explain differences in their effects on textile fabrics when they undergo washing [20]. The implication is that GTP and ATL wax prints are more able to resist the effect (tensile strength) of Omo multiactive during washing than Ariel enzymax.

5. Conclusions and Recommendations

The study concluded that, Noncompliance with the standardisation of detergents cause excessive colour bleeding and loss of tensile strength as fabrics are subjected to washing. It is recommended that the Ghana Standards Authority should ensure that detergents on the local market meet the standard chemical specifications of washing detergents. This will help to protect consumers by reducing the degrading effect of the detergents on their wax prints, as well as increasing the durability of their fabrics. It is also recommended that the Ghana Standards Authority could also publish the names of detergents which do not meet their chemical specifications to deter people from patronising their products. This will help to ensure that all detergents on the market have a minimal degrading effect on textile fabrics. The Ghana Standards Authority should educate the general public on the effect of non-standardised detergents on textile fabrics. With this, consumers will inspect the logo of the Ghana Standards Authority before procuring any washing detergent. This will help to produce the standardisation of washing detergents among manufacturers who want to sell on the Ghanaian market. Ghana Standards Authority should make it compulsory for the manufacturers of washing detergents to indicate the correct chemical composition of their products on the packages. This will enable consumers to compare the chemical contents of washing detergents and their likely effect. The on their textile fabrics before purchasing a particular detergent. It will also enable manufacturers of detergents to conform to the standard chemical composition of washing detergents.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

References

[1] Enzyme Technical Association. Enzymes: A primer on use and benefits today and tomorrow. Massachusetts: Enzyme Technical Association. 2001.

[2] Don, S.M. Effects of chemical constituents of laundry detergents and methods of stain removal. Available online: http://www.scribd.eom/doc/l 1337847/Laundry-Detergents-and-Stain-Removal (accessed on 24 September 2011)

[3] Housecraft, C.E.; Constable, C.E. Component of Detergents and their Actions. Volume 114, issue 21 - ACS Publications. American Chemical Society. Publication acs.org/HOC/jpcafh/114/12. 2010.

[4] Aehle, W. Enzymes in industry: Production and applications (3rd ed.). 2007.

[5] Mohr, M. The art of soap making: A Harrowsmith contemporary primer. New York: Firefly Books. 1979.

[6] Ramkumar, S.S.; Abdalah, G. Surface characterization of enzyme treated fabrics. *Colourage,* 2001, 48(4), 1-15.

[7] Stalmans, M.; Guhl, W. An introduction to the historical developments of laundry. Belgium: Prentice-Hall. 2003.

[8] Johnson, R.M. Cotton, Biotechnologies Advances. Properties of Cotton. Goggle Book.com.gh/books=1439880573. 2009.

[9] Industrial Fabrics Association International (2008). Award-ILC dover ISO 9001 Overview. ISO 9001 Quality Overview - ILC Dover. Available online: www. ilcdover. com index, cfm ?fuseaction = trees. IreePage (accessed on 19 December 2020).

[10] Shurkian, O.; Amirbayat, J.; Gong, R.H. Effects of Repeated Laundering and Crease-Resistant Treatment on Fabric Properties. *Journal of Textile Engineering,* 2002, 48 (J), 1-4.

[11] Collier, M.A. A handbook of textiles (2nded). New York: Pregamon Press. 2002.

[12] Joseph, M. L Introductory textile science (3rd ed.). New York: Holt. 1988.

[13] Fianu, D.A.G.; Sallah, R.A.; Ayertey, A. The effect of sunlight and drying methods on the strength of Ghanaian Real Wax printed fabrics. *International Journal of Consumer Studies,* 2005, 29 (1), 34-40.

[14] Danquah, A.P. The effect of thread type, stitch density and washing on seam performance of a Ghanaian real wax printed fabric. Unpublished master's thesis. University of Cape Coast, Cape Coast, Ghana. 2010.

[15] Commey, G.; Amankrah, D.V.; Amenya, A. Physical Properties of Fabrics: Chemical Compositions of Selected Detergent on Colourfastness of GTP wax Print and ATL Wax Print 9Indigo) in Ghana. *Journal of Art and Design,* 2021, 1(1), 17-27.

[16] Anand, S.C.; Weisgerber, F.E. Usage of the Tresca yield condition in finite element plane strain analysis. *International Journal of Solids and Structures,* 1978, 14(S), 625-637.

[17] Rankine, W. On the stability of loose earth. *Philosophical Transactions of the Royal Society of London,* 1850, 147, 57-67.

[18] Kadolph S.J.; Langford, A.L. Textiles (8\d.). New Jersey. Prentice Hall, Inc. 1998.

[19] Rhinehart and Winston Joseph, M. L. Introductory textile science (5th ed). Chicago: Holt. 1986.

[20] Toshikj, E.; Mangovska, B. Effect of laundering of cotton knitted, 2011.

[21] Fabrics with different detergents on the dimensional stability and colourfastness. Available online: http://www.fibre2fashion.com/industry-article/36/3525/effect-of-laundering-of-cotton-knitted-fabrics-with-different-detergentsl.asp (accessed on 9 September 2021).

© 2022 by the author(s); licensee International Technology and Science Publications (ITS), this work for open access publication is under the Creative Commons Attribution International License (CC BY 4.0). (http://creativecommons.org/licenses/by/4.0/)