UNIVERSITY OF CAPE COAST

IMPACT OF KEY SOAP WITH LAUNDRY BLUE AND NEW OMO ON GHANAIAN COTTON PRINTED FABRIC

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BY

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Thesis submitted to the Department of Vocational and Technical Education of the Faculty of Science and Technology Education of the College of Education, University of Cape Coast, in partial fulfillment of the requirements for the award of Master of Philosophy degree in Home Economics

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature:.. Date:..........................

Name: Cynthia Agyeiwaa Kusi

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature:.................................. Date:........................

Name: Prof. Modesta Gavor

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Name: …………………………………………………………………………..

ABSTRACT

In the process of cleaning garments, various agents or additives are used such as fabric softeners, spray starch and bluing. The purpose of this study was to determine the effect of key soap with laundry blue as a colour enhancer; and Omo on selected performance properties of 'black and white Ghanaian cotton printed fabrics. With the aid of experimental procedures, the study was carried out using two different types of 'black and white' Ghanaian cotton printed fabrics. The total number of specimens used for the study was 132. The parameters investigated included tensile strength properties, colourfastness to washing and dimensional stability (shrinkage) to washing. The data was analysed using stastistical test tool i.e. multivariate analysis of variance (MANOVA) were used for assessing the interaction effect of factors such as colour, strength, elongation and dimensional stability. Differences were observed with specimens washed with new omo detergent and rinsed in normal water; those that were washed with 'key' soap and rinsed with laundry blue and those that were just washed with laundry blue in terms of strength, elongation, shrinkage, and colourfastness.

KEYWORDS

Fabric

Dimensional Stability

Tensile Strength

Colourfastness

Fabric Performance

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DEDICATION

To my Husband, Desmond Tutu- Atabuatsi, and Children: Neyram, Edinam and Delase. You are my inspiration

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LIST OF ABBREVIATIONS

UCC	University of Cape Coast
ISO	International Standards Organization
GSA	Ghana Standards Authority

CHAPTER ONE

INTRODUCTION

Several chemicals or additives, including fabric softeners, spray starch, and bluing, are used when cleaning clothes. The goal of this study was to ascertain the impact of key soap and Omo on specific performance characteristics of "black and white Ghanaian cotton printed fabrics." The investigation was conducted utilizing two distinct kinds of "black and white" Ghanaian cotton printed fabrics and experimental techniques.

Several researchers (Gangwisch, Trimmer, & Gross, 1973; Mustalish, 2013, Leverette, 2019) have all highlighted the discolouration of certain textiles after repeated use and laundering. Gangwisch, Trimmer, & Gross, explained that in the washing of textiles with detergent compositions which do not contain bluing agents or fluorescent brighteners, the washed clothes often exhibit a yellowish colour, apparently due to materials deposited on or remaining on the articles washed. These residues adsorb blue light. To counteract this effect, bluing agents have been employed either in separate bluing operations or incorporated with the detergent materials.

In effect, a detergent, or soap and a bluing dye are used during the washing of fabrics, and the ‘black and white’ Ghanaian cotton print is of no exception. On this basis, this project experimented with the ‘Omo’ detergent, which contains optical brightening agents and ‘Key’ bar soap (which has no optical brightener), and laundry blue in washing fabric samples and analysed the influence (s) these washing agents may have on the 'black and white' Ghanaian cotton print.

Background to the Study

Cotton's extensive applications and favorable characteristics have led to its widespread use as a textile fiber in the textile industry. During the production of yarn till it becomes a fabric, fibres and undergo different manufacturing process to give it the unique textile properties consumers so desire and to increase its performance during usage. These manufacturing processes in one way or the other contaminate the fabric with impurities such as lubricants, (machine oils), tars, and greases. These impurities give the cotton substrate some hydrophobic properties, which hinders major wet processing like colouration (printing and dyeing) (Dyeing Booklet, 2002).

Many finished goods, especially textiles, need to be exceptionally white in order to be printed, dyed a light or pastel colour, or sold as market white. To prevent fiber degradation, which can cause fabric to yellow or even lose strength, preparation operations must be properly managed. Unsatisfactory process control and/or a low-quality textile substrate can both contribute to poor preparation process results. Additionally, fabric yellowing that occurs during storage could be the result of fiber damage sustained throughout the preparation procedure sequence. Therefore, preparation procedures are essential for optimal textile quality yet frequently ignored (Dyeing Booklet, 2002).

Of all the preparation process, scouring is the single process that seeks to remove most impurities other than the natural colouring matter of the cotton fabric. Scouring is likened to laundering; and most often than not it can be said to be 'industrial laundering'. Both knits and wovens go through the scouring process, which involves washing the cloth to get rid of any impurities. Typically, the only significant contaminant left over after this treatment is the fiber's natural color (Dyeing booklet, 2012). This shows that cleaning to remove impurities is essential in promoting the life spun of a textile substrate. Detergents and alkali are used in the procedure to wash away these contaminants. Oily, greasy liquids and solids can combine with water with the help of detergents, which can then hold them in solution or suspension until they can be thrown away.

The preparation processes discussed above, if not done well will leave a substandard textile substrate mainly characterized by yellowing especially for whites, which becomes evident during storage. Poor performance in many subsequent procedures, particularly dyeing and chemical finishing, is caused by insufficient scouring. Fabric can yellow during storage as a result of residual oils that were left on it. Poor performance of the final product and strained customer relationships may result from this. The protoplasmic remnants of the protein and flavone pigments in cotton flower petals are also connected to the yellowish or brownish color of cotton garments (Afshan, Akter, Sarker, Ferdous, Islam, Sultana, & Rubel, 2019).

Cotton and other natural fibers have a yellowish or brown tint because of impurities, which absorb more light in the visible spectrum's blue area. Bleaching serves the purpose of removing yellow impurities that absorb blue (Afshan, Akter, Sarker, Ferdous, Islam, Sultana, & Rubel, 2019).

According to research by Mustalish (2000), bleaching can be carried out chemically or biologically. Most bleaching agents have some negative effects on fiber; thus, the process should be carried out with the least amount of harm to the cloth being bleached. However, the bleaching process is unable to totally get rid of the fabric's yellowness. When sunlight shines on a chemically bleached fabric that both has an optical brightening agent and a bluing agent, such as Ultramarine Blue, the bluing agent absorbs some of the incident light's yellow rays, making the reflected light deficient in yellow rays. The fabric's lingering yellowish impurities are absorbed.

Lin, Shamey & Hinks, (2012) have said that essentially colorless fluorescent dyes, fluorescent brighteners (FBs) or optical brighteners (OBs) are used to whiten textiles. The textile substrate is treated with FBs if a greater degree of whiteness is necessary or desired, which otherwise would not be attainable by using a bleaching process or using a bluing agent. The development of whiteness is caused by the production of a visible blue light and the absorption of light in the UV band (330–380 nm) (400–450 nm).

Esteves, Noronha, Marinho, (2004); and McElhone, (1995) also explains how Optical brighteners or Flourescent whitening work for the attainment of a pure white fabric. The invisible ultra violet section of the daylight spectrum is absorbed by fluorescent whitening agents (FWAs), which then transform this energy into the longer-wavelength visible region of the spectrum, or into blue to blue-violet light. This can be used to make up for any light that is lost to absorption, giving the cloth a "neutrally" pure white appearance. In most circumstances, the addition of an optical brightener or fluorescent whitening chemical in colored fabrics will intensify the colors.

The depleted blue component of the incident light is replaced by other ways so that the proper balance is restored, providing the white effect, which can be used to rectify the yellowish color of the chemically bleached fabric. This is accomplished by exposing the cotton cloth that has been chemically bleached and additionally treated with a fluorescent brightening agent to sunshine. Short-wavelength light (violet to blue) absorbs, giving clothes a yellow hue (Esteves, Noronha, Marinho, 2004; and McElhone, 1995).

The method of caring for a textile substrate is also important to avoid discoloration. Fabric care involves laundering (washing, drying, pressing) mending, folding, and putting away (storing) clothes and household fabrics. Fabric care helps to save money that would have been used to replace garment ruined through improper care and help to save laundry bills. Also, proper care helps to extend the length of service of the fabric or garment to users (Fabric Link 2006).

Viola & Ahuwan (2016), states that fabric care helps to save money that would have been used to replace garment ruined through improper care and help to save laundry bills. Also, proper care helps to extend the length of service of the garment to users. The most important thing, Kadolph (2014) indicates, a consumer put into consideration when buying and taking care of fabric is how best to reduce or eliminate fading from occurring. Therefore, to avoid wasting money, they tend to go for foreign fabrics which they consider to be colourfast more than Ghanaian made fabric but sometimes the reverse is the case (Kadolph, 2014).

As fabrics are used, dirt, soil, grease, and perspiration from the body all accumulate to make it dirty. It becomes imperative to wash these textile products to remove the dirt and make them clean and safe for use again. The efficacy and effectiveness of fabrics and products may alter during laundry. To determine whether a fabric is suitable, it is important to look at how it performs after laundering (Agrawal, Nierstrasz, Klug - Santner, Gübitz, Lenting & Warmoeskerken, (2007).

The extent to which laundering affects fabric properties therefore has to be analyzed to assist the apparel manufacturers in developing laundering recommendations based on the fabric's performance and in selecting fabrics which will serve their useful purpose to consumer satisfaction (Obiona,2011).

Weber, Lynes & Young (2017) documented again that washing a fabric or garment by hand or by machine with a soil removing product can be described as laundering; whilst Anyakoha and Eluwa, (2010); and Obiona, (2017) add that during washing some other finishing treatments such as bluing, starching and ironing are carried out. They emphasized once more that the client needed to understand the correct way to wash each type of garment and fabric.

Anyakaoha and Eluwa go on to explain that the laundry process involves sorting the items to be washed, mending the items, eliminating all stains from the items, steeping or soaking white cotton or colorfast items, washing the items according to fabric types, rinsing the washed items, boiling the items if necessary, applying blue and/or starch if necessary, drying the items, ironing, or finishing the laundered items, airing the finished items, and finishing.

Cleaning clothes and fabrics is aided by laundry detergent. Laundering agents, according to Anyakoha and Eluwa (2010), are compounds that assist in the removal of dirt during washing. Solvents, detergents, alkalis, acids, bleaches, softeners, fragrances, and bluing agents are a few of them. Rubbing or friction, kneading and squeezing, squeezing alone, and kneading alone are all methods of cleaning textiles. Following cleaning, the cloth can receive an optional finishing treatment such as blueing, stiffening, or softening. Anyakoha and Eluwa (2010) further pointed out that stiffening agents include various laundry starches, including hot water starch, cold water starch, spray or aerosol starches: glue and gum arabic. Stiffening chemicals are used in laundry to provide cotton and linen garments a smooth surface, a fresh appearance, and the ability to maintain cleanliness for longer periods of time.

Home washing can be compared to a moderate scouring process that is frequently carried out in machines that, despite being smaller, have a design that is similar to that of those used for processing component goods in the textile industry. Whether used to prepare gray goods or wash off coloured and completed items, the physical and chemical impacts of such a process often do not raise any red flags. However, the cumulative effects of doing the procedure anywhere between 25 and 50 times in the first year of use may adversely harm some textiles (Bishop,1995).

According to Bishop, examining these long-term consequences is expensive and typically not included in the quality control practices used by textile producers or merchants. However, a greater understanding of the impacts of frequent domestic washing and of customer concerns over the care of washable textiles may pay off in terms of improving the perceived quality of clothing, for little to no additional cost in manufacturing.

Bishop (1995) emphasizes once more that producers of fabric washing products have consistently tried to construct their goods within the limitations imposed by textile substrates. No matter how effective a product's cleaning abilities, it is obvious that any product that is shown to harm textiles will be derided by consumer organizations and rejected by consumers. Products that have the potential to cause injury have the necessary warning labels because of this. For instance, brands that use proteolytic enzymes typically advise customers against soaking wool or silk clothing.

Esteves, Noronha, & Marinho, (2004) went further to give an account of the cycle of laundering of textile fabrics: The bleach's effects start to fade once the fabric is used. When dirt and stains damage the color, the fabric is washed to remove them. Additionally, optical brighteners are frequently included in the washing agents and commercial detergents that are currently on the market, and as a result, the fabric becomes whiter while being washed. When laundry is machine-washed, fabric softener, also known as fabric conditioner, minimizes static cling and bestows many other beneficial qualities (Zareen, Akter, Sarker, Ferdous, Islam, Sultana, & Rubel, 2019).

Esteves, Noronha, and Marinho reiterated that subsequent rinses remove the soapy mixture after the detergent and water pull off the debris and stains. The stains can occasionally be removed with the aid of moderate bleach. If everything is done correctly, the fabric is clean but not "snow-white." 'Blue' is added to the mixture to offset the remaining yellowing material.

In the rinse cycle, bluing liquid, often known as laundry bluing or simply "blue," is used to make white clothes appear whiter. Since their invention, coloring compounds have been used for numerous things, such as cosmetics and science experiments. The practice of bluing is used to make white clothing appear restored because of the fading of prior whitening procedures and general accumulation of dinginess (Reinbold, 2021).

Since laundering is a complex process that involves physicochemical and mechanical factors concurrently, its interaction and synergy are dependent on the duration of the washing time and temperature. The mechanism of laundering, however, is not easy to identify. Physicochemical understanding of the effects of factors such as the kinds of soil, the detergent composition, and washing temperature has been obtained (Fianu, Sallah, & Ayertey, 2005).

Several researchers (Gangwisch, Trimmer, & Gross, 1973; Mustalish, 2013, Leverette, 2019) have all highlighted the discolouration of certain textiles after repeated use and laundering. Gangwisch, Trimmer, & Gross, explained that in the washing of textiles with detergent compositions which do not contain bluing agents or fluorescent brighteners, the washed clothes often exhibit a yellowish colour, apparently due to materials deposited on or remaining on the articles washed. These residues adsorb blue light.

To counteract this effect, bluing agents have been employed either in separate bluing operations or incorporated with the detergent materials. A little bluing in the washing process or in the last rinse water adds the necessary tint that makes the fabric snow-white. So, in effect, a detergent and a bluing agent are used during the washing of fabrics, and the ‘black and white’ Ghanaian cotton print is of no exception. In certain situations, individuals may need to invest a considerable amount of money in clothes specifically tailored for special occasions that these ‘black and white’ fabrics are used for. Given the significant expense involved, it is reasonable to assume that such individuals would expect these garments to maintain their original quality and condition for an extended period (Monnie & Bosso, 2021)

On this basis, this study experimented with the ‘Omo’ which contains optical brightening agents and ‘Key’ bar soap (which has no optical brightener) and laundry blue and analyzed the influence it may have on the ‘black and white’ Ghanaian cotton print.

The analysis of the effects of these washing aids were based on selected fabric performance characteristics, which are key indicators of a quality fabric. Cloth properties are those aspects of a fabric that affect its usability, comfort, and performance. This widely accepted phenomena, are affected by many attributes and can be assessed either subjectively or by an objective measurement. The geometrical arrangement of fibers, which varies widely depending on the construction of the fabric, the type of fibers used, and other characteristics introduced by weaving, affects a fabric's performance in addition to its intrinsic fiber properties (Fergusson & Padhye, 2019).

Performance also refers to how a fabric will react during the life of the garment or item and Gawthorpe (2014) viewed that the female perception of cloths is probably more concerned with appearance than with comfort. Nevertheless, if cloths are to serve their proper purpose, they must satisfy other requirement other than smartness. Some fabrics are chosen for their tensile strength, others are chosen for their colour or abrasion resistance. The knowledge of fibres and fabrics will help to improve consumer’s skills, give them confidence that they need to make wise fabric choices, help one to take better care of one’s purchases, thus making one’s cloth to last longer and one will be more satisfied with them (FabricLink, 2006).

Ghanaians use the term "Ghanaian wax print fabric" to refer to wax and roller printed fabrics that are woven and printed there utilizing resin, dye, and wax techniques to create a distinctive indigenous design known as wax print. Most of the time, 100% cotton fiber yarns are used to create these printed fabrics (Viola, & Ahuwan, 2016). The 'black and white' printed fabric is an example of such prints.

Ghanaian printed fabrics are frequently used for a variety of applications in Ghana due to their cooling impact and other benefits associated with cotton fabrics, such as durability and simple sweat and heat evacuation made possible by the plain weave construction method (Obiana, 2011). Joseph (1988) also established that customers should think about the tensile strength, colour fastness, and elongation of the cotton fabric they buy when put under stress, such washing. A quality fabric must be able to survive regular wear, laundering, and dry cleaning without tearing or losing its color, according to Mehta and Bhardwaj's (1998) research.

Ghanaians frequently purchase African prints. Products from Tex Styles Ghana Limited, formerly known as Ghana Textile Print, Akosombo Textile Limited (ATL), and Printex Ghana Limited are among the cotton wax prints with Ghanaian provenance. Both Ghanaian and foreign buyers frequently employ Ghanaian genuine prints, such as real wax, real java, batik, tie-dye, and fancy prints, for clothes and other reasons (Kwame, 2012).

Cotton fabrics often require bluing during production to enhance their visual appeal, as the bleaching process alone may not effectively whiten them and can leave a yellowish-gray tint. However, the bluing applied during manufacturing may fade over time due to storage and cleaning, leading to gradual yellowing of the fabric, which was never truly white from the start. Moreover, the buildup of dirt and oils on the fabric can accelerate discoloration. To address this issue, it is common practice to add bluing agents to the washing process to revive or preserve the fabric's blue tint (Hand, 2019). Various care practices are used to maintain clothing in good condition and always looking new. Laundry (washing), dry cleaning, and ironing are some examples of these processes (Marshall, Jackson, Stanley, Kefgen & Touche Specht 2012). All through the process of care, especially, laundering, various agents or additives are used. These agents either removes dirt or aid in enhancing the colour or handle of fabrics. Fabric softeners, spray starch, and bluing are a few examples of such chemicals or additives. These additives need to be researched since they might contain components that could interact with the chemical makeup of the fabric to either improve or ruin some of the performance characteristics of the fabrics they are used on (Monnie & Bosso, 2021). Bluing, also known as laundry blue or washing blue, is a traditional home laundry detergent that is used to rinse white garments to enhance their look (Hand, 2017).

The "black and white" roller cotton printed fabrics have remained a highly sought-after material that has evolved into a vital component of Ghanaians' lively culture. More recently, designers from all over the world have begun to embrace it. Additionally, according to Orhin (2007), the "black and white" prints have names that represent or clarify the customs, beliefs, and culture of Ghanaians. Daddah, Dogbey, Osei, & Dedume, in (2015) highlighted once more that because each of these materials tells a tale to both the wearer and its admirers, they hold a special importance in the hearts of their wearers and fans. The fabric is among the few fabrics that have their names printed on the selvedge. Howard, Sarpong, & Amankwah, (2012) assert that names given to fabrics are symbolic.

The "black and white" cotton printed garments have a considerable communicative significance, denoting status or wealth and communicating messages as a kind of non-verbal communication in Ghanaians' daily lives, notably in their ceremonies (Smith & Ayavoro, 2016).

Despite the attractive qualities of these Ghanaian black and textile prints, it has been found that most of them have a shorter lifespan than imported prints in terms of quality, strength, and colour (Amenya,2022).

Statement of the Problem

Several studies have indicated that washing can have a significant impact on the appearance and functional characteristics of textiles. In fact, laundering is widely recognized as a primary culprit in the degradation of washable fabrics. The intricate actions involved in washing are expected to contribute to the decline of fabric performance. For example, soaps and the mechanical agitation during washing can alter the properties of fabrics by reducing the surface tension of water and impeding its ability to spread uniformly over wet textiles (Orzada, Moore, Collier, & Chen, 2009).

Consumers often use various additives to maintain the appearance of their clothing items, but they may not consider the potential impact of these additives on the products they wish to preserve. According to Hand (2017), there are numerous washing additives available on the market, but it is important to determine through experiments whether they truly deliver the benefits promised by the manufacturers without causing any harm to the garments.

Furthermore, cautionary instructions, such as the appropriate quantities to use, when and how to use the additives, may vary depending on the fabric type. For example, the amount of bluing and soaps to use varies depending on the load size and whether it is being used in the wash or rinse water (Education Innovators, 2017).

Even though detergent manufacturers are now using optical brightening agents instead of bluing, some households still use blue. This supports the anecdotal knowledge that detergents cause an effect on printed fabrics and consumers of these prints use Key soap to wash and use blue as a colour enhancer.

Bluing does not remove stains, but only enhances the fabric's appearance (Education Innovators, 2017). However, excessive use of bluing to achieve better results may negatively affect the fabric's properties. Nonetheless, there has been little research on the effects of bluing on the performance properties of fabrics, particularly on Ghanaian cotton printed fabrics, which are highly valued for their "black and white" design (Monnie & Bosso, 2021).

White fabrics (the white background colour of ‘black and white’ fabrics) are more prone to getting dirty and stained because of the activities they are commonly used for. This necessitates frequent washing after every use if one desires to keep the fabric looking clean and fresh before putting it away for storage. (Amenya, 2022).

The inappropriate selection and use of commonly used washing aids can result in several performance challenges on certain parameters of this fabric and eventually cause a failure or disappointment of the product. The in-depth knowledge of the variables that underwrite a better 'black and white' print performance in usage can only be established through experimenting and testing, to document the results and to add up to knowledge.

The common detergents that have been used over time in Ghana are omo and key soap. It is for this reason that this dissertation seeks to find out the effect Omo and Key soap with laundry blue as a colour enhancer on the strength, colour, and dimensional Stability of 'Black and White' Ghanaian Printed Cotton fabrics.

Purpose of the Study

This study explores the effects of 'Omo' detergent, key soap with laundry blue on colour, strength and dimensional stability of black and white Ghanaian printed cotton fabrics after three washing cycles.

Objectives of the Study

The objectives of the study are to:

1. examine the structural attributes of 'black and white' Ghanaian cotton prints
2. examine the effects of key bar soap plus new 'Omo' on colour, tensile strength, and dimensional stability of 'black and white' Ghanaian cotton prints.

Significance of the Study

This study will help users of 'black and white' prints to know the appropriate selection and use of laundry agents that would help maintain this fabric. This study will also provide a documentation of the impact that key soap plus laundry blue and ‘new omo’ has on the colour, dimensional stability and strength properties of the ‘black and white’ cotton printed fabrics. Additionally, the project will offer fundamental data for both research and teaching.

Ghanaians cherish the ‘black and white’ fabric and are concerned with how to care for it. When it comes to making sure this cloth or fabric’s life span is extended, and fit for the end use, the colour, tensile strength and dimensional properties are key performance indicators (Fianu, Sallah, & Ayertey, 2005). One of the major reasons for the consumer not being satisfied with a fabric after some care practices such as laundering and storage, is when these care practices are negatively affected due to some inappropriate selection and use of laundry agents such as detergents and ‘blue’ (Monnie & Bosso, 2021).

Delimitations

The scope of this study covered two types of Ghanaian cotton printed ‘black and white’ fabrics from two Ghanaian Textiles manufacturing Company: labelled Fabric A and Fabric B.

Two different types of soaps (key soap and Omo), and laundry blue were used. Specimens from the two fabrics were subjected to three washing cycles and their strength and elongation, colour fastness and dimensional stability to washing were tested, and quantitatively analysed using Inferential Statistics. The findings and implications were documented.

Limitations

There was no accurate data on measurement ratio of the laundry blue in relation to size and weight of fabric. This was absent on the product label, and the GSA testing laboratory did also not have any information on that. During the pre-testing period, the testing team had to go through several trials before arriving at an accurate quantity of Blue to be used for the size of the fabric specimen. Thus, one gramme (1 g) of blue was diluted with about a thousand and four hundred liters (1400 L) of water.

The usage of textile fabrics from two local manufacturing businesses and soaps from two local manufacturing businesses out of the many locally produced textiles and soaps also placed limitations on the study. Due to this, it was difficult to generalize the findings to all "black and white Ghanaian cotton fabrics.

By concentrating on three performance parameters of these fabrics, the study was once more constrained. In other words, there are numerous markers that can be used to evaluate a fabric's performance, but the study only looked at three. This limited the interpretations of the textiles' behavior during washing to only the three attributes.

Definition of Terms

Printed Fabrics: They refer to fabrics that have been created, then embellished with motifs, patterns, or designs.

Fabric Count: It speaks about the quantity of warp yarns (ends) and filler yarns (picks) per unit of measurement as measured when the fabric was held with no tension and was flat and wrinkle-free.

Fabric Weight: It refers to the mass per unit area measured in ounces per square.

Colour fastness is the resistance of a material to change any of its colour characteristics or extent of transfer of its colorants to adjacent white materials in touch.

The dimensional stability: refers to the alteration in fabric size caused by the qualities of a material and any potential thermal contraction force during processing.

Strength of Fibre: It refers to the ability to resist stress. It is expressed as tensile strength, in pound per square inch, or tenacity, in grams per denier.

African prints: They are industrially produced colourful cotton cloths. There are the wax prints which are batik-inspired printing. There is also just the roller printed cloths.

Key Soap: It is the brand name given to the bar soap produced for washing by "Uniliver" Ghana Limited.

New 'Omo': It is a brand name of a washing detergent manufactured by Uniliver Ghana Limited used for washing and cleaning.

'Blue': It is a powdered optical brightener and a weak dye that is as an after - wash to mask the yellowing in white fabrics. It is usually used with soaps that does not have optical brighteners, and seldomly used with detergents, as most household detergents contain fluorescent/ optical brighteners.

Fabric A: The 'black and white' Ghanaian cotton printed fabric manufactured by Ghana Text Styles Prints (FABRIC A) which was used for the study.

Fabric B: the 'black and white' Ghanaian cotton printed fabric manufactured by Printex Company Limited, which was used for the study.

Organization of the Study

The remaining material is divided into four chapters. The second chapter reviews literature that is pertinent to the study. The theoretical and conceptual underpinnings of the investigation are once more presented in this chapter. The study's methodology, including the research design, materials, sample and sample preparation, tools, data collection methods, and data analysis, is covered in Chapter 3. The study's findings are presented in Chapter 4 along with a discussion. The study's summary is given in the fifth and final chapter, Chapter 5, along with recommendations for future research.

CHAPTER TWO

LITERATURE REVIEW

This research is aimed at investigating the impact on 'black and white' Ghanaian cotton printed fabric when washed with the new 'Omo'; and the impact on same fabric when washed with 'key' bar soap and rinsed with laundry blue. This section examines relevant literature on the elements and traits that contribute to the production of high-quality "black and white" printed fabric after three washing cycles. The chapter's literature is organized into the following sections:

1. Empirical Review: Fabric Performance
2. Conceptual Base of the Study: Cleaning of Fabrics
3. Laundering
4. Effect of washing on Fabric properties:
    a. Colour fastness
    b. Strength (tensile strength)
    c. Dimensional stability (shrinkage)
5. Brief History and significance of the 'black and white' Ghanaian cotton prints

Empirical Review

Textile fabric Performance

Textile fibers are used to create textile fabrics. According to Mather and Wardman (2015), the fineness, length, and extremely thin nature of textile fibers are possibly their most glaring characteristics. Although there are many different types of fibrous structures in nature, only those that can be used to make textile fabrics are employed. Key qualities for clothes are softness, flexibility, moisture absorption, and dyeability. Effectively, the performance of fabrics is influenced by both their initial characteristics (when they are new) and the surroundings they are exposed to while being used (Barnett & Slater, 1991).

Vigo emphasized in 2013 that a fabric's end use conditions ultimately determine how well a textile performs. Performance characteristics of fabrics, such as strength, dimensional stability, weight, and colorfastness to agents, can also be used to gauge their level of quality (Kadolph, 2014). The type of raw material used (fibre type), the yarn twist, the yarn count, the cover factor, and the method of fabric manufacturing all have an impact on the performance attributes of the fabrics (Retief & De Klerk, 2003).

The suggested range of performance characteristics is broad and depends on the type of clothing under investigation, the purpose of the study, the environment in which it is worn, and the wearer (Masteikait et al., 2013). Vigo (2013) asserts that textile refurbishment has a detrimental impact on how well a fabric performs. Textile refurbishment is another intricate aspect of textile performance in addition to mechanical deformation, exposure to various detergents, bleaching agents, solvents, and textile auxiliaries. Heat and mechanical deformation are also required for the fabric or textile product to dry.

Fan and Hunter (2009) expands Vigo's (2013) refurbishing factor by claiming that it affects the fabric's serviceability. They clarified that refurbishment often refers to the cleaning and upkeep procedures carried out on the apparel or fabric throughout its use or wear life. Both authors continued by pointing out that all types of laundering domestic or industrial, in aqueous media; dry cleaning, in solvent media; pressing; and ironing can lessen the performance of fabrics.

The main reason why dry washing alters several fabric mechanical properties that are connected to fabric handling is because it alters the fabric structure (Vigo, 2013). However, the outcome will be influenced by the dry-cleaning conditions (such as the amount of solvent and water used, temperature, mechanical action, pressing, etc.) as well as the kind, history, and characteristics of the fabric (Kadolph, 2014)

In general, as Kadolph (2014) says, washing has the tendency to enhance the cotton fabric's shear and bending stiffness and hysteresis while decreasing its extensibility, which results in a degradation (increased harshness) in the fabric handle.

Conceptual Framework of the Study

Cleaning of fabrics

According to Bishop (1995), from the perspective of the textile manufacturer, local laundering of clothing is comparable to a mild cleaning (technically known as scouring). Although smaller, the machines or basins used for this cleaning operation are alike in design to those employed for cloth pre-treatment in the textile industry.

Again, Marshal et al (2004) asserts that when used to prepare grey goods or to wash off coloured and complete items, such a technique usually has minimal negative physical and chemical impacts. However, the cumulative effects of performing the procedure repeatedly possibly 25–50 times in the first year of use can be incredibly harmful to some textiles (Bishop 1995). For this study's analysis of the effects of the repeated washing procedure on the fabrics, the sampled fabrics were washed three times in quick succession.

Significant presence of fabrics and soaps of different kinds can be found on the Ghanaian market. But then, the consumer’s preference for a certain fabric is dependent on the occasion, and the fabric’s design (Kwame, 2012). The use of the ‘black and white’ cotton fabric is seen during both happy and sober moments; like naming ceremonies, and the celebration of a person's life when he/she dies and the funeral Thanksgiving Day (Amenya, 2022).

Additionally, the type of soap used in laundry is influenced by the colour of the fabric, as this has an impact on how well the cloth performs during cleaning and maintenance. According to Kadolph (2014), caring for customers is a key component of customer satisfaction for both fashion industry experts and clothing manufacturers.

Professionals of clothing and textiles also address issues such as how products respond to care such as soil and stain removal and shrinkage; how effective laundry products are at returning garments to a just-purchased condition such as colour retention and abrasion resistance; and how the recommended process affects design features, creases, and seams (Kadolph, 2014).

Documentation from Marshal, Jackson, Stanley, Kefgen, & Touchie Specht (2004) shows that after a garment meets a wearer's feelings, social life style, beliefs and practices, and corporal desires, it is exposed to a varied pressure such as ecological contaminants (like acid rain) dirt and pollen, moisture (sweat and rain); creasing; tinges from food contact or fragrance; light and sunshine; elongating from movement and abrasion. Marshal et al went on to say that certain elements are necessary for effective clothing maintenance. These elements/factors are:

1. Fibres, fabrication, dyes and finishes that make up the fabric of the garment
2. Chemical structure of the products used to clean garments and their interaction with the fabric's fibres, dyes, and finishes

3. Temperature of the water or air, as well as how vigorously you agitate the clothing
4. Quality of the garment construction

This notion has been illustrated diagrammatically in Figure 1.

Factors that affect cleaning of fabrics:

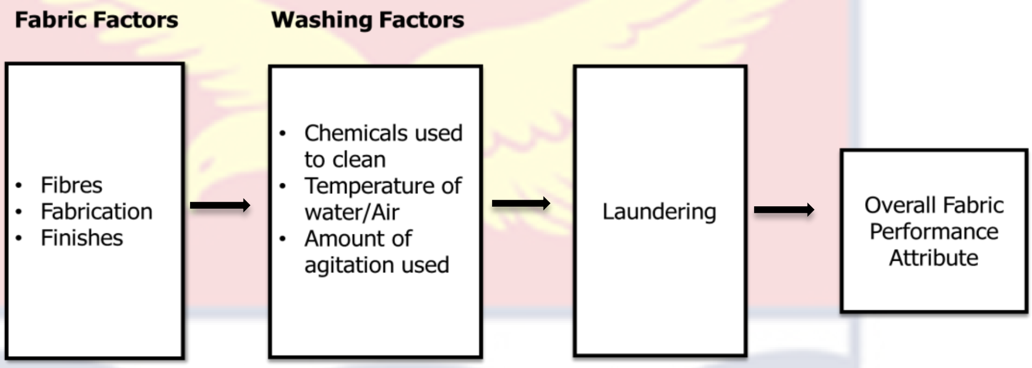

Figure 1: Conceptual Base of the Study (developed by the researcher)

Smulders, Rähse, von Rybinski, Steber, Sung, and Wiebel, (2013) also reiterate that the successful outcome of the laundry process depends on various chemical and physical factors, as outlined by the Sinner Circle. These factors include temperature, chemistry, mechanical action, and time, which collectively contribute to achieving satisfactory washing performance. In other words, these four factors are the only ones that need to be considered to ensure optimal washing results.

Kadolph (2014) attests to the fact that while fibres are a significant factor in determining appropriate care, other factors also influence care labels. Kadolph (2014) explains that care appropriate for textile products also depends on its dyes and pigments, fabrication, finish, product construction, other materials (such as trims, support materials, linings, and buttons, etc.) type of soil, and extent of soiling.

For the purpose of this study, factors of fibre properties, factors of laundering (wet cleaning agents), wear and soil attributes in washing processes were examined. The aforementioned elements are interconnected and frequently rely on the same or similar fabric qualities (Fan & Hunter,2009). The key attributes that were considered are fabric and the laundering agents used on them. The laundering agents that were examined were soap, laundry blue and detergents.

Laundering

According to Marshal, Jackson, Stanley, Kefgen, and Touchie Specht, (2004), laundering is the process of hand or machine washing and drying apparel items to remove soil and stains as well as to restore items to their first-purchased appearance. Marshal et al further stipulated that laundering can take place in the home, in laundromat, or at a professional laundering facility. And Kadolph (2014), sees laundering as the most common means of cleaning consumer textiles.

Variables in Domestic and Industrial Laundering

The variables/parameters that underwrites washing of fabrics considered for this work were backed by Fergusson's, (2019) research. Fergusson identifies a number of elements in the household and commercial washing of fabrics and clothes and names the most essential ones as : (i) the amount of liquid in the machine or wash basin in relation to the weight of the fabric being washed, or the "liquor ratio"; (ii) the effectiveness of the rinsing process, such as the number of rinse cycles and the "liquor to fabric ratio"; (iii) the type of detergent and alkali as well as the presence of other cleaning aids, buffers, and additives, such as bluing or optical whitening agents.

In actuality, each of these affects how a dyed fabric performs (Cotton Incorporated, 2002), of which the 'black and white' cotton prints are of no exception. The effect is obvious particularly over the life of the garment/fabric. Drying settings also has an effect on the definitive performance of a fabric after washing (Marshal et al, 2004).

As outlined by Cotton Incorporated (2002), producers can track every advice and precaution to develop a fabric with the best performance qualities, Consumer practices, on the other hand, have an impact on colourfastness qualities. Some of these practices are the detergent one uses and how the clothes are washed. Cotton Incorporated goes on to report that while evaluating the colorfastness capabilities of a product (particularly textiles), it is important to utilise the right test technique that truly replicates consumer laundering behaviours. For this research, parameters like wash temperatures which was set at 30 degrees for all the three wash cycles, and the choice of soaps and laundry blue, are common Ghanaian consumer wash practices and wash additives. Consumers launder their garments at lower temps as a result of rising energy expenses (Market Express, 2006). One of the most popular subsectors of the home laundry market is detergents with "colour safe" or activated peroxyl bleaching ingredients, which increase cleaning effectiveness at lower wash temperatures (Cotton Incorporated, 2002).

Laundry Products

The variety of washable fabrics, particularly machine-washable textiles, has grown drastically over the years. In addition to the increased number of dye classes, fiber types, and fabric finishes available for washing, some recent advancements such as the development of microfibers have changed the washing properties of previously well-known dye-substrate combinations. Increasingly complete tints and brilliant hues in new forms of casual apparel and sporting have resulted from global fashion trends and changing lifestyles (Bishop, 1995).

Kadolph (2014) adds that manufacturers of household detergents now face new challenges (and opportunities) as the features of ordinary domestic wash loads continue to evolve. The abundance of brands available on supermarket shelves that currently offer exceptional cleaning at low wash temperatures, specific care for colored fabrics like African wax and roller printed fabrics, and specific care for delicate fibers like wool and silk is their response.

According to Koomson (2012), the leading manufacturer of homecare and laundry products in Ghana, Unilever Ghana Limited, has unveiled an improved version of the well-known detergent "Omo" (Koomson, 2012). The Brands Building Director of Unilever Ghana, Maidie Arkutu, reiterates that the new and improved Omo washing powder has proactive cleaning molecules that penetrate deeply into fabrics to remove challenging, crusted stains while leaving no shadow stains behind. The same company also has a caked soap (Brilliant) that consumer can also use for both white and coloured textiles. These new additions of detergents are in response to fashion and consumer dictates on the evolution of domestic washing process and the advancement of the life span of African printed fabrics.

Marshal Jackson, Stanley, Kefgen, and Touchie Specht, (2004) also attest that today’s grocery store's detergent section has an overwhelming selection of laundry supplies. Nevertheless, it is critical to match the laundry product to the fabric's properties and cleaning requirements. Soaps and detergents, bleaches, water softeners and conditioners, pre-treatments, fabric softeners, and fabric finishes like starches and blues are all examples of laundry products.

Optical Brighteners

Fluorescers, fluorescent whitening agents (FWAs), and optical brightening agents (OBAs) are all names for essentially colourless dyes that have strong near-UV absorption maxima between 300 and 400 nm (typically around 350 nm) and re-emit the absorbed energy as violet to blue visible light at about 400-440 nm (Bishop, 1995).

Bishop, adds that these dyes have been widely used since the 1950s in fabric washing products (as well as in the textile and paper sectors) to enhance the appearance of whiteness in bleached fabrics. These dyes served as the foundation for the various detergents' advertising claims that their products wash "whiter than white," "adds brilliance to whiteness," and other similar phrases. Miss Acquah, a category manager for Home Care at Unilever, explains that the Business noticed that when clothing is stained with filth, they become dull, especially white ones, and that this new Omo comes with specific cleaning qualities that make dull garments brighter (Koomson, 2012).

Fluorescers make white cotton appear bluer and brighter, which is almost universally favoured by customers. However, this has the drawback of making pink and red colours appear notably bluer and making pale yellow and beige tones appear "washed-out" (Bishop, 1995). This is just a partial solution to the issue because fluorescers, like other direct dyes, have poor wash-fastness and have a tendency to desorb and transfer from one piece of clothing to another throughout the washing process (Bishop, 1995).

Apart from OBAs being used in soaps and detergents that are used to wash clothes, consumers also use various additives to maintain the appearance of their products, and Monnie & Bosso (2021) questions if consumers do think of Apart from OBAs being used in soaps and detergents for washing clothes, consumers also use other additives to preserve the appearance of their products, and Monnie and Bosso (2021) wonder if consumers consider the consequences these additives may have on the things they want to maintain. Example of such additives are starch, blue, and softeners. Blue which forms part of the basis of this work is a common washing additive used in the rinse cycle during washing, especially for white fabrics.

Kwame (2012) stipulates that household managers in the Ghanaian community use this bluing chemical with the aim of preserving or enhancing the appearance of "black," "white," and "blue," as well as any white fabrics with African prints. Monnie and Bosso (2021) go on that the Ghanaian home caretakers who use this bluing chemical do so in order to maintain or improve the look of the 'black' and 'white' and ' white and blue; Ghanaian printed cloths in addition to all white coloured textiles (Monnie & Bosso, 2021).

Bluing, also known as laundry blue or washing blue, is a longstanding laundering solution used to advance the appearance of white garments (Hand, 2017). According to Educational Innovations Inc., (2017), the amount of blue to use is determined on the size (number and weight) of the items being washed, and whether the blue is going to be used in the wash or rinse water.

To avoid some fibre absorbing too much undiluted bluing and developing blue spotting, bluing must always be diluted before being added to wash or rinse water (Hand, 2017). Bluing does not eliminate stains; it simply brightens the fabric's look (Educational Innovations Inc., 2017). If a person wants to get a really good impact of blue on his/her clothes, he or she can increase the amount specified, although this may detract from the fabric's appearance or alter some of its properties. While bluing agents have been used on fabrics for many years, their impact on fabric performance has gotten little expose, particularly in the case of the popular African printed fabrics.

Despite the fact that detergent producers are introducing optical brightening ingredients to replace the task of bluing, bluing is still used in certain Ghanaian houses today.

Soaps and Detergents

In practical term, soap is defined as a fatty acids' alkali salt. Soap is what happens when a fatty acid reacts with a strong base (alkali) (Chandler's Soaps, 2010). Soap may be a solid, liquid, or powdered substance created by potassium or sodium hydroxide reacting with animal or vegetable oils, as indicated by Hopkins (2010). Unilever's 'key' bar soap used for the washing of the fabric specimens is an example of a vegetable oil-based soap (Kwame, 2012). Water is frequently used with soaps, which may also contain scents and other ingredients.

Soaps are derived from natural fats and oils, but soapless detergents are produced in vast numbers using petrochemicals (Ameyibor, Kosi, Wiredu, & Manfred, 1999). This is how soaps vary from detergents. Despite these variations in production and composition, soaps and detergents serve a similar purpose in assisting water's cleansing effect (Henney & Byett, 2015). And to Fergusson (2008) detergents and soaps are vital for cleaning textile textiles, both during production and after they have been worn.

Laundry detergent, according to Bajpai (2007), is a substance that comprises a surfactant and other components to clean clothing during the washing process. Laundry detergent is also a sort of surfactant that is added to the laundry when it is being washed to help get the laundry cleaner.

Domestic and commercial laundry detergent systems vary widely, with some containing more alkali than others and some incorporating bleaching agents that produce oxygen, like sodium perborate or sodium percarbonate. Surfactants, sodium sulfate, sodium carbonate, sodium silicate, sodium aluminosilicate, clay, enzymes, scent, sodium carboxymethyl cellulose, optical brighteners, and polycarboxylates are among the chemicals in the new omo that was used to wash the specimens (Amenya, 2022). The oxygen generating bleaching compounds in this product is the *sodium carbonate*, which perhaps helps to brightens the appearance of clothes (Fergusson, 2008). Table 2 depicts an example of a common household powder detergent composition as reported by Fergusson.

Table 2: Domestic washing detergent constituents

Constituent	Percentage (%)
Active detergent (alkyl benzene sulphonate)	24%
Tri poly phosphate	30%
Sodium silicate	8%
Sodium Carbonate Na_2CO_3	2%
Sodium perborate	6%
Sodium sulphate Na_2SO_4	20%
Carboxymethyl cellulose	8%

Foaming agent	2%
Optical brightening agent	Trace

The work of the components is then described by Fergusson (2008). In the detergent, phosphate, silicate, and sodium carbonate function as "builders," increasing its effectiveness and aiding in the removal of grease and dirt from the fabric. After the cloth has been removed, the emulsion is stabilized with carboxymethyl cellulose, preventing the re-deposition of suspended dirt particles. Because the detergent, alkyl benzene sulphonate, does not foam well, a foaming agent must be added. The neutralization of the sulphonic acid in the detergent produces sodium sulphate as a by-product (Adams, Slocum, & Monroe Keyserling, 1994).

Cleaning Action of Soaps and Detergent on Fabrics

Bloomfield, Exner, Signorelli, and Scott (2013) also go into how detergents clean fabrics by noting that various bleach components can be used to chemically inactivate germs on clothes during laundering. Normally, oxygen bleaches (persalts) with a low temperature activator are employed today, or chlorine-based bleaching agents are added to the wash load, as is common in several countries. According to Reinhardt and Borchers (2009), the bleach process in general-purpose laundry detergent powders is mostly dependent on active oxygen delivered via percarbonate and a bleach activator like TAED. (TAED is an organic molecule with the formula CH3C $(O)_2$ NCH2CH2N(C(O)CH3$)_2$. This white solid is extensively used in laundry detergents as a bleach activator as well as in paper pulp (Fergusson, 2008).

The main goal of active oxygen bleach (AOB) is to get better cleaning and whitening results. Oxygen-based bleaches also cause chemical inactivation of bacteria, fungi, and viruses, and the surfactant itself has a chemical inactivation effect on some species (Bloomfield, et al, 2013).

Fergusson (2008), however asserts that, oxygen-based bleaches cause chemical inactivation of bacteria, fungi, and viruses, and the surfactant itself has a chemical inactivation effect on some species. The intensity of this effect will be determined by the concentration, wash temperature, pH, and soiling level, among other factors. As the wash temperature drops, the rate and extent of active oxygen release, and therefore the microbiocidal action, diminishes, however bleach activator manufacturers claim that effective bleaching action can be supplied even at temperatures as low as 20°C (Bishop, 1995).

Considering that they can be automatically dispensed into the washing machine, give clothes softness, anti-static properties, and resilience, are kind to the eyes and skin, and have good water dispersibility, Bajpai (2007) noted with keen observation that laundry detergents are growing in popularity. Because it is consumed when it is used, the selling of laundry detergent is also a significant industry.

Kadolph (2014) notes that there are many types or brands of laundry detergent available, and many of them promote particular qualities as marketing benefits. Based on their characteristics and roles in the final product, the basic components that make up a laundry detergent composition can be classified into many groups. Bajpai (2007) reports that in addition to removing dirt, stains, and filth from surfaces or textiles, raw ingredients such surfactants, builders, bleaching agents, enzymes also produce a pleasant feel and aroma. Surfactants are appropriate for washing due to their physico-chemical characteristics. Historically, laundry detergent has been a granular or powdery product. However, throughout time, the use of liquid laundry detergents has increased to the point where it is now on par with, if not higher than, the use of solid detergent (Bajpai, 2007).

Due to law, the composition of household detergents has altered in most developed nations, lowering the permissible phosphate concentration in home and industrial effluent. Phosphate levels in household detergents are now routinely capped at around 10% (Kadolph, 2014).

Pure water cannot remove fatty or organic soiling by serving as an emulsifier, hence detergents and soaps are employed to clean (Lohman, 2002). Water cannot permeate grease and oil because their polarities are diametrically opposite. And Kwame (2012) adds that soaps work by allowing oil and water to combine, allowing oily dirt to be eliminated during rinsing. During World War I and World War II, there was a shortage of animal and vegetable fats required to create soap, prompting the development of detergents (Kadolph, 2014).

The surface tension of water is broken by soaps, allowing them to spread and cover or penetrate the surfaces being cleaned more thoroughly. Although soap has significant drawbacks, it is an effective cleaner in soft water (Hand, 2017). Hand (2017) claims again that soap scums, which are sticky, gel-like masses that collect on clothing or washing equipment, are produced when soap interacts with calcium and magnesium ions in hard water. This worsens the problem of the insoluble soil in addition to lowering the soap concentration. Brady, Russell, and Holum (2000) attested that soap is abused in the process of creating scum on the surface of clothes. More soap must then be used to make up for this wastage before washing can begin. The precipitate that forms tend to re-deposit again, this time as soap scum on the fabric (Brady et al, 2000).

Surfactants, which may be cheaply made from petrochemicals, are the main components of detergents (Tyebkhan, 2002). Surfactants make water wetter by reducing its surface tension, which makes it less likely to stick to itself and more likely to interact with oil and grease. Surfactants are only one ingredient in modern detergents. Surfactants are only part of what modern detergents include. To boost the cleansing power of modern soap, several compounds known as builders are added to the combination (Gitobu, 2012). Builders, according to Brady et al. (2000), are alkaline substances like sodium tripolyphosphate (STD) that help soften hard water and promote washing by mixing up with grease on textiles or clothes that are heavily soiled.

Kadolph (2014) documents that cleaning supplies may include enzymes to break down protein-based stains, bleach to lighten stains and give cleaning chemicals more strength, and blue dyes to prevent yellowing. Detergents, like soaps, contain hydrophilic (water-loving) and hydrophobic (water-hating) molecule chains (Sanders, 2002). Hydrophobic hydrocarbons are attracted to oil and grease but reject water. The hydrophilic and oil-binding ends of the same molecule attract water and oil, respectively. Detergents and soaps only work to bond to the soil without the addition of mechanical agitation or force to the equation.

The washing activity of soap is influenced by its polar and non-polar structures, as well as the application of solubility principles (Ohpardt, 2003). The non-polarity of the lengthy hydrocarbon chain is evident.

Effects of Laundering (Washing) on Fabrics' Fibre Properties

Bloomfield, et al (2013) observes that wash and rinse cycles contribute to reducing microbial contamination during laundering. Moreover, Bishop's (1995) research reveales that fabric washing product makers have consistently made an effort to design their goods well within the restrictions given by textile substrates. No matter how effective a product's cleaning abilities, it is obvious that any product that is shown to harm textiles will be derided by consumer organizations and rejected by consumers. Products that have the potential to cause injury have the necessary warning labels because of this. For instance, brands that use proteolytic enzymes typically advise customers against soaking wool or silk clothing (Kadolph, 2014).

Bishop (1995) claims once more that home consumers (as well as those working in commercial laundries) are aware that the wet rubbing and beating processes necessary for good cleaning are at least partially to blame for the degradation of fabrics that have been washed, used, or worn repeatedly. It is well established that washing procedures typically cause more fabric damage than use or wear. For instance, according to data from a common wash and wear testing (Mohamed, 2014), hospital uniforms composed of 50/50 polyester and cotton had a 43% tensile strength loss after 25 cycles of washing and wearing, while the "washed only" control articles suffered a 39% strength loss. Therefore, in this specific instance, the wash process was responsible for 70% of the overall damage. Shrinkage, distortion, fiber damage, fabrics becoming stiff and harsh, colour fading, cross-staining by fugitive dyes, and other fabric changes that take place during washing all depend heavily on the type of fiber used, the construction of the fabric, the dye used, the finishing techniques used, as well as the wash procedure and the finished product (Mather and Wardman, 2015).

Washing effects have been thoroughly discussed by Bishop (1995). The mechanical motion utilized in washing processes varied a lot depending on the hand washing methods and washing machine kinds available in different countries. But it seems reasonable to assume that comparable changes must happen, albeit at different speeds, depending on the mechanical rigor of the wash technique utilized for each specific combination of fiber type and fabric construction.

There have not been many research comparing various handwashing and machine-washing techniques (Mather and Warman, 2015), but the available data is sufficient to imply that hand washing isn't always safer than machine washing (Bishop, 1995). Some hand washing techniques are thought to be particularly harmful, such as rubbing clothing against the ribbed concrete surfaces of the common wash "tanques" found throughout many South American countries. Similarly, using heavy wooden rods or bats to beat wet garments against walls or rocks in some parts of India and Southeast Asia is more violent than using a washing machine (Bishop, 1995).

Mather and Warman (2015) documents that the movement of yarns in relation to one another, the migration of fibers within yarns, and the beating and abrasion of individual fibers are possible causes of the mechanically induced changes in textiles that occur during washing and tumble-drying procedures. These kinds of changes could result in: (i) modifications to the size, shape, and fabric thickness of clothing; (ii) fuzzing, pilling, felting, and fiber loss; and (iii) fiber splitting, fibrillation, and breaking. The goals of this research were inspired by the variables Bishop (1995) and Mather and Wardman (2015) listed.

Some fabrics may slightly fade when washed at home with even a regular detergent, while fabrics washed with detergents that contain active bleach may suffer severe color intensity losses depending on how sensitive the dye is to such detergents (Mather and Wardman, 2015). Consumers can also choose from detergents that contain enzymes to get rid of the fabric's surface cellulosic fibers. Many times, changes in the fabric's surface brought on by abrasion during washing might be blamed for the loss or appearance of colour. Kadolph (2014) also says that by lessening the fuzziness of a fabric's surface, detergents containing enzymes typically diminish the color shift associated with home laundering. The ability of a fabric to retain its colour is also affected by the washing process. However, consumer habits like washing garments backwards, using smaller loads, softening in the last rinse, and speeding up the tumble-drying process reduce color fading (Cotton Incorporated, 2002).

Laundry has a considerable impact on a fabric's mechanical, physical, and aesthetic qualities. It is a major factor in washable textiles degrading and alters the performance and aesthetic qualities of fabrics (Orzada, Moore, Collier, and Chen (2009).

Breese et al. decisively discovered in 1994 that microscopically, cleaned fabric resembles materials from actual wear investigations. Fabric characteristics are also impacted by detergents and the agitation process used in laundering; detergents reduce the water's surface tension and its capacity to spread over and wet fabrics (AATCC, 2004).

From the ongoing discussions it can be inferred that the choice of soap and detergent, the temperature of the water for the washing, and wash procedures are among the key cause of fabric surface change after washing (Marshal et al, 2004). Some of the surface changes as mentioned by the authors are colour change (fading) cause by rubbing of the fabric, which causes abrasion and colour loss. It is against this backdrop that this research was carried out to ascertain these changes that occur after a fabric has been laundered.

However, the fabric changes that take place during washing, such as shrinkage, distortion, fiber damage, fabrics becoming stiff and harsh, colour fading, and cross-staining by fugitive dyes, are all highly dependent on the type of fiber, the construction of the fabric, the dye used, the finishing techniques used, as well as the wash procedure and the finished product (Mashal et al, 2004).

When the need to remove soils arises, it is important to consider the fiber properties that affect how a fabric performs in use. According to Vigo (2013), the characteristics of the textile substrate (hardness, roughness, and cross-sectional shape of fibers, fabric construction, yarn twist and structure, swelling (during cleaning), affect how soils can be removed from a fabric; properties of the soil (amount present, particle size, and geometry of solid soils); and soil properties (amount present, particle).

All fabrics degrade gradually, according to Barnett and Slater (1991), through a variety of mechanisms, including mechanical degradation, microbial/insect damage, shrinkage, color loss, and staining. These are the elements that shorten its useful life. Environmental factors (such as weathering) as well as washing, ironing, dry-cleaning, and storage conditions can lead to damage. Weathering, or the combined influence of daylight, temperature, humidity, rain, abrasive dust, reactive gases (pollution), and cosmic radiation, is one of these variables that is most prevalent. The degradation of fabrics exposed to the elements for an extended length of time is caused by weathering (Barnett & Slater, 1991).

Fan and Hunter (2009) adds again that refurbishment has an influence on fabric serviceability. Refurbishment often refers to the cleaning and upkeep procedures carried out on the apparel or fabric throughout its use or wear life. Fan and Hunter (2009) again highlight that fabric performance can be affected by laundering procedures, including home or commercial (in aqueous media), dry-cleaning (in solvent media), pressing, and ironing.

For instance, Kadolph (2014) stipulates that dry cleaning alters a variety of fabric mechanical properties that are connected to fabric handling, primarily as a result of altering fabric structure. However, the outcome will be influenced by the dry-cleaning conditions (such as the amount of solvent and water used, temperature, mechanical action, and pressing) as well as the kind, history, and characteristics of the fabric. Laundering typically tends to enhance the cotton fabric's shear and bending stiffness and hysteresis while reducing its extensibility, which results in a degradation (increased harshness) in the fabric handling.

Based on the determinants for fabric quality and suitability for a particular end-use, the fabric characteristics that were examined in this study were fibre strength and elongation at-break, weight of the fabric, colourfastness to washing, and dimensional stability (shrinkage). On the foundation of the ongoing discussions and the extent of literature it is clear that fabric performance is affected by both internal and external factors. The internal factors being fibre type, yarn type, and weave structure and construction (Marshal et al, 2004). Though the internal factors seem to be subtle, and may cloud the judgement of a quality fabric; these factors can also not be ignored in the discussion.

Effect of washing on fibre properties

Kadolph (2014) stresses that to analyse a fabric in order to predict its performance, the starting point must be the fibre. Understanding a fiber's characteristics will make it easier to predict how it will affect a fabric's and a product's performance. This starts a conversation about the features of the cloth itself as well as the characteristics of the cotton fiber itself.

Fibre properties such as length, diameters, density, cross-sectional shape, yarn crimp, tensile strength and elongation are important properties which play major roles in the performance of fabrics.

Effect of washing on tensile strength of a fibre

Tensile strength is defined by Cook (1985) as the material's breaking strength, which is often given as for per unit cross-sectional area. These phrases can be used to characterise a bundle of fibers or yarns' capacity to withstand breaking when put under tension. According to Goffe (2011), tensile strength is a crucial, although likely overused, criteria of textile performance.

Viscoelastic behaviour is exhibited by textile fibers. Because of this viscoelasticity, fiber deformations and recoveries rely on the passage of time. The fiber is reported to display creep when a load is applied and creep recovery when a load is removed. In this research, this particular property is measured after each washing cycle to see the difference in the strength of the fibres (Goffe, 2011).

Elongation at break/load-elongation Behaviour

A fiber will stretch to a certain extent when it is subjected to strain. In terms of the percentage of the initial length of the fiber, this stretching is referred to as elongation or extension. It can be quantified as either the elongation attained when the fiber breaks or as an elongation under a specific stress (Cook, 1985).

Natural fibers' elongation behavior is widely understood (Cook, 1985). For instance, cotton has a much higher strength but noticeably lower elongation to rupture than wool, which has a low strength and high elongation. Strength and elongation are typically axiomatically inversely connected. In other words, the elongation decreases the higher the strengthening. As a result, the elongation at break for the two textiles utilized in the experiment was recorded.

Cook (1985) again indicates that tensile properties of a fibre are affected significantly by the water it absorbs. One of the performance parameters on which this experiment was carried out and tested was the fabric specimen’s elongation at break after it has been washed with only omo in one instance, and key soap and rinsed in blue in another instance. It was realised that washing had some influence on how the fabric specimen stretches and tore.

Cook (1985) notes that a fiber that readily absorbs water will typically lose tensile strength when wet, however cotton is an exception. There may be more variables. Additionally, the length at break is lengthened. When fibers absorb moisture, they may swell significantly. However, Kadolph et al (2008), underscores the fact that the tenacity of a wet fibre might frequently differ from the tenacity of that same fibre when it is dry. Although the fabric strength depends, to a large degree, on fibre strength, yarn and fabric structure may be varied to yield stronger or weaker fabrics made from the same fibres.

Chemical properties of fibres

Modern methods of processing fibers, yarns, and fabrics frequently require a wide range of chemicals (Cotton Incorporated, 2002). The completed cloth is prepared using a variety of chemicals, including bleaching agents, detergents, alkaline scouring agents, dyeing assistants/auxiliaries, and others. Kadolph (2014) is keen to note that these pollutants must be withstood by the fiber itself without causing damage. This work exposed the fabric samples under study to washing agents like laundry blue, soap and detergent to examine the extent to which these washing agents can affect the fabrics.

Effect of washing on the Colourfastness of fibre

The American Association of Textile Chemists and Colorists (2004) defined colorfastness as a material's resistance to change in any of its color characteristics, to transfer its colorant(s) to adjacent materials, or both, as a result of exposure to any environment that might be encountered during the processing, testing, storage, or use of the material. In other words, it is a fabric's capacity to maintain its color over the duration of the use for which it was intended (Cotton Incorporated, 2002; AATCC, 2004).

To give the consumer a good product, a variety of colourfastness attributes must be taken into account. Hamburger (1998) states that, colour fastness for each physical and chemical action is determined by the degree of paling or fading of the initial colour and the degree of white material colouring caused by the action. Colour fastness criteria are used to determine how pale and coloured white materials are (grey scales). A dye may react to one agent rather quickly while reacting to another just moderately quickly, according to Kadolph (2014). Standard protocols are used to test the color fastness to some degree. For a particular function, textile materials frequently need to adhere to certain fastness requirements. It is by this standard that the samples of ‘black and white’ fabrics were tested. And for this work, the fabric samples’ colourfastness was tested against washing.

Cotton Incorporated (2002) underscores the fact that a product type determines the type of colourfastness required, and hence, which test techniques are pertinent. For instance, upholstery fabrics need to be extremely lightfast and crock-fast, yet apparel fabrics like the black and white Ghanaian cotton designs need to be wash-fast. In view of this the fabric samples’ colourfastness to washing was tested after three wash cycles to ascertain the effects. Consequently, manufacturers must also know a fabric’s intended end use in order to make processing decisions that will produce a product of acceptable performance (Cotton incorporates, 2002).

The Cotton Corporation (2002) continues that today's consumers are more educated than ever in a technical bulletin. They are mindful of upkeep and durability in addition to comfort and style. Customers want a high-quality product. Furthermore, market research reveals that consumers frequently rely their buying decisions on colour. Therefore, one of the most crucial characteristics of a textile product is a fabric's capacity to preserve its original colour. These are among other reason why the colourfastness parameter of the 'black and white' prints was tested.

Numerous factors that happen in both the pre-consumer and post-consumer stages have an impact on the colourfastness or colour retention of cotton fabrics. The performance properties of a fabric are impacted by differences in raw materials, chemicals, production techniques, and consumer behaviour. Therefore, in order to accomplish the end aim of consumer happiness, manufacturers must comprehend how the numerous factors effect colorfastness (Cotton Incorporated, 2002).

Elebiyo (2000) then states that variables such as light, exposure to the sun, soap solution, distilled lime, sea water, washing, perspiration, ironing, rubbing, and dry cleaning are responsible for colour fading. These elements alter the physical and chemical makeup of dyes, reducing their ability to adhere to fibers, and causing permanent alterations to the colour of the material and touching surfaces.

Effect of washing on the Dimensional Stability and Appearance Retention of Fibres

When a fabric is washed or dried by a machine, its shape may be destroyed. This is due to the fact that some materials shrink when exposed to heat or moisture. Dimensional change, as defined by Morton and Hearle (1998), is the expansion or contraction of a fabric's length or width. They refer to a reduction in size as shrinkage and an increase as growth. They also noticed that a fabric's capacity to withstand stretching or shrinking is known as its dimensional stability.

Dimensional stability is the capacity of a textile material to keep or regain its initial geometric configuration, according to the Textile Glossary (2001). A fabric's capacity to regain its original dimensions following laundering or dry cleaning is stated as a percentage. For instance, 2%-dimensional restorability/stability denotes the ability of a fabric to be restored to within 2% of its original dimensions using standard home pressing techniques, even though the cloth may shrink more than this during washing. Cook (1985) acknowledges that cotton fiber is dimensionally stable on its own. But cotton fibers themselves do not significantly contribute to any shrinking; rather, stresses produced by spinning and weaving cause a cotton garment to shrink to some level.

Brief history and significance of the ‘black and white’ Ghanaian cotton prints

Weiner and Schneider (1991) notes that textiles/clothes are generally interesting because they enable creative adornment, connect commodities to socially valued proprieties, and serve as significant materials in the construction of identity. Clothes have symbolic significance across all cultures and societies. Apparel choices made for funerals, marriages, outdoor rituals, and other cultural and social occasions indicate cultural fluency and a sense of belonging in Ghana, where textiles and clothing are of particular importance.

Ghanaians were avid buyers of African prints that European missionaries and traders had introduced to the West African market in the 19th century (Smith and Ayavaro, 2016). The term "classical prints" was frequently used to describe these early African prints. Customers that value the appearance, skill, longevity, and status that go along with pricey wax prints spend money on "genuine" or "authentic" wax prints.

Howard, Sarpong and Amankwah (2012) also asserts that roller prints, which come in variations known as fancy print, mini wax, and Java, are the other major type of African print cloth. The designs on cotton fabric's one side are frequently printed on prints in this category, which are produced without the use of wax. Although some roller prints pretend to be "craquelé," the visual dynamic and irregularity of "genuine wax" can be seen through their mechanical bubbling and "imperfections." (Howard et al, 2012).

The prints are now largely produced in Ghana and are of cultural, social, and economic significance (McCall, 2011). Ghana is currently the origin of many beautiful and exclusive prints. They include tie-dye, batik, real wax, and real coffee. The prints' patterns depict proverbs, rhymes, and traditional African fables that are relevant to the user (Lauren, 2010). The colours are also significant since it indicates social class, age, ethnicity, and marital status.

Grey baft is first washed, bleached, mercerised, and stretched before being used to create wax and roller prints. The manufacturing of roller prints enables a wider range of colours and more intricate designs. One brass roller is engraved with the design for each colour that will be used while roller printing. Then, one by one, the rollers are connected to the printing apparatus. It is simpler to identify the correct side of the cloth because dye is applied to just one side of the fabric as it travels through the rollers. Most of what is known as the roller prints are ‘fancy’ prints (Smith & Ayavoro, 2016).

Most materials used to create traditional and modern apparel in Africa are 100% cotton (Lauren, 2010). The ‘black and white’ Ghanaian prints is a cotton fabric. Thus, it possesses all the good qualities of the cotton fibre. As Nkeonye (2009) underwrites, the cotton fabric is comfortable and appropriate for all year-round use. It is the fibre most preferred for warm-weather clothing, especially where the climate is hot and humid, like Ghana. Nkeonye further explains that cotton is one of the most useful and versatile of fibre which is used for a wide variety of fabrics for both clothing and home finishing. Weber, Lynes, J., & Young (2017) again notes that cotton is strong absorbent, comfortable to wear, and washable. He said, it can be washed in high temperature and with strong soaps or detergents and that cotton accepts dyes readily.

In order to meet the changing tastes and demands of textile consumers, textile producers have likewise changed their design and color preferences over time. This has given rise to contemporary designs (otherwise known as fancy prints) that have been embraced by the public especially the youth (Abraham, Frimpong, & Asinyo, 2019). The ‘black and white’ prints are classical examples of the fancy prints. In Ghana, they are produced by Ghana Tex Styles Prints (GTP) Akosombo Textile Limited (ATL), and Printex Ghana Limited (Monnie & Bosso, 2021).

In Ghanaian tradition, outdooring and naming rituals, funerals for people who were 70 years or older to honor them for having lived a long life, and other joyous occasions typically call for the usage of the "black and white" and "blue" printed fabrics (Wright, 2019). Consumers’ preference for a particular ‘black and white’ fabric is guided by the concept of the design and its name, as well as the colour; in this case how the black on white plays out aesthetically. In some cases, people are required to pay a premium amount for clothing that is manufactured just for these occasions. An individual would anticipate that if they were to spend money on such clothing, it would remain in the same condition for a longer amount of time (Monnie & Bosso, 2020).

In recent years, designers from all over the world have begun to embrace the "black and white" roller printed fabrics, which have remained a highly sought-after fabric and have become an essential element of the colorful culture of Ghanaians (Smith & Ayavaro, 2016). The fabric is among the few contemporary fabrics that have the names of the fabric design printed on the selvedge. Kyerematen, (1965) asserts that names given to fabrics are symbolic. These names denote special meanings to wearers, apart from the white background. Orhin (2007) indicates that the 'black and white' prints have names that depict or explain the beliefs, practices, and culture of Ghanaians. Each of these materials has a unique meaning for both the wearer and its admirers since it tells a unique tale to both.

Chapter Summary

Cotton is the best all-purpose utility fiber that nature has to offer. Cotton materials have excellent wearing features as well as exceptional durability. Cotton has innate strength. This quality, combined with cotton's resilience in alkaline and aqueous solutions, makes cotton clothing machine-washable repeatedly. This and many other reasons make the 'black and white' prints one of the sought-after cloths in Ghana.

It can also be deduced from the ongoing discussion that the performance attributes of fabrics are equally important to how a fabric can be said to be fit for purpose. The performance qualities of the fabric can be impacted by a variety of factors, including fiber quality, yarn formation, fabric construction, wet processing, and customer habits. The decisions made during textile wet processing have the biggest influence on the dimensional, strength, and colorfastness characteristics of cotton fabrics of all these factors. The choice of dye is equally crucial. However, consumer behaviors like detergent choice and laundry methods also have a significant impact on a fabric's ability to retain color as well as its strength and shape; these have been important elements for the overall purpose of this study. Customer satisfaction should consequently increase as producers gain expertise and knowledge in comprehending and managing the numerous factors that affect how to care for fabrics in order to extend their useful lives.

CHAPTER THREE

RESEARCH METHODS

This section defines the procedures that was followed to realise the objectives of this work. The chapter looks deep into the following components: the first section gives an account of the research design, the second on materials used for the experiment, the third section presents sample and sampling procedures that was used for the study, the fourth on the data gathering procedure. The chapter ends with information on how data was analysed and interpreted.

Research Design

The research design used for this work was the quantitative research design. According to Baker (2017), to be able to describe causal relationships, the quantitative research designs are often used. This design can also be used to look for associations or relationships between variables. Baker continues that quantitative research can also be viewed as experimental. This work is a quantitative experimental reading because it investigates the effect of 'Key' soap plus laundry blue and new 'Omo' on colour, strength and dimensional stability of Ghanaian printed 'black and white' cotton fabrics after three washing cycles. Ganeshpurkar, Pandey, Asati, Maheshwari, and Tekade (2018) also adds that in this type of experimental research, which is also adopted in quantitative study, statistics can be used to answer questions bothering on differences and associations. And so, for this work, following the experimental procedures, values that were recorded after each test were analysed with statistical instruments that looked at differences and associations. The quantitative approach used for the study, helped to collect data from a representative sample which allowed for generalisation and replication (Creswell, 2009).

The experimental type of research that was employed is the factorial design, because it was seen as the ideal way to really examine the variables thoroughly. Customer satisfaction should consequently increase as producers gain expertise and knowledge in comprehending and managing the numerous factors that affect how to care for fabrics in order to extend their useful lives. Ary, Jacobs and Razavieh (2002), also explains further that in a factorial design the investigator works around two or more variables concurrently so that the autonomous effect of each variable on the dependent variables as well as the effects caused by the interactions among the several variables will be known. In this case, a 2×3×3 factorial design was employed for the study that involved one brand of detergent (new 'Omo'), and one brand of ('Key' soap & laundry blue); specimen of 'black and white' Ghanaian printed cotton fabrics (from two Ghanaian Textiles Manufacturing Companies) and 'three cycles of washing'. For ethical reasons the names of the two companies were withheld, thus fabrics from these companies were labelled Fabrics 'A' and Fabric 'B'.

The three independent variables in this study are ‘Key’ bar soap plus laundry blue; and new ‘omo’. Each of these independent variables were manipulated singly in three washing cycles to evaluate each of their effects on the dependent variables as to the degree of colour change, dimensional stability, and tensile strength of the fabric samples.

Pre-testing

As indicated by Salkind (2010) and Cohen, Manion, and Morrison, (2018), the basic premise behind pretesting in experimental procedure is to attain a pre-test measure of the outcome of interest before undertaking an experimental action. A post-test on the same measure is frequently conducted after therapy has taken place. The researcher must perform a pre-test of the experimental procedures before carrying out the actual experiment in order to find any potential hiccups and bottlenecks in the investigation. Since the ISO standard 124:2019 specifies that the researcher conducting the study would have to determine the amount of chemicals (soaps and blue) to use, a pre-test was conducted to identify any potential snags as well as to determine the amount of soap and blue which will be suitable for washing and rinsing the fabric specimen, taking into account the weight and size of the specimen under study.

Again, as indicated by ISO 13934-1:2019 for testing African prints for fabric strength and elongation, the fabric was left to relax and was conditioned for 24 hours. A piece of fabric measuring 700mm×350mm was cut from each of the two ‘black and white’ cotton printed fabrics. A specimen block (7×30) was placed along the grain of these fabrics to help cut the fabric. In testing for the strength of a fabric, both the warp and the weft yarns will have to be tested for their strength. So, the fabric was cut in the warp and weft direction, thus 35 samples each from the warp and weft direction of the fabric.

In order to test five specimens for strength and elongation, five specimens must be used, and the mean of the five specimens is used to calculate the strength and elongation of each specimen. The same tools used in the main study to measure strength, elongation, dimensional stability, and color were used for the pretesting. The pre-testing was done to figure out how much soap and detergent would be needed to wash the sample. Also, the pretesting helped to know the quantity of ‘blue’ that would be required for each washed specimen. As indicated by ISO 124:2019 for testing African Prints, the researcher would have to decide on the quantity of chemicals to use. With this intent 1 gram of ‘blue’ was mixed with 1,400 liters of water. Due to the weight of the specimen in relation to the fastness of the ‘blue’, the solution had to be more than the soap solution used to prepare the specimens in the weft direction.

Sampling Procedure

The performance characteristics of the fabrics from two Textile Companies, the soaps and ‘blue’ were assessed based on the Ghana Standards Authority’s (GSA) specification that is, ISO standard 124:2019. Twelve yards of printed fabrics from two textiles companies were purchased from the market. Per the testing specification by the Ghana Standards Authority198 specimens in total were gathered for the trials, and 132 specimens were sampled to make it simple to distribute the specimens among the numerous tests that were carried out. In order to acquire an accurate representation of the fabric's whole surface, the specimens were carefully selected using the basic random sampling approach, which involved cutting specimens from various areas on the cloth.

Table 1: Random Sampling of the Specimen in the Warp and Weft direction of the fabric

F	P	F	P	F	P	F	P	F	P
P	F	P	F	P	F	P	F	P	F
F	P	F	P	F	P	F	P	F	P
P	F	P	F	P	F	P	F	P	F
F	P	F	P	F	P	F	P	F	P
P	F	P	F	P	F	P	F	P	F
F	P	F	P	F	P	F	P	F	P
P	F	P	F	P	F	P	F	P	F

Where (P=warp; F-weft)

Data Collection Instruments

Materials

The researcher used fabrics produced from two Textiles manufacturing Companies, because these two companies are perceived to produce good quality prints, especially, the 'black and white' cotton prints.

The detergent new 'Omo' produced by 'Uniliver' Ghana Limited was considered for the experiment because 'Omo' is a household washing agent in the Ghanaian homes used to wash fabrics that are white. This detergent contains enhanced optical brighteners that is supposed to effectively remove dirt and enhance the appearance of white fabrics (Monnie & Bosso, 2021).

The 'Key' bar soap with laundry blue were also used because anecdotal evidence shows that the Ghanaian, after washing with 'Key' soap will go ahead and use the laundry blue in the rinse cycle of the washing especially for fabrics that are 'whites. Fianu, Sallah and Ayertey (2005) used 'key' soap for their study on how sunshine and aeration procedures influence the strength of Ghanaian printed Real Wax fabrics. They detailed that 'key' soap is among the prevalent soaps used by Ghanaians to wash coloured clothes.

Furthermore, Kwame (2012) documented that 'key' soap stands tall in the soaps used in washing in Ghana. The soap is cheap, and very common on Ghanaian markets. Moreover, Market Express (2006), asserted that the 'key' bar soap is also a soap that has been used for washing garments in Ghanaian houses for a very long time and is still used by a significant portion of Ghanaians. For many years, this soap has become a Ghanaian tradition and not just a soap. Market Express (2006) strengthens the argument that 'it washes great, and perfect for coloured fabrics. These statements influenced the soap's selection for this research.

Preparation of the Specimen

Conditioning of Fabric

To get them ready for the tests, the cut specimens went through several preparation procedures. In accordance with international standard 13935-1 in ISO (1999), all test samples were relaxed for 24 hours at a temperature of 25 °C and a relative humidity of 48 °C (E).

Labelling of Specimens

The specimens were labeled according to the specimen's direction (warp, weft), the kind of cloth, and the quantity of washes. For each fabric was labelled with the letters A and B, respectively. Washed specimens were labeled 0, 1, 2, or 3 depending on how many times they had been washed. Key soap was labelled 'C', Blue was labelled 'D', and Omo was labelled 'E'.

Table 3: Labelling of Materials

NAME	LABEL

Warp direction	P
Weft direction	F
Fabric A	A
Fabric B	B
First washing	1
Second washing	2
Third washing	3
Unwashed	0
Key soap	C
Blue	D
Omo	E

Tensile test of fabric

Seventy samples were used to test for tensile strength for both Fabric A, and Fabric B. In testing for the strength of a fabric, both the warp and the weft were tested for their strength. So, the fabric was cut in the warp and weft direction, thus 35 samples each from the warp and weft direction of the fabric was used to test for the fabric strength. Table 4 contains the following information:

Table 4: Number of Tensile Strength Test Specimens

Soap type	**Fabric type**	**Yarn direction**	**30 mins. washing**	**No. of washing**	**Control**
Key Soap & 'blue'	Fabric A	Warp	15	3	5
	Fabric B	Weft	15		5
'Omo'	Fabric A	Warp	15	3	5
	Fabric B	Weft	15		5
A total of 70 samples were collected					

Colour fastness to washing

For colour fastness to washing, 5 specimens were used, each from Fabric A and Fabric B as shown in Table 5.

Table 5: Number of samples for Testing Colour Fastness

Soap type	Fabric type	30 mins. washing	30 mins washing	30 mins washing	Control
Key soap with 'blue'	FABRIC A Printex	**5** **5**	5 5	5 5	5 5
'Omo'	FABRIC A Printex	**5** **5**	5 5	5 5	5 5
There were a total of 20 specimens in this collection					

Dimensional Stability to Washing

To test the fabric specimens for dimensional stability after washing, 3 specimens, were used from Fabric A and Fabric B, as shown in Table 6; in all 18 specimens were used; 12 samples were used for the test and 6served as control specimens.

Table 6: Number of Samples used for Dimensional Stability

Soap type	Fabric type	30 mins. washing	No of wash	Control
Key soap & 'blue'	Fabric A Fabric B	3 3	3	3
'Omo'	Fabric A Fabric B	3 3	3	3
Total number of specimens: 18				

Instrumentation

The Textile Testing Laboratory of the Ghana Standards Authority has all the equipment required for the tests and has been judged reliable for usage.

The samples were cleaned using the Launder-Ometer (Gyrowash 315) standard. A magnifying lens was used to determine the weave structure of the fabric and a tensile testing machine (Hounsfield H5K-5) to determine the tensile strength of the two different types of cloth. ‘Adams's’ equipment, a weighing balance, was used to compare the weight of the materials before and after washing.

The specimens were cut with a pair of scissors and a sample cutter was used in cutting specimens for weighing. To determine the colour change after washing, the geometric grey scale used in a colour assessment chamber was used. Pictures of the instruments used for the study can be viewed from Appendices at pages 115 and 116.

Data Collection Procedure

Weighing of the Fabric Weight

The sample cutter was used to cut three specimens, measuring 10 ×10cm and weighed to determine the weight of the fabric. The cut sample was put on the Adam Equipment one at a time to determine the cloth weight, and its weight was recorded. Each cut sample piece's area for weight testing was 1.01cm^2. The average fabric weight was then computed by taking the mean of the three samples from each fabric type and dividing it by the area. The total grammage of the three specimens was 110.55gcm^2.

Preparation of Soap Solution

For washing the test specimens, solutions of "Key" soap and "Omo" were created. The solution that needed to be made was decided by the specimen's weight. It should be remembered that 1 L of water requires 5g of soap and 1 gram of specimen weight requires 50ml of soap solution. Two specimens, each weighing 6g, were used for this study, and 8 Callister cylinders, each holding 5 specimens, were used in one round of washing. Soap (key soap and new omo, each 10 g) was dissolved in 400 ml of water to create the stock solution. In one round of washing, the 400 ml of soap solution was sufficient to wash 15 specimens, with each cylinder requiring 400 ml of soap solution. This was done in order not use more than required soap in relation to the weights of the specimen. In preparation of the soap stock, distilled water was used and not tap water. This is because tap water contains dissolved salts which might interfere with the standard soap. Distilled water has no dissolved salts.

Preparation of the Laundry 'blue'

1 gram of 'blue' was mixed with 1,400ml of water. The ratio of the water in relation to the quantity of blue was more since the weight of the specimen was small in relation to the fastness of the 'blue'.

Washing of Specimens

The first set of specimens were laundered without any of the soaps or blue. This was necessary to get a standard control measure against all the other treatments, i.e., key soap plus blue, and new Omo detergent. The Launder-Ometer was preheated to 30 °C, and washing took place for 30 minutes before being rinsed in tap water and then the blue solution.

The rest of the specimens were launderd using the 'key' soap solution in the Standard Launder-Ometer (Gyrowash 315). The Launder-Ometer was again preheated to 30 °C, and washing took place for 30 minutes before being rinsed in tap water and then the blue solution. Another set of specimens was washed with the 'omo' solution and rinsed in normal tap water.

The drying for both fabrics was done in a standard conditioned room for 24hrs for each cycle of washing. After drying, the specimens were not ironed, but were tested for change in fabric strength, colour and dimensional shape that have occurred after the washing. The five samples were placed one at a time on the weighing balance (Adams's apparatus), and their values were recorded separately for each fabric type.

Testing tensile strength and elongation at break of the fabric

A magnifying glass was used to determine a straight weave structure where both warp and weft yarns meet at a 90 degrees angle. This ensured that the cutting of the fabric is done not on a deformed yarn; and also, to have an accurate cutting for the individual yarns that were frayed. Each specimen sized 30cm by 7cm and was cut in both warp and weft ways using a sample block. For weft yarns, the fabric was cut across the grain, and for warp yarns, the fabric was cut along the grain. After cutting, each specimen was frayed at 2 cm off at all sides to achieve the 30cm×5cm size required for testing. The fraying of at least 2cm, ensured that all loose ends the scissors might have left in the specimen were taken out during the fraying process.

With the use of a tensile testing machine, the ISO 13934-1 (2019) standard was applied to assess fabric strength and elongation (Mark-10 Force Gauge Model M5-500). There were 35 specimens in total: 15 from the warp and 15 from the weft, as well as five (5) control specimens. On the tensile testing apparatus, the gauge length was 100mm, and the rate of extension or speed was 25mm/minute.

After each wash cycle, the force (strength) at break and the elongation (extension) at break were documented for each specimen in both the warp and weft ways. These were also carried out on the unwashed specimens that served as controls. Maximum rupture forces were measured in newtons (N). Elongation was measured in millimeters and calculated using the ISO 13934-1 formula (2019).

Testing for dimensional stability

Each fabric was cut into two 10cm×10cm specimens with the yarns running parallel to the edges in both directions (warp and weft) and tagged for easy identification. On each specimen, two lines were drawn 10cm apart and 2.5cm from the specimen boundaries. And especially for the 'black and white' fabric the square lines were marked on where the designs were. Tacked stitches were made on the squared marked area. The specimens were washed and dried at room temperature using the Standard Launder-Ometer (Gyrowash 315). The distance between the designated lines (10cm×10cm) was then measured using a tape measure from the warp and weft direction of the specimen and documented to see if any change in the original dimension (10cm10cm) had happened. The computation was done as thus:

$$\text{Dimensional Change} = \frac{\text{Change in Length}}{\text{Original Length}} \times 100$$

Testing for colour fastness to washing

Following washing and drying, the test for colour change after washing was done. The geometric grey scale was used to assess the color change in 18 washed specimens from the two fabric types in order to determine any colour changes that may had happened after washing. The specimens that served as the 'control' and those that got the 'treatment' (from each washing cycle) were positioned closely beside each other in the same orientation under a florescent light system for the visual assessment test.

The colour values between the treated specimens and the control specimens were computed. The amplitude and degrees of contrast offered by the grey scale values were used to describe the differences in shade or colour. The grey scale's colorfastness ratings varied from excellent to poor, with grade 5 denoting exceptional, grade 4 denoting very good, grade 3 denoting decent, grade 2 denoting reasonably acceptable, and grade 1 denoting poor colour fastness to washing. All treated samples of each fabric type were compared to the standard rating for each yarn direction (warp and weft), soap type, and washing cycle time, and the difference in colour change were noted.

The technicians at the textile laboratory of the Ghana Standards Authority helped with all of these testing techniques. It is, also, worth-noting that the test methods that was used for this work was curled from the ISO standards, adopted by the GSA. The duration of the experiments was from the 9th January, 2020 to the 5th of February, 2021.

Data Analysis

There are several test statistics such as Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root for assessing the interaction effect of factors in MANOVA analysis. Wilk's Lambda which is one of the most used test statistic for MANOVA, was used to analyse the interactive effect between the variables the objective of this study which was to determine whether any effects or variances existed and among the groups.

It is, also, worth-noting that the test methods that was used for this work was curled from the ISO standards, adopted by the GSA. Before the data were collected on the results of the experiments, the specimens were accustomed for a day to get it in a stress-free state at a relative humidity of 48 2% and a temperature of 25° 1 °C in accordance with ISO 139 (2009). For accurate findings, it is crucial that the test subjects are at a comfortable temperature and in a relaxed state prior to the test. Readings were taken for each of the identified tests on both washed and unwashed specimens

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

The study sought to find out the effect of soap type, washing blue (whitening agent) and wash cycle have on the colour, tensile strength and dimensional stability of two fabric types (Fabric A and Fabric B) produced in Ghana. The experiment was conducted using "key bar soap" and "new Omo" as the soap type with and without washing "blue" as whitening agent through three washing cycles (first, second and third washings).

The results of the objective for the study were used to conduct data analysis and interpretation. This research was also based on data from a laboratory experiment that yielded a 100% return rate. The chapter presents the results of each of the tests identified from washed, and unwashed specimens. The raw data from the laboratory were computed using Microsoft Excel, and the data for the study were analysed using the Statistical Package and Service Solution (SPSS) for Windows version 26.

The research outcomes were shown based on the objectives formulated for the study. The Chapter is organized under the following headings:

1. The structural attributes of fabric samples used in the study
2. Effect of soap type and wash cycles on the colour fastness, tensile properties, and dimensional stability of the two Ghanaian cotton printed fabrics:
    a. Assessing the interaction effect of factors

b. The interaction effect between soap type and the number of wash cycles.

c. The interaction effect between washing blue and the number of wash cycles.

d. The actual measure of the fabric's tensile strength and dimensional stability which the effects are exhibited.

e. The interaction effect between soap type and the number of wash cycles.

f. Interaction effect between the washing blue and washed cycle

g. Multiple Comparisons Tests based on Soap type

h. Comparisons Tests based on washing blue

Results

Objective 1: To examine the structural attributes of fabric samples used in the study

Structural attributes include yarn count, fabric thickness, and fabric weight, which can significantly impact the performance of a textile fabric. For this study, selected structural and performance characteristics such as yarn count, tensile strength, elongation, and fabric weight of the two fabrics were considered to see how their differences are likely to impact their performance. In order to do this, means and standard deviation for the characteristics of both textiles were computed. The findings are shown in Table 7. The two fabrics were 100% cotton with a plain weave of 1×1 repeat in warp and weft directions.

Table 7 is the result of the means and standard deviations of the fabrics.

Results from table 7 shows that there were more warp and weft yarns in fabric A than in fabric B. However, although fabric A was stronger in the warp direction the reverse was true for the weft direction. The weight of the fabrics also demonstrated that fabric B with fewer yarn counts weighed than fabric B.

Table 7: Fabric Performance characteristics of the two fabrics

Fabric attributes	Number of specimens	Mean	Standard Deviation
Fabric A			
Yarn counts			
Warp	5	98 E.P. I	9.8
Weft	5	56.4 P.P. I	4.7
Tensile strength (N)			
Warp	5	507	3.697
Weft	5	308	4.539
Elongation			
Warp	5	11.81	2.069
Weft	5	37.89	6.241
Weight (g/m^2)	3	110.55	7.6
Fabric B			
Yarn counts			
Warp	5	96.5 E.P. I	11.8
Weft	5	55.9 P.P. I	6.7
Tensile Strength (N)			
Warp	5	450	2.914
Weft	5	323	3.006
Elongation (%)			
Warp	5	12.69	2.43
Weft	5	44.81	6.24
Weight (g/m^2)	3	128.9	7.8

Field data, Kusi (2021)

Additionally, fabric A shows a warp count higher that a weft count with a corresponding higher strength in the warp direction than the weft direction. For elongation, however, it was higher in the weft direction than in the warp. The results for fabric B followed a similar trend.

Objective 2a. Effect of soap type and wash cycles on the colour fastness of 'black and white' cotton textile fabrics

Both fabrics were tested for colour fastness using the Greyscale. On the greyscale, calibration is in ranges; from 1 to 5, with 1 denoting weak colourfastness and 5 denoting excellent colourfastness. As a result, the Greyscale is divided into five categories: **1**, 1-2, **2**, 2-3, **3**, 3-4, **4**, 4-5, and **5**. A cotton cloth passes the colour fastness test if it can preserve at least 4 units of its colour on the greyscale, according to GS ISO 124: 2019.

The proceeding section (Table 8) presents results on the effect of washing with the new omo and then key soap plus laundry blue on the colour fastness of sample fabrics A and B 'black and white cotton printed fabrics after three washing cycles.

Fabric A

Table 8: Effect of soap type and wash cycles on colour of fabric A

Fabric Type	**Soap type**	**Control**	**Wash Cycles**		
			1st wash	2nd wash	3rd wash
Fabric A	Key soap (plus blue)	4-5	4-5	4	4
	New 'Omo'	4-5	4-5	4-5	4-5

Source: field data, Kusi, (2021)

Fabric B

Table 9: effect of Key soap and new Omo on the colour of Fabric B

Fabric Type	**Soap Type**	**Control**	**Wash Cycles**		
Fabric B	Key soap (plus blue)	4-5	1st wash	2nd wash	3rd wash
			4	4	4
	New 'Omo'	4-5	4-5	4-5	4-5

Source: field data, Kusi, (2021)

Objective 2 Effect of soap type and wash cycle on the Tensile Strength and dimensional stability of Fabric A

The results for the multivariate analysis of variance (MANOVA) for the variables for tensile strength is presented in Table 10 for fabric A.

There are several test statistics such as Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root for assessing the interaction effect of factors in MANOVA analysis (Ary & Jacobs, 2002).

Table 10: Multivariate Tests on Fabric A

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.
Intercept	0.001	7533.712	6.000	52.000	0.000
Soap type	0.572	6.491	6.000	52.000	0.000
Washing blue	0.560	6.801	6.000	52.000	0.000
Washed cycle	0.165	12.683	12.000	104.000	0.000
Soap type * Washing blue	0.117	65.470	6.000	52.000	0.000
Soap type * Washed cycle	0.708	1.630	12.000	104.000	0.094
Washing blue * Washed cycle	0.716	1.579	12.000	104.000	0.109

Soap type * Washing blue * Washed cycle	0.113	17.154	12.000	104.000	0.000

Design: *Intercept + Soap type + Washing blue + Washed cycle + Soap type*Washing blue + Soap type*Washed cycle + Washing blue*Washed cycle + Soap type*Washing blue*Washed cycle*

Thus, using Wilk's Lambda which is one of the most used test statistics for MANOVA (Ary & Jacobs, 2002), it can be observed from Table 10 that with Wilks' Lambda value of 0.117 (p = 0.000), there was a statistically significant interaction between the soap type and washing blue used in washing the Fabric '**A'** across the measures for the fabric's tensile strength and dimensional stability (Strength Warp, Strength Weft, Elongation Warp and Elongation Weft Shrinkage Warp, Shrinkage Weft,). On the other hand, with a Wilks' Lambda of 0.708 (p = 0.094), Table 10 again shows that the interaction effect of the soap type and washed cycle of the Fabric 'A's warp and weft's strength, shrinkage and elongation were statistically insignificant at 0.05 significance level. Similarly, it was observed that there was a statistically insignificant interaction effects of the washing blue and the washed cycle of the fabric on the its tensile strength and dimensional stability with a Wilks' Lambda of 0.716 (p = 0.109). Finally, it can be observed from Table 10 that – with Wilks' Lambda value of 0.113 (p = 0.000) – a combination of the three factors; the soap type, washing blue and the number of times Fabric A was washed, has a statistically significant effect on the fabric's tensile strength and dimensional stability.

Having found that there was a statistically significant interaction between the soap type, washing blue and washed cycle on the Fabric 'A's tensile strength and dimensional stability, it was necessary to know the actual measure of the fabric's tensile strength and dimensional stability which the effects are exhibited. Thus, Table 10 again provides the results of the test on the individual measures of tensile strength and dimensional stability.

Table 11: Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	R^2 (Adj. R^2)
Corrected Model	Strength Warp	354143.600	12	29511.967	24.060	.000	0.835 (0.800)
	Strength Weft	186512.586	12	15542.715	13.063	.000	0.733 (0.677)
	Shrinkage Warp	52.643	12	4.387	14.538	.000	0.754 (0.702)
	Shrinkage Weft	142.286	12	11.857	73.463	.000	0.939 (0.926)
	Elongation Warp	218.445	12	18.204	25.123	.000	0.841 (0.808)
	Elongation Weft	3955.630	12	329.636	17.492	.000	0.786 (0.741)
Intercept	Strength Warp	12449495.022	1	12449495.022	10149.451	.000	
	Strength Weft	5750809.745	1	5750809.745	4833.148	.000	
	Shrinkage Warp	163.792	1	163.792	542.799	.000	
	Shrinkage Weft	521.951	1	521.951	3233.825	.000	
	Elongation Warp	11830.685	1	11830.685	16327.669	.000	
	Elongation Weft	96221.017	1	96221.017	5106.051	.000	
Soap type	Strength Warp	9176.067	1	9176.067	7.481	.008	
	Strength Weft	8616.017	1	8616.017	7.241	.009	
	Shrinkage Warp	0.817	1	0.817	2.706	.105	
	Shrinkage Weft	2.400	1	2.400	14.870	.000	
	Elongation Warp	0.121	1	0.121	0.168	.684	
	Elongation Weft	83.073	1	83.073	4.408	.040	
Washing blue	Strength Warp	806.667	1	806.667	.658	.421	
	Strength Weft	88.817	1	88.817	.075	.786	
	Shrinkage Warp	1.350	1	1.350	4.474	.039	
	Shrinkage Weft	5.400	1	5.400	33.457	.000	
	Elongation Warp	0.048	1	0.048	0.066	.797	
	Elongation Weft	57.233	1	57.233	3.037	.087	
Washed cycle	Strength Warp	83746.800	2	41873.400	34.137	.000	
	Strength Weft	93929.200	2	46964.600	39.470	.000	
	Shrinkage Warp	1.733	2	0.867	2.872	.065	
	Shrinkage Weft	7.300	2	3.650	22.614	.000	
	Elongation Warp	15.523	2	7.761	10.712	.000	
	Elongation Weft	92.332	2	46.166	2.450	.095	
Soap type * Washing blue	Strength Warp	156877.067	1	156877.067	127.894	.000	
	Strength Weft	17170.417	1	17170.417	14.431	.000	

	Shrinkage Warp	12.150	1	12.150	40.265	.000
	Shrinkage Weft	11.267	1	11.267	69.804	.000
	Elongation Warp	35.420	1	35.420	48.884	.000
	Elongation Weft	2529.803	1	2529.803	134.246	.000
Soap type * Washed cycle	Strength Warp	7276.933	2	3638.467	2.966	.059
	Strength Weft	6902.933	2	3451.467	2.901	.063
	Shrinkage Warp	0.133	2	0.067	0.221	.802
	Shrinkage Weft	0.700	2	0.350	2.168	.124
	Elongation Warp	0.907	2	0.454	0.626	.538
	Elongation Weft	48.076	2	24.038	1.276	.287
Washing blue * Washed cycle	Strength Warp	8051.733	2	4025.867	3.282	.045
	Strength Weft	3100.933	2	1550.467	1.303	.280
	Shrinkage Warp	1.200	2	0.600	1.988	.146
	Shrinkage Weft	0.700	2	0.350	2.168	.124
	Elongation Warp	1.022	2	0.511	0.705	.498
	Elongation Weft	70.712	2	35.356	1.876	.163
Soap type * Washing blue * Washed cycle	Strength Warp	24666.533	2	12333.267	10.055	.000
	Strength Weft	22413.733	2	11206.867	9.419	.000
	Shrinkage Warp	.400	2	0.200	0.663	.519
	Shrinkage Weft	3.433	2	1.717	10.636	.000
	Elongation Warp	132.642	2	66.321	91.531	.000
	Elongation Weft	1074.172	2	537.086	28.501	.000
Error	Strength Warp	69917.200	57	1226.618		
	Strength Weft	67822.500	57	1189.868		
	Shrinkage Warp	17.200	57	0.302		
	Shrinkage Weft	9.200	57	0.161		
	Elongation Warp	41.301	57	0.725		
	Elongation Weft	1074.137	57	18.845		
Total	Strength Warp	13103536.000	70			
	Strength Weft	6096182.000	70			
	Shrinkage Warp	279.000	70			
	Shrinkage Weft	818.000	70			
	Elongation Warp	12990.260	70			
	Elongation Weft	106269.430	70			
Corrected Total	Strength Warp	424060.800	69			
	Strength Weft	254335.086	69			
	Shrinkage Warp	69.843	69			
	Shrinkage Weft	151.486	69			
	Elongation Warp	259.746	69			
	Elongation Weft	5029.767	69			

Source: Field Data Kusi, (2021)

It can be observed from Table 11 that, with all the sig. values equal to 0.000, there are statistically significant interactions effects between the soap type and the washing blue on the tensile strength and dimension stability characteristics of the Fabric A fabric (strength warp, $F_{(1, 57)}$ = 127.894, p = 0.000; strength weft, $F_{(1, 57)}$ = 14.431, p = 0.000; shrinkage warp, $F_{(1, 57)}$ = 40.265, p = 0.000; shrinkage weft, $F_{(1, 57)}$ = 69.804, p = 0.000; elongation warp, $F_{(1, 57)}$ = 48.884, p = 0.000; and elongation weft, $F_{(1, 57)}$ = 134.246, p = 0.000).

With p-values of between 0.124 and 0.802, it can be observed from Table 11 that the observed interaction effects of the soap type and washed cycle on the tensile strength and the dimensional characteristics of the Fabric A such as shrinkage warp, $F_{(2, 57)}$ = 0.221, p = 0.802; shrinkage weft, $F_{(2, 57)}$ = 2.168, p = 0.124; elongation warp, $F_{(2, 57)}$ = 0.626, p =.538; and elongation weft, $F_{(2, 57)}$ = 1.276, p = 0.287, were statistically insignificant. Table 11 also shows that the interaction effects of the soap type and washed cycle on the strength warp and weft of the Fabric A were statistically insignificant (strength warp, $F_{(2, 57)}$ = 2.966, p = 0.059; strength weft, $F_{(2, 57)}$ = 2.901, p = 0.063).

On the effect of the interaction between the washing blue and washed cycle on the tensile strength and dimensional stability characteristics of the Fabric A, Table 11 similarly indicates that there were insignificant effects (strength weft, $F_{(2, 57)}$ = 1.303, p = 0.280; shrinkage warp, $F_{(2, 57)}$ = 1.988, p = 0.146; shrinkage weft, $F_{(2, 57)}$ = 2.168, p = 0.124; elongation warp, $F_{(2, 57)}$ = 0.705, p = 0.498; and elongation weft, $F_{(2, 57)}$ = 1.876, p = 0.163) except the fabric's strength warp, $F_{(2, 57)}$ = 3.282, p = 0.045.

Regarding the effect of the interaction between the soap type, the washing blue and the washed cycle, it can be observed from Table 11 that with the exception of the shrinkage warp of the Fabric 'A', ($F_{(2, 57)}$ = 0.663, p = 0.519), the effects of the soap type, the washing blue and the washed cycle on the tensile strength and dimensional stability characteristics of the fabric were statistically significant (Strength Warp, $F_{(2, 57)}$ = 10.055, p = 0.000; Strength Weft, $F_{(2, 57)}$ = 9.419, p = 0.000; Shrinkage Weft, $F_{(2, 57)}$ = 10.636, p = 0.000; Elongation Warp, $F_{(2, 57)}$ = 91.531, p = 0.000; Elongation Weft, $F_{(2, 57)}$ = 28.501, p = 0.000).

Table 12: Tukey Post Hoc Multiple Comparisons Tests on Fabric A based on Soap type

Dependent Variable	(I) Soap type	(J) Soap type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Strength Warp	No washing agent	Key bar soap	98.47*	12.789	.000	67.69	129.24
		New Omo	73.73*	12.789	.000	42.96	104.51
	Key bar soap	No washing agent	-98.47*	12.789	.000	-129.24	-67.69
		New Omo	-24.73*	9.043	.022	-46.49	-2.97
	New Omo	No washing agent	-73.73*	12.789	.000	-104.51	-42.96
		Key bar soap	24.73*	9.043	.022	2.97	46.49
Strength Weft	No washing agent	Key bar soap	75.23*	12.596	.000	44.92	105.54
		New Omo	51.27*	12.596	.000	20.96	81.58
	Key bar soap	No washing agent	-75.23*	12.596	.000	-105.54	-44.92
		New Omo	-23.97*	8.906	.025	-45.40	-2.53
	New Omo	No washing agent	-51.27*	12.596	.000	-81.58	-20.96
		Key bar soap	23.97*	8.906	.025	2.53	45.40
Shrinkage Warp	No washing agent	Key bar soap	-1.90*	.201	.000	-2.38	-1.42
		New Omo	-2.13*	.201	.000	-2.62	-1.65

	Key bar soap	No washing agent	1.90*	.201	.000	1.42	2.38
		New Omo	-.23	.142	.235	-.57	.11
	New Omo	No washing agent	2.13*	.201	.000	1.65	2.62
		Key bar soap	.23	.142	.235	-.11	.57
Shrinkage Weft	No washing agent	Key bar soap	-3.40*	.147	.000	-3.75	-3.05
		New Omo	-3.80*	.147	.000	-4.15	-3.45
	Key bar soap	No washing agent	3.40*	.147	.000	3.05	3.75
		New Omo	-.40*	.104	.001	-.65	-.15
	New Omo	No washing agent	3.80*	.147	.000	3.45	4.15
		Key bar soap	.40*	.104	.001	.15	.65
Elongation Warp	No washing agent	Key bar soap	-1.910*	.3108	.000	-2.658	-1.162
		New Omo	-2.000*	.3108	.000	-2.748	-1.252
	Key bar soap	No washing agent	1.910*	.3108	.000	1.162	2.658
		New Omo	-.090	.2198	.912	-.619	.439
	New Omo	No washing agent	2.000*	.3108	.000	1.252	2.748
		Key bar soap	.090	.2198	.912	-.439	.619
Elongation Weft	No washing agent	Key bar soap	1.0133	1.58512	.799	-2.8011	4.8278
		New Omo	-1.3400	1.58512	.677	-5.1545	2.4745
	Key bar soap	No washing agent	-1.0133	1.58512	.799	-4.8278	2.8011
		New Omo	-2.3533	1.12085	.099	-5.0506	.3439
	New Omo	No washing agent	1.3400	1.58512	.677	-2.4745	5.1545
		Key bar soap	2.3533	1.12085	.099	-.3439	5.0506

Based on observed means.

The error term is Mean Square (Error) = 18.845.

*. The mean difference is significant at the .05 level.

It can be observed from Table 12 that strength warp of the unwashed Fabric A (not treated in any way) was significantly higher than those washed (or treated) with Key bar soap and new Omo detergent by 98.47 (p = 0.000) and 73.73 (p = 0.000) respectively. Also, the strength warp of fabric A washed with Key bar soap was found to be significantly less than those washed with New Omo washing detergent (24.73, p = 0.022). Table 12 also shows that the strength weft of the unwashed Fabric A was significantly higher than those washed with Key bar soap (75.23, p = 0.000) and New Omo washing detergent (51.27, p = 0.000). Moreover, the strength weft of the same fabric which had been washed with Key bar soap was significantly lower than that washed with New Omo detergent (23.97, p = 0.000).

About the Fabric A's shrinkage, Table 12 shows that the unwashed fabric's shrinkage warp was significantly less than those which were washed with Key bar soap (-1.90, p = 0.000) and New Omo washing detergent (-2.13, p = 0.000). Also, the shrinkage warp of the fabric A which was washed with key bar soap was slightly less than that which was washed with New Omo washing detergent (-0.23). However, this observed difference was statistically insignificant – with p = 0.235. Table 12 further revealed that the shrinkage weft of the Fabric A fabric that was washed with New Omo detergent was significantly higher than that which had either been washed with Key bar soap (0.40, p = 0.001) or never washed (3.80, p = 0.000). However, the shrinkage weft of the fabric which had been washed Key bar soap was significantly higher than that which had not been washed (3.40, p = 0.000).

Considering Fabric 'A's elongation, Table 12 shows that the fabric's elongation warp was significantly lower when it had received no treatment at all than when it was washed with Key bar soap and New Omo detergent by 1.910 (p = 0.000) and 2.000 (p = 0.000) respectively. Using New Omo detergent to wash the FABRIC A fabric produced a slightly higher elongation warp than when Key bar soap was used (0.09). However, the slightly higher elongation warp was statistically insignificant (*p* = 0.000). On the weft, Table 12 shows that fabric 'A's elongation in the weft was insignificantly slightly higher when Key bar soap was used to wash it as compared with when it was washed with New Omo washing detergent (-2.353, *p* = 0.099) and when it had not been washed at all (-1.013, *p* = 0.799). However, there was an insignificant mean difference of 1.340 (*p* = 0.677) between the elongation weft of the fabric when it was washed with New Omo washing detergent and when it had not been washed at all.

Table 13: Tukey Post Hoc Multiple Comparisons Tests on Fabric A based on washing blue

Dependent Variable	(I) Washing blue type	(J) Washing blue type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Strength Warp	Unwashed	With blue	82.43*	12.789	.000	51.66	113.21
		Without blue	89.77*	12.789	.000	58.99	120.54
	With blue	Unwashed	-82.43*	12.789	.000	-113.21	-51.66
		Without blue	7.33	9.043	.698	-14.43	29.09
	Without blue	Unwashed	-89.77*	12.789	.000	-120.54	-58.99
		With blue	-7.33	9.043	.698	-29.09	14.43
Strength Weft	Unwashed	With blue	62.03*	12.596	.000	31.72	92.34
		Without blue	64.47*	12.596	.000	34.16	94.78
	With blue	Unwashed	-62.03*	12.596	.000	-92.34	-31.72
		Without blue	2.43	8.906	.960	-19.00	23.87
	Without blue	Unwashed	-64.47*	12.596	.000	-94.78	-34.16
		With blue	-2.43	8.906	.960	-23.87	19.00
Shrinkage Warp	Unwashed	With blue	-1.87*	.201	.000	-2.35	-1.38
		Without blue	-2.17*	.201	.000	-2.65	-1.68
	With blue	Unwashed	1.87*	.201	.000	1.38	2.35
		Without blue	-.30	.142	.096	-.64	.04
	Without blue	Unwashed	2.17*	.201	.000	1.68	2.65
		With blue	.30	.142	.096	-.04	.64
Shrinkage Weft	Unwashed	With blue	-3.30*	.147	.000	-3.65	-2.95
		Without blue	-3.90*	.147	.000	-4.25	-3.55
	With blue	Unwashed	3.30*	.147	.000	2.95	3.65
		Without blue	-.60*	.104	.000	-.85	-.35
	Without blue	Unwashed	3.90*	.147	.000	3.55	4.25
		With blue	.60*	.104	.000	.35	.85
Elongation Warp	Unwashed	With blue	-1.927*	.3108	.000	-2.675	-1.179
		Without blue	-1.983*	.3108	.000	-2.731	-1.235
	With blue	Unwashed	1.927*	.3108	.000	1.179	2.675
		Without blue	-.057	.2198	.964	-.586	.472
	Without blue	Unwashed	1.983*	.3108	.000	1.235	2.731

		With blue	.057	.2198	.964	-.472	.586
Elongation Weft	Unwashed	With blue	-1.1400	1.58512	.753	-4.9545	2.6745
		Without blue	.8133	1.58512	.865	-3.0011	4.6278
	With blue	Unwashed	1.1400	1.58512	.753	-2.6745	4.9545
		Without blue	1.9533	1.12085	.198	-.7439	4.6506
	Without blue	Unwashed	-.8133	1.58512	.865	-4.6278	3.0011
		With blue	-1.9533	1.12085	.198	-4.6506	.7439

Based on observed means.
The error term is Mean Square (Error) = 18.845.
*. The mean difference is significant at the .05 level.

It can be observed from Table 13 that strength warp of the unwashed fabric was significantly higher than those washed with washing blue and without washing blue by 82.43 (p = 0.000) and 89.77 (p = 0.000) respectively. The strength warp of fabric A, when washed with blue was found to be insignificantly higher than that washed without washing blue (7.33, p = 0.698). Table 13 also shows that the strength weft of the unwashed FABRIC A fabric was significantly higher than those washed with washing blue (62.03, p = 0.000) and without washing blue (64.47, p = 0.000). Furthermore, the strength weft of the fabric which had been washed with washing blue was slightly higher than that washed without washing blue. However, the observed difference was statistically insignificant (2.43, p = 0.960).

Regarding fabric A's shrinkage, Table 13 shows that the unwashed fabric's shrinkage warp was significantly lower than those washed with washing blue (-1.87, p = 0.000) and without washing blue (-2.17, p = 0.000). The shrinkage warp of the fabric that was washed with washing blue was insignificantly slightly less than that which was washed without washing blue (-0.30, p = 0.096). The table further reveals that the shrinkage weft of the unwashed fabric A was significantly lower than those washed with and without washing blue (-3.30, p = 0.000 and -3.90, p = 0.000). Moreover, the shrinkage the weft direction of the fabric when washed with washing blue was found to be significantly lower than that which had never been washed (-0.60, *p* = 0.000).

For elongation in the warp and weft yarns, Table 13 shows that the unwashed fabric A's elongation warp was significantly lower than those washed with washing blue (-1.927, *p* = 0.000) and without washing blue (-1.983, *p* = 0.000). However, washing the fabric 'A' with washing blue produced an insignificantly slightly lower elongation warp than when it was washed without washing blue (-0.057, *p* = 0.964). On the weft, Table 13 shows that fabric 'A's elongation in the weft was insignificantly slightly higher when washing blue was used to wash it vis-a-vis when it was washed without washing blue (unwashed, 1.140, *p* = 0.753; without washing blue, 1.953, *p* = 0.198). Moreover, the elongation weft of the unwashed fabric 'A' was insignificantly higher than that washed without washing blue (0.813, *p* = 0.865).

Fabric B

The results for the multivariate analysis of variance (MANOVA) for the variables for tensile strength is presented in Table 14 for fabric B.

Table 14: Multivariate Tests on Fabric B Fabric

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.
Intercept	0.001	6866.803	6.000	52.000	0.000
Soap type	0.656	4.540	6.000	52.000	0.001
Washing blue	0.944	0.513	6.000	52.000	0.796
Washed cycle	0.097	19.201	12.000	104.000	0.000
Soap type * Washing blue	0.674	4.187	6.000	52.000	0.002
Soap type * Washed cycle	0.487	3.755	12.000	104.000	0.000

Washing blue * Washed cycle	0.454	4.200	12.000	104.000	0.000
Soap type * Washing blue * Washed cycle	0.339	6.208	12.000	104.000	0.000

Design: *Intercept + Soap type + Washing blue + Washed cycle + Soap type*Washing blue + Soap type*Washed cycle + Washing blue*Washed cycle + Soap type*Washing blue*Washed cycle*

Likewise, using Wilk's Lambda, Table 14 shows that with Wilks' Lambda value of 52.000 (p = 0.796), there was a statistically insignificant effect of washing blue on the Fabric B's measures for tensile strength and dimensional stability. On the contrary, the effect of the soap type and washed cycle as well as their interactions with the washing blue had statistically significant effects on the fabric's tensile strength and dimensional stability measures (soap type, Wilks' Lambda = 0.656, p = 0.001; washed cycle, Wilks' Lambda = 0.097, p = 0.000; soap type*washing blue, Wilks' Lambda = 0.674, p = 0.002; soap type*washed cycle, Wilks' Lambda = 0.487, p = 0.000; washing blue*washed cycle, Wilks' Lambda = 0.454, p = 0.000; soap type*washing blue*washed cycle, Wilks' Lambda = 0.339, p = 0.000).

Knowing that there was a statistically significant interaction between the soap type, washing blue and washed cycle on the Fabric B's tensile strength and dimensional stability, the study sought to find out the exact tensile strength and dimensional stability measure(s) which had been affected. In view of this, Table 15 shows the results of the test on the individual measures of tensile strength and dimensional stability.

Table 15: Tests of Between-Subjects Effects on Fabric B Fabric

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	R^2 (Adj. R^2)
Corrected Model	Strength Warp	364889.386	12	30407.449	18.481	.000	0.796 (0.752)

	Strength Weft	279312.571	12	23276.048	27.729	.000	0.854 (0 .823)
	Shrinkage Warp	23.043	12	1.920	7.396	.000	0 .609 (0.527)
	Shrinkage Weft	145.886	12	12.157	91.179	.000	0 .950 (0.940)
	Elongation Warp	78.725	12	6.560	12.771	.000	0 .729 (0.672)
	Elongation Weft	1586.114	12	132.176	12.512	.000	0 .725 (0.667)
Intercept	Strength Warp	9901479.224	1	9901479.224	6017.808	.000	
	Strength Weft	5344380.823	1	5344380.823	6366.720	.000	
	Shrinkage Warp	88.614	1	88.614	341.283	.000	
	Shrinkage Weft	666.042	1	666.042	4995.315	.000	
	Elongation Warp	11174.433	1	11174.433	21752.764	.000	
	Elongation Weft	131530.960	1	131530.960	12450.950	.000	
Soap type	Strength Warp	17374.017	1	17374.017	10.559	.002	
	Strength Weft	5645.400	1	5645.400	6.725	.012	
	Shrinkage Warp	.417	1	.417	1.605	.210	
	Shrinkage Weft	1.067	1	1.067	8.000	.006	
	Elongation Warp	.096	1	.096	.187	.667	
	Elongation Weft	82.134	1	82.134	7.775	.007	
Washing blue	Strength Warp	58.017	1	58.017	.035	.852	
	Strength Weft	1.667	1	1.667	.002	.965	
	Shrinkage Warp	.017	1	.017	.064	.801	
	Shrinkage Weft	.067	1	.067	.500	.482	
	Elongation Warp	.033	1	.033	.064	.802	
	Elongation Weft	23.814	1	23.814	2.254	.139	
Washed cycle	Strength Warp	208640.100	2	104320.050	63.402	.000	
	Strength Weft	211417.633	2	105708.817	125.930	.000	
	Shrinkage Warp	.433	2	.217	.834	.439	
	Shrinkage Weft	.233	2	.117	.875	.422	
	Elongation Warp	33.124	2	16.562	32.240	.000	
	Elongation Weft	246.306	2	123.153	11.658	.000	
Soap type * Washing blue	Strength Warp	156.817	1	156.817	.095	.759	
	Strength Weft	5.400	1	5.400	.006	.936	
	Shrinkage Warp	.017	1	.017	.064	.801	
	Shrinkage Weft	.067	1	.067	.500	.482	
	Elongation Warp	8.817	1	8.817	17.163	.000	

	Elongation Weft	26.401	1	26.401	2.499	.119
Soap type * Washed cycle	Strength Warp	28948.033	2	14474.017	8.797	.000
	Strength Weft	13450.300	2	6725.150	8.012	.001
	Shrinkage Warp	.633	2	.317	1.220	.303
	Shrinkage Weft	.633	2	.317	2.375	.102
	Elongation Warp	.052	2	.026	.051	.951
	Elongation Weft	101.773	2	50.887	4.817	.012
Washing blue * Washed cycle	Strength Warp	135.033	2	67.517	.041	.960
	Strength Weft	2.033	2	1.017	.001	.999
	Shrinkage Warp	1.033	2	.517	1.990	.146
	Shrinkage Weft	1.233	2	.617	4.625	.014
	Elongation Warp	.177	2	.089	.173	.842
	Elongation Weft	394.221	2	197.110	18.659	.000
Soap type * Washing blue * Washed cycle	Strength Warp	225.633	2	112.817	.069	.934
	Strength Weft	17.100	2	8.550	.010	.990
	Shrinkage Warp	1.633	2	.817	3.145	.051
	Shrinkage Weft	.833	2	.417	3.125	.052
	Elongation Warp	5.157	2	2.579	5.020	.010
	Elongation Weft	629.270	2	314.635	29.784	.000
Error	Strength Warp	93785.700	57	1645.363		
	Strength Weft	47847.200	57	839.425		
	Shrinkage Warp	14.800	57	.260		
	Shrinkage Weft	7.600	57	.133		
	Elongation Warp	29.281	57	.514		
	Elongation Weft	602.144	57	10.564		
Total	Strength Warp	10391124.000	70			
	Strength Weft	5711494.000	70			
	Shrinkage Warp	151.000	70			
	Shrinkage Weft	1004.000	70			
	Elongation Warp	12133.810	70			
	Elongation Weft	142018.800	70			
Corrected Total	Strength Warp	458675.086	69			
	Strength Weft	327159.771	69			
	Shrinkage Warp	37.843	69			
	Shrinkage Weft	153.486	69			

Elongation Warp	108.006	69
Elongation Weft	2188.258	69

Source: Field Data (2021)

Table 15 reveals that apart from Fabric B's elongation warp which was significantly affected by the interaction of the soap type and the washing blue, $F_{(1, 57)} = 17.163$, p = 0.000, all the other tensile strength and dimensional stability measures were statistically insignificant (strength warp, $F_{(1, 57)}$ = 0.095, p = 0.759; strength weft, $F_{(1, 57)}$ = 0.006, p = 0.936; shrinkage warp, $F_{(1, 57)}$ = 0.064, p = 0.801; shrinkage weft, $F_{(1, 57)}$ = 0.500, p = 0.482; elongation weft, $F_{(1, 57)}$ = 2.499, p = 0.119). It can also be seen from Table 16 that the effect of the interactions of the soap type and washed cycle on the strength warp ($F_{2, 57)}$ = 8.797, p - 0.000) and weft ($F_{(2, 57)}$ = 8.012, p = 0.001), and elongation weft were statistically significant ($F_{(2, 57)}$ = 4.817, p = 0.012). Contrarily, the effect of the interaction between the soap type and washed cycle on the shrinkage warp, ($F_{(2, 57)}$ = 1.220, p = 0.303), shrinkage weft, ($F_{(2, 57)}$ = 2.375, p = 0.102) and elongation warp, ($F_{(2, 57)}$ = 0.051, p = 0.951) were statistically insignificant.

Regarding the effect of the interaction between the washing blue and washed cycle on the tensile strength and the dimensional stability of the Fabric B, it can be observed from Table 16 that the shrinkage weft, $F_{(2, 57)}$ = 4.625, p = 0.014, and elongation weft, $F_{(2, 57)}$ = 18.659, p = 0.000. were statistically significant. However, the fabric's strength warp ($F_{(2, 57)}$ = 0.041, p = 0.960), strength weft ($F_{(2, 57)}$ = 0.001, p = 0.999), shrinkage warp ($F_{(2, 57)}$ = 1.990, p = 0.146) and elongation warp ($F_{(2, 57)}$ = 0.173, p = 0.842) were statistical insignificant. Finally, considering the interaction effect of the soap type, washing blue and washed cycles, Table 16 indicates that the elongation warp ($F_{(2, 57)}$ = 5.020, p = 0.010) and elongation weft ($F_{(2, 57)}$ = 29.784, p = 0.000) of the Fabric B fabric are affected. On the other hand, the fabric's strength warp ($F_{(2, 57)}$ = 0.069, p = 0.934), strength weft ($F_{(2, 57)}$ = 0.010, p = 0.990), shrinkage warp ($F_{(2, 57)}$ = 3.145, p = 0.051), shrinkage weft ($F_{(2, 57)}$ = 3.125, p = 0.052) were not affected by the interaction of the effects of the soap type, washing blue and washed cycles.

Table 16: Tukey Post Hoc Multiple Comparisons Tests on Fabric B Fabric based on Soap type

Dependent Variable	(I) Soap type	(J) Soap type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Strength Warp	No washing agent	Key bar soap	129.97*	14.812	.000	94.32	165.61
		New Omo	95.93*	14.812	.000	60.29	131.58
	Key bar soap	No washing agent	-129.97*	14.812	.000	-165.61	-94.32
		New Omo	-34.03*	10.473	.005	-59.24	-8.83
	New Omo	No washing agent	-95.93*	14.812	.000	-131.58	-60.29
		Key bar soap	34.03*	10.473	.005	8.83	59.24
Strength Weft	No washing agent	Key bar soap	85.13*	10.579	.000	59.67	110.59
		New Omo	65.73*	10.579	.000	40.27	91.19
	Key bar soap	No washing agent	-85.13*	10.579	.000	-110.59	-59.67
		New Omo	-19.40*	7.481	.032	-37.40	-1.40
	New Omo	No washing agent	-65.73*	10.579	.000	-91.19	-40.27
		Key bar soap	19.40*	7.481	.032	1.40	37.40
Shrinkage Warp	No washing agent	Key bar soap	-1.57*	.186	.000	-2.01	-1.12
		New Omo	-1.40*	.186	.000	-1.85	-.95
	Key bar soap	No washing agent	1.57*	.186	.000	1.12	2.01
		New Omo	.17	.132	.420	-.15	.48
	New Omo	No washing agent	1.40*	.186	.000	.95	1.85
		Key bar soap	-.17	.132	.420	-.48	.15
Shrinkage Weft	No washing agent	Key bar soap	-4.20*	.133	.000	-4.52	-3.88
		New Omo	-3.93*	.133	.000	-4.25	-3.61
	Key bar soap	No washing agent	4.20*	.133	.000	3.88	4.52
		New Omo	.27*	.094	.017	.04	.49

	New Omo	No washing agent	3.93*	.133	.000	3.61	4.25
		Key bar soap	-.27*	.094	.017	-.49	-.04
Elongation Warp	No washing agent	Key bar soap	-1.870*	.2617	.000	-2.500	-1.240
		New Omo	-1.950*	.2617	.000	-2.580	-1.320
	Key bar soap	No washing agent	1.870*	.2617	.000	1.240	2.500
		New Omo	-.080	.1851	.902	-.525	.365
	New Omo	No washing agent	1.950*	.2617	.000	1.320	2.580
		Key bar soap	.080	.1851	.902	-.365	.525
Elongation Weft	No washing agent	Key bar soap	-1.9267	1.18681	.244	-4.7826	.9293
		New Omo	-4.2667*	1.18681	.002	-7.1226	-1.4107
	Key bar soap	No washing agent	1.9267	1.18681	.244	-.9293	4.7826
		New Omo	-2.3400*	.83920	.019	-4.3595	-.3205
	New Omo	No washing agent	4.2667*	1.18681	.002	1.4107	7.1226
		Key bar soap	2.3400*	.83920	.019	.3205	4.3595

Based on observed means.
The error term is Mean Square (Error) = 10.564.
*. The mean difference is significant at the .05 level.

It can be deduced from Table 16 that the unwashed fabric's strength in the warp was significantly higher than those which were washed with Key bar soap (129.97, p = 0.000) and New Omo washing detergent (95.93, p = 0.000). Also, the strength in the warp of the Fabric B which was washed with Key bar soap was significantly lower than that which was washed with New Omo washing detergent (-34.03, p = 0.005). Table 17 further revealed that the strength in the weft of the unwashed Fabric B was significantly higher than that which had either been washed with Key bar soap (85.13, p = 0.000) or New Omo washing detergent (65.73, p = 0.000). However, the strength in the weft of the fabric which had been washed Key bar soap was significantly lower than that which had been washed with New Omo detergent (-19.40, p = 0.032).

For Fabric B's shrinkage in the warp and weft, Table 16 shows that the unwashed fabric's shrinkage in the warp was significantly lower than when it was washed with Key bar soap and New Omo detergent by 1.57 (p = 0.000) and 1.40 (p = 0.000) respectively. Washing the Fabric B with New Omo detergent produced an insignificantly slightly lower shrinkage warp than when Key bar soap was used in washing (-0.17, p = 0.420). On the shrinkage weft, Table 17 shows that the unwashed Fabric B fabric's shrinkage weft was significantly lower than when it was washed with Key bar soap (-4.20, p = 0.000) and New Omo washing detergent (-3.93, p = 0.000). However, there was a significant mean difference of 0.27 (p = 0.017) in the fabric's shrinkage weft when it was washed with Key bar soap and New Omo washing detergent.

Regarding the elongation of the Fabric B, it can be observed from Table 16 that elongation warp of the unwashed Fabric B fabric was significantly lower than those washed with Key bar soap and New Omo detergent by 1.87 (p = 0.000) and 1.95 (p = 0.000) respectively. Furthermore, the elongation warp of the fabric washed with Key bar soap was insignificantly lower than that washed with New Omo washing detergent (-0.080, p = 0.902).

Table 16 also shows that the elongation weft of the unwashed Fabric B was slightly lower than those washed with Key bar soap and New Omo washing detergent by 1.9267 and 4.2667 respectively. However, the mean difference in the fabric elongation weft when it was washed with New Omo washing detergent was statistically significant (p = 0.002) while insignificant when it was washed with Key bar soap. Additionally, the elongation weft of the fabric which had been washed with Key bar soap was significantly lower than that washed with New Omo detergent (-2.340, p = 0.019).

Table 17: Tukey Post Hoc Multiple Comparisons Tests on Fabric B based on washing blue

Dependent Variable	(I) Washing blue type	(J) Washing blue type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound

Strength Warp	Unwashed	With blue	111.97*	14.812	.000	76.32	147.61
		Without blue	113.93*	14.812	.000	78.29	149.58
	With blue	Unwashed	-111.97*	14.812	.000	-147.61	-76.32
		Without blue	1.97	10.473	.981	-23.24	27.17
	Without blue	Unwashed	-113.93*	14.812	.000	-149.58	-78.29
		With blue	-1.97	10.473	.981	-27.17	23.24
Strength Weft	Unwashed	With blue	75.60*	10.579	.000	50.14	101.06
		Without blue	75.27*	10.579	.000	49.81	100.73
	With blue	Unwashed	-75.60*	10.579	.000	-101.06	-50.14
		Without blue	-.33	7.481	.999	-18.34	17.67
	Without blue	Unwashed	-75.27*	10.579	.000	-100.73	-49.81
		With blue	.33	7.481	.999	-17.67	18.34
Shrinkage Warp	Unwashed	With blue	-1.47*	.186	.000	-1.91	-1.02
		Without blue	-1.50*	.186	.000	-1.95	-1.05
	With blue	Unwashed	1.47*	.186	.000	1.02	1.91
		Without blue	-.03	.132	.965	-.35	.28
	Without blue	Unwashed	1.50*	.186	.000	1.05	1.95
		With blue	.03	.132	.965	-.28	.35
Shrinkage Weft	Unwashed	With blue	-4.10*	.133	.000	-4.42	-3.78
		Without blue	-4.03*	.133	.000	-4.35	-3.71
	With blue	Unwashed	4.10*	.133	.000	3.78	4.42
		Without blue	.07	.094	.760	-.16	.29
	Without blue	Unwashed	4.03*	.133	.000	3.71	4.35
		With blue	-.07	.094	.760	-.29	.16
Elongation Warp	Unwashed	With blue	-1.887*	.2617	.000	-2.516	-1.257
		Without blue	-1.933*	.2617	.000	-2.563	-1.304
	With blue	Unwashed	1.887*	.2617	.000	1.257	2.516
		Without blue	-.047	.1851	.966	-.492	.399
	Without blue	Unwashed	1.933*	.2617	.000	1.304	2.563
		With blue	.047	.1851	.966	-.399	.492
Elongation Weft	Unwashed	With blue	-3.7267*	1.18681	.007	-6.5826	-.8707
		Without blue	-2.4667	1.18681	.103	-5.3226	.3893
	With blue	Unwashed	3.7267*	1.18681	.007	.8707	6.5826
		Without blue	1.2600	.83920	.298	-.7595	3.2795
	Without blue	Unwashed	2.4667	1.18681	.103	-.3893	5.3226
		With blue	-1.2600	.83920	.298	-3.2795	.7595

Based on observed means.
The error term is Mean Square (Error) = 10.564.
*. The mean difference is significant at the .05 level.

Table 17 shows that the unwashed Fabric B's strength in the warp was significantly higher than that washed with washing blue (111.97, p = 0.000) and without washing blue (113.93, p = 0.000). The table further shows that washing the Fabric B with washing blue produced an insignificantly slightly higher strength warp than when it was washed without washing blue (1.97, p =

0.981). On the weft, Table 18 again shows that the Fabric B fabric's strength weft was significantly higher when unwashed than when washed washing blue (75.60, p = 0.000) and without washing blue (75.27, p = 0.000). Moreover, the strength weft of the Fabric B washed with washing blue was insignificantly lower than that washed without washing blue (-0.33, p = 0.999).

From Table 17, the shrinkage warp of the unwashed Fabric B was significantly lower than those washed with washing blue and without washing blue by 1.47 (p = 0.000) and 1.50 (p = 0.000) respectively. The shrinkage warp of the Fabric B when washed with blue was found to be insignificantly slightly lower than that washed without washing blue (-0.03, p = 0.965).

Table 17 also shows that the shrinkage in the weft of the unwashed Fabric B was significantly lower than those washed with washing blue (-4.10, p = 0.000) and without washing blue (-4.03, p = 0.000). Moreover, the shrinkage weft of the fabric which was washed with washing blue was slightly higher than that washed without washing blue. However, the observed mean difference was statistically insignificant (0.07, p = 0.760).

Finally, with regards to the Fabric B's elongation, Table 18 shows that the unwashed fabric's elongation warp was significantly lower than that washed with washing blue (-1.887, p = 0.000) and without washing blue (-1.933, p = 0.000). The elongation warp of this same fabric that was washed with washing blue was insignificantly slightly lower than that which was washed without washing blue (-0.047, p = 0.966). Table 18 further reveals that the elongation weft of the unwashed Fabric B was significantly lower than that washed with washing blue (-3.7267, p = 0.007) and insignificantly lower than that washed without washing blue (-2.4667, p = 0.103). Furthermore, the elongation weft of the fabric washed with washing blue was insignificantly higher than that washed without washing blue (1.2600, $p = 0.298$).

Overall, both soaps caused both fabrics to shrink making the fabrics dimensionally unstable. That notwithstanding, both fabrics met the minimum requirement of dimensional change as spelt out by the GSA standard.

Discussions

This section summarizes the study's findings considering the stated goals.

Structural and performance characteristics of the sample fabrics

For objective one, the structural characteristics of the sample fabrics (yarn count, density, and strength) were examined.

Two sets of yarns (warp and weft) are used in the manufacturing of fabrics. Sackey (2002) asserts that yarns are the 'building blocks in the manufacturing of fabrics. This means that whatever yarns are used should be of good quality in terms of strength and fineness. Yarn quality is an important factor related to the quality of the resultant fabric. fabric properties such as yarn counts, yarn strength, weave structure and fabric weight are all important factors to be considered to assess a fabric's performance attribute (Kadolph,2014). Given this, the basic structural characteristics of the two fabrics were assessed. It was confirmed that both two fabrics were 100% plain woven cotton fabric.

Fabric A

Plain weaves, according to Kadolph (2014), use half the number of picks per inch as to the number of ends per inch. Since the warp bears the brunt of a fabric's strain, it has a higher yarn count than the weft. From the results of this work (Table 1), the warp yarns of fabric ‘A’ had more yarn counts (98 E.P. I) than the weft yarns (56.4 P.P. I). The high number of yarn counts in the warp direction undoubtedly explains Suansoreong’s (1994) documentation that the warp direction is the strongest part of the fabric on the assumption that the yarns in both directions are the same. This also supports Kadolph’s (2014) work that warp yarn counts tend to be higher than weft yarn counts because of the high demands placed on them during the weaving process. The fabric also recorded weight of 110.55g/m^2, which is in line with the GSA requirement stating that, an African printed cotton fabric should weigh not less than 107g/m^2.

In terms of tensile properties, the warp yarns of Fabric A exhibited less extensibility (11.81%) than the weft yarns (37.89). Additionally, the study's findings back up the widely held belief that though the warp yarns are stronger than weft threads, the weft direction of fabric has more elasticity than the warp direction due to the stiffness that is characterized by the warp yarns. The values from the results (Table 1) further demonstrate that Fabric A’s warp direction’s mean tensile strength was higher (507 N) than the weft yarns (308 N). It's worth noting, however, that in terms of weight and breaking strength, this fabric did not also fall short of the Ghana Standards Authority's GS 124: 2019 minimum requirements. The standard quotes a minimum tensile strength of (240N) for warp and (220N) for weft for 100% cotton printed fabrics.

Fabric B

For Fabric B, the warp yarns also had more yarn counts (96.5 E.P. I) than the weft yarns (55.9 P.P. I). In terms of strength, the warp yarns recorded high tensile strength (450 N) than the weft (323 N) which indicates that the warp strength is much stronger than the weft yarns. Though the warp ends are stronger, the weft yarns also have more elasticity (Suansoreong,1994). Warp ends' elongation at break for this fabric was (12.69%) and for its weft yarns (44.81%). In weight, the fabric weighed (128.9 g/m^2) and this value is within the GSA standard specification of a minimum weight of (107g/m^2), (GS 124:2019).

It can be said conclusively from the findings that the warp direction of both fabrics had more yarn count than that of the weft direction. Fabric 'A' having more yarn count than fabric 'B' in both directions did not really tell on the overall weight of fabric 'A' as fabric B weighed (128.9 g/m^2) a little more than 'A'(110.55g/m^2).

It is not unexpected that there are more strands in the warp than in the weft because the results of the tests indicated that the warp threads in both textiles were stronger than the weft threads. In fact, both fabrics' warp yarns showed less elongation than their weft yarn counterparts.

Again, the results in (Table 1) underscore the fact that each of the fabrics under study is different in its own unique way and this could be attributed to variations in the yarns in the fabrics which gives each fabric its unique properties. The standard reference on important parts of fiber performance is provided by the properties of textile fibers, and as a result, different structural characteristics of textile fabrics are likely to produce varied results when put through the same strain test (Joseph, 1998; Hearle & Morton, 2008).

On this backdrop, it can also be said that the differences in the yarn count in the warp and weft directions, and the weight of the two fabrics, are indications their difference in structural attributes might produce differences in performance too after they have been washed with either key soap plus blue or new Omo.

Effect of Key soap (plus laundry blue) and new Omo; and wash cycles on colour, tensile properties and dimensional stability of two selected Ghanaian cotton printed fabrics

Colour fastness

Objective two of this study was to find out how washing of the fabrics with both soaps can affect the colour, of the two ‘black and white’ Ghanaian cotton Printed fabrics (fabric A and fabric B).

Both fabric's colorfastness to washing was tested using the Grey scale. Grayscale calibration ranges from 1 to 5, with 1 representing weak colorfastness and 5 representing great colorfastness. As a result, the grey scale is calibrated into the following values: 1, 2, 3, 4, 5, 6. A cotton fabric passes the color fastness test, under GS 124 (2019), when it can maintain at least 3–4 units of color on the grey scale.

Fabric ‘A’

It was observed that the colour loss in Fabric ‘A’ when washed with both Key soap (plus blue) scored (4/5) on the greyscale after the first wash and subsequently, remained at (4) after the 2nd and 3rd wash. New Omo’s effect, was quite negligible, as it scored an average value of (4/5) in all three wash cycles. New Omo's effect on the fabric was lesser as compared to key soap (plus blue). The result of the study could be due to maintaining washing liquor temperature at a constant of 30^{oc} in all three wash cycles, thus an increase in the temperature of washing water can increase soil removal and colour loss, (Paek 2004).

The varied effect of the soaps could also be linked to the structural attributes of this fabric, which is likely to yield different results as the fabric undergoes the same strain tests (Hearle and Morton, 2008). Additionally, the difference in the manufacturing processes of the soaps used in washing is also likely to have different effects on cotton fabrics when subjected to washing, Atkins (2003).

Although the test results revealed that key soap plus laundry blue and new Omo caused some colour loss in Fabric sample A, The fabric complied with the Ghana Standards Authority for African Print's standard criterion for colorfastness, which calls for a minimum color loss after washing of 4 (GS ISO 124: 2019). This indicates that in terms of colourfastness, whether Fabric A was washed with key soap and rinsed with blue; or washed with only new Omo, its colour fastness to washing was satisfactory.

Fabric B

For Fabric B, the colour loss value (4) attained after the 1st wash with key soap (plus laundry blue) remained the same in both the 2nd and 3rd wash. Omo caused the same fabric to lose a point five (0.5) of its colour (4-5) after all three wash cycles. It can be said that key soap (plus laundry blue) caused more colour loss in Fabric B than Omo. This could also be linked to factors like maintaining the washing liquor at 30^{o} in all three cycles, and the type of soap used (key soap plus blue, and new Omo detergent), as the soap's manufacturing process, can influence the colour of the fabric. This fabric did also not fall short of the standard specification by GSA 124:2019, as its colour loss was satisfactory.

In summary, it could be observed that Key soap (plus laundry blue) and new Omo caused some colour loss in both fabrics. But key soap (plus laundry blue) caused more colour loss in Fabric A than in Fabric B. The varied effect that was observed could be attributed to the structural differences of the two fabrics that was observed in Table 1. Heaele & Morton (2008) have alluded to the fact that colour loss is more resistant in heavier fabrics than in lighter fabrics. From the laboratory test results, (Table 1), the mean weight of the Fabric B specimens was 128.9g/m^2, which was higher than the mean weight of the fabric A specimens of 110.55g/m^2.

Tensile properties and dimensional stability

Objective 2 of this work again was to find out how the two soap types and the three wash cycles affected the tensile properties of the two fabrics. The length of the washing cycle and temperature of the water used in washing, have an impact on how the mechanical and physicochemical factors interact and affect the fabric during the process of washing (Cho, Yun & Park, 2017). Atkins's (2003) is also quick to note that the chemical characteristics of soaps could also be responsible for some of the observed changes in tensile strength of most textile fabrics.

Considering these literatures, study considered the interaction effect of how the tensile and elongation properties of the sample fabrics were affected by the duration of washing with the two types of soaps. This is required since the performance of any textile fabric depends on several factors, including the fiber qualities, colors, fabrication, finish, weave structure, and fabric care, such as washing (Kadolph, 2014). Fabric durability performance must be determined using fabric strength tests. The yarn pack, weave type, and fabric weight all affect a fabric's strength (Ozdil, Ozdogan and Oktem, 2013).

Fabric A

Assessing the interaction effect of factors

For a 2×3×3 factorial design, it is most appropriate to test the interaction effects first, prior to resting the main effects. (Ary & Jacobs, 2002). From the results, there was a statistically significant interaction between the soap type and washing blue used in washing the Fabric ‘A' across the measures for the fabric’s tensile strength and dimensional stability (Strength Warp, Strength Weft, Shrinkage Warp, Shrinkage Weft, Elongation Warp and Elongation Weft). This result suggests that the combination of the type of soap used (Key soap plus laundry blue or new Omo) and the presence of washing blue had a significant impact on Fabric 'A's tensile strength and dimensional stability. Users and manufacturers need to consider the specific combination of soap and washing blue when caring for or processing Fabric 'A.' Careful selection of detergent and additives is crucial to maintaining the fabric's performance attributes.

The interaction effect between soap type and the number of wash cycles

The interaction effect between soap type and the number of wash cycles on Fabric 'A's warp and weft tensile strength, shrinkage, and elongation was found to be statistically insignificant. This suggests that the number of wash cycles may not significantly impact these specific fabric properties when considering the choice of soap. Users may not need to be overly concerned about the number of wash cycles when selecting between the two types of soap for Fabric 'A.'

The interaction effect between washing blue and the number of wash cycles

The interaction effect between the presence of washing blue and the number of wash cycles on Fabric 'A's tensile strength and dimensional stability was also statistically insignificant. This implies that, for Fabric 'A,' the use of washing blue and the number of wash cycles may not significantly affect these properties when other factors are considered. Users may have flexibility in choosing whether or not to use washing blue and in determining the number of wash cycles.

The most significant finding is that the combination of all three factors, namely soap type, washing blue, and the number of wash cycles, had a significant effect on Fabric 'A's tensile strength and dimensional stability. This highlights the complexity of fabric behaviour when multiple factors are involved in the washing process. Users and manufacturers should pay close attention to all three factors when dealing with Fabric 'A' to ensure desired fabric performance.

In conclusion, these results underscore the importance of considering multiple factors, including soap type, washing blue, and the number of wash cycles, when assessing the impact of washing on Fabric 'A's properties. Careful selection and control of these factors can help maintain the fabric's desired tensile strength and dimensional stability. Additionally, these findings emphasize the need for a holistic approach to fabric care and processing, considering the interplay of various factors in achieving the desired outcomes.

The actual measure of the fabric's tensile strength and dimensional stability which the effects are exhibited

The results from Table 11 provide valuable insights into the interaction effects between soap type, washing blue, and the number of wash cycles on Fabric 'A's tensile strength and dimensional stability characteristics.

This result indicates that the combination of soap type (Key soap plus laundry blue or new Omo) and the presence of washing blue significantly influences Fabric 'A's tensile strength and dimensional stability. Users and manufacturers must consider this interaction effect when choosing the detergent and additives for washing Fabric 'A.' Careful selection of detergent and the presence of washing blue can have a substantial impact on the fabric's properties.

The interaction effect between soap type and the number of wash cycles

The interaction effect between soap type and the number of wash cycles on various fabric characteristics, such as shrinkage, elongation, and tensile strength, was found to be statistically insignificant. This suggests that the number of wash cycles may not significantly affect these fabric properties when considering the choice of soap for Fabric 'A.' Users may not need to be overly concerned about the number of wash cycles when selecting between the two types of soap.

The interaction effect between washing blue and the number of wash cycles on most fabric characteristics, including strength, shrinkage, elongation, was statistically insignificant. This implies that, for Fabric 'A,' the use of washing blue and the number of wash cycles may not significantly affect these properties, except for the fabric's strength warp. Users may have flexibility in choosing whether to use washing blue and determining the number of wash cycles for most properties.

The most significant finding is that the combination of all three factors: soap type, washing blue, and the number of wash cycles, had a significant effect on Fabric 'A's tensile strength and dimensional stability, except for shrinkage warp. This highlights the complex interplay of multiple factors in influencing the fabric's performance attributes. Users and manufacturers should consider all three factors carefully when dealing with Fabric 'A' to achieve the desired fabric properties.

In summary, these results underscore the complexity of fabric behavior when multiple factors interact during the washing process. The choice of soap type, the presence of washing blue, and the number of wash cycles all play a crucial role in determining Fabric 'A's tensile strength and dimensional stability. Users and manufacturers must carefully consider these factors to maintain or achieve the desired fabric performance. Additionally, the findings highlight the need for a comprehensive approach to fabric care, taking into account the intricate interactions among various factors.

Thus, the result could not produce any significant effect of the two soaps used in three wash cycles of this fabric. This could be ascribed to variations in the chemical compositions of the two soaps as well as manufacturing techniques, stipulated by Atkins in 2003. According to Atkins (2003), differences in soap manufacturing procedures are expected to have varying impacts on washed fabrics.

Interaction effect between the washing blue and washed cycle of the Fabric A

The results indicated mostly insignificant effects, with no significant differences observed for strength weft ($F(2, 57) = 1.303$, $p = 0.280$), shrinkage warp ($F(2, 57) = 1.988$, $p = 0.146$), shrinkage weft ($F(2, 57) = 2.168$, $p = 0.124$), elongation warp ($F(2, 57) = 0.705$, $p = 0.498$), and elongation weft ($F(2, 57) = 1.876$, $p = 0.163$). However, there was a significant effect observed for fabric strength in the warp direction ($F(2, 57) = 3.282$, $p = 0.045$).

The interaction between soap type, washing blue, and the wash cycle also had a noticeable impact, as shown in Table 11. Except for the shrinkage warp of Fabric 'A' ($F(2, 57) = 0.663$, $p = 0.519$), the effects of soap type, washing blue, and the wash cycle were statistically significant across various the various fabric characteristics. Specifically, they significantly influenced the tensile strength and dimensional stability of the fabric, as indicated by the results in table 11.

This could be because of structural differences that exist on the fabric part where the sample was cut for testing. Another reason for this result could also be the inadequate removal of water during the drying process on that sample, as any additional moisture in a cotton fabric exposes the fabric to the tendency to shrink and especially for warp ends which are already under pressure.

Another reason why the fabric showed dimensional instability was because of the fabric being a plain-woven fabric. In (2016) Sheikh, Kabir, Hannan, & Khan, found that the percentage shrinkage for plain fabric is comparatively higher than for twill fabric. And, the fact that both fabrics are woven, exposes the fabrics to be dimensionally unstable as compared to nonwovens (TianYuTextiles, 2020). They explained further that because woven fabrics are necessarily stretched on the loom in the process of weaving, dyeing, printing, and finishing, there is tension on the fabric. The fabric further swells when it comes into contact with water, thus causing dimensional instability after washing (Sheik et al, 2016).

Multiple Comparisons Tests on Fabric A based on Soap type

Unwashed Fabric 'A' had significantly lower elongation warp compared to fabric treated with both Key bar soap and New Omo detergent. This suggests that washing treatments increased the fabric's warp elongation. The difference in elongation warp between Fabric 'A' treated with Key bar soap and New Omo detergent was statistically insignificant, indicating a similar effect on warp elongation.

Elongation weft showed insignificant differences between treatments, except for a slight increase in elongation when Key bar soap was used, which was statistically insignificant. Washing treatments increased warp elongation but had little effect on weft elongation. Users may need to consider fabric elongation properties when designing and using Fabric 'A' for various applications.

For shrinkage, Unwashed Fabric 'A' exhibited significantly lower shrinkage warp compared to fabric treated with Key bar soap and New Omo detergent. This suggests that both washing treatments increased the fabric's warp shrinkage. The difference in shrinkage between Fabric 'A' treated with Key bar soap and New Omo detergent was statistically insignificant, indicating that both detergents had a similar impact on warp shrinkage. For shrinkage weft, Fabric 'A' treated with New Omo detergent exhibited significantly higher shrinkage than both Key bar soap-treated fabric and unwashed fabric. However, Key bar soap-treated fabric had significantly higher shrinkage weft compared to unwashed fabric. Washing treatments increased both warp and weft shrinkage. This may have implications for the fit and size stability of garments made from Fabric 'A.' Users should be cautious when washing this fabric to avoid excessive shrinkage.

Comparisons Tests on Fabric A based on washing blue

The results presented in Table 13 provide insights into the effects of washing Fabric 'A' with and without washing blue on its tensile strength and elongation characteristics in both warp and weft directions.

Unwashed Fabric 'A' had significantly higher strength warp and strength weft compared to fabric that was washed both with washing blue and without washing blue. This suggests that washing, regardless of the presence of washing blue, reduced the fabric's tensile strength in both warp and weft directions.

The strength warp of Fabric 'A' washed with washing blue was insignificantly higher than that washed without washing blue, with a very small observed difference that was statistically insignificant.

Similarly, the strength of weft of Fabric 'A' washed with washing blue was insignificantly higher than that washed without washing blue, with a statistically insignificant observed difference.

Unwashed Fabric 'A' had significantly lower elongation in warp compared to fabric that was washed both with washing blue and without washing blue. This indicates that washing treatments, regardless of washing blue, increased the fabric's warp elongation.

However, washing Fabric 'A' with washing blue produced an insignificantly slightly lower elongation warp compared to washing without washing blue, with a negligible observed difference that was statistically insignificant.

Elongation in the weft direction showed mixed results. Fabric 'A' exhibited insignificantly slightly higher elongation in the weft when washed with washing blue compared to washing without washing blue, but this difference was statistically insignificant.

The results suggest that washing, with or without washing blue, tends to reduce the tensile strength of Fabric 'A' in both warp and weft directions. Users of this fabric should be aware that washing may impact its strength, and this can have implications for its performance in various applications.

Washing treatments, regardless of washing blue, increased the elongation of Fabric 'A' in the warp direction. This may make the fabric more suitable for applications that require some degree of stretch or flexibility. However, the observed differences in elongation between washing with and without washing blue were statistically insignificant, indicating that the presence of washing blue does not significantly affect elongation.

Users may choose to wash Fabric 'A' with or without washing blue based on their preferences and specific requirements. The presence of washing blue had minimal to no significant impact on tensile strength and elongation, allowing flexibility in the washing process.

In summary, these results suggest that washing, whether with or without washing blue, can affect the tensile strength and elongation characteristics of Fabric 'A.' Users should consider these factors when using the fabric for various purposes, and they have the flexibility to choose their preferred washing method based on their specific needs and desired fabric properties.

Fabric B

The results for the multivariate analysis of variance (MANOVA) for the variables for tensile strength is presented in Table 14 for fabric B.

Assessing the interaction effect of factors of Fabric B

The results presented in Table 14 indicate the effects of various factors, including soap type, washed cycle, and washing blue, on the tensile strength and dimensional stability measures of Fabric B.

According to Wilks' Lambda value of 52.000 ($p = 0.796$), washing blue had a statistically insignificant effect on the tensile strength and dimensional stability measures of Fabric B. In other words, the presence or absence of washing blue during the washing process did not significantly impact these fabric characteristics.

The effect of soap type on Fabric B's tensile strength and dimensional stability measures was statistically significant (soap type, Wilks' Lambda = 0.656, $p = 0.001$). This means that the choice of soap type used for washing

Fabric B had a notable impact on these fabric properties. Users should consider this result when selecting a soap type for washing Fabric B, as it can influence the fabric's tensile strength and dimensional stability.

The washed cycle also had a statistically significant effect on Fabric B's tensile strength and dimensional stability measures (washed cycle, Wilks' Lambda = 0.097, p = 0.000). This suggests that the number of wash cycles the fabric undergoes can significantly affect these fabric characteristics. Users should be aware that multiple wash cycles may have a more pronounced impact on Fabric B's tensile strength and dimensional stability.

The interaction effect between soap type and the number of wash cycles

The interactions between soap type, washed cycle, and washing blue had statistically significant effects on Fabric B's tensile strength and dimensional stability measures (soap type, washing blue, soap type, washed cycle, washing blue, washed cycle, soap type. washing blue*washed cycle). These interactions indicate that the combined influence of soap type, washed cycle, and washing blue is more significant than the individual effects of each factor. Users should carefully consider these interactions when washing Fabric B to achieve the desired fabric characteristics.

The statistically insignificant effect of washing blue suggests that users may not need to prioritize the presence or absence of washing blue when washing Fabric B. It is unlikely to have a significant impact on tensile strength and dimensional stability.

Users should carefully choose the type of soap they use to wash Fabric B, as it has a significant impact on the fabric's tensile strength and dimensional stability. Different soaps may produce varying results, so selecting the right soap type is crucial for maintaining or achieving the desired fabric properties.

The number of wash cycles should also be considered, as multiple washes can significantly affect Fabric B's tensile strength and dimensional stability. Users should balance the need for cleaning with the potential impact on fabric properties.

The interactions between soap type, washed cycle, and washing blue underscore the complexity of fabric behavior during washing. Users should be aware of these interactions and may need to experiment to find the optimal washing conditions that align with their specific requirements.

In conclusion, these results highlight the importance of soap type and the number of wash cycles when considering the tensile strength and dimensional stability of Fabric B. While washing blue may not be a critical factor, the interactions between these variables should be carefully considered for effective fabric care and maintenance.

The interaction effect between washing blue and the number of wash cycles

The results presented in Table 15 indicate the effects of factors like soap type, washed cycle, and washing blue, on the tensile strength and dimensional stability measures of Fabric B.

According to Table 15, Wilks' Lambda value of 52.000 ($p = 0.796$) indicate that washing blue had a statistically insignificant effect on the tensile strength and dimensional stability measures of Fabric B. In other words, the presence or absence of washing blue during the washing process did not significantly impact these fabric characteristics.

The effect of soap type on Fabric B's tensile strength and dimensional stability measures was statistically significant (soap type, Wilks' Lambda = 0.656, $p = 0.001$). This means that the choice of soap type used for washing Fabric B had a notable impact on these fabric properties. Users should consider this result when selecting a soap type for washing Fabric B, as it can influence the fabric's tensile strength and dimensional stability.

The washed cycle also had a statistically significant effect on Fabric B's tensile strength and dimensional stability measures (washed cycle, Wilks' Lambda = 0.097, $p = 0.000$). This suggests that the number of wash cycles the fabric undergoes can significantly affect these fabric characteristics. Users should be aware that multiple wash cycles may have a more pronounced impact on Fabric B's tensile strength and dimensional stability.

The interactions between soap type, washed cycle, and washing blue had statistically significant effects on Fabric B's tensile strength and dimensional stability measures (soap type, washing blue, soap type, washed cycle, washing blue washed cycle, soap type, washing blue*washed cycle). These interactions indicate that the combined influence of soap type, washed cycle, and washing blue is more significant than the individual effects of each factor. Users should carefully consider these interactions when washing Fabric B to achieve the desired fabric characteristics.

The statistically insignificant effect of washing blue suggests that users may not need to prioritize the presence or absence of washing blue when washing Fabric B. It is unlikely to have a significant impact on tensile strength and dimensional stability. Users should carefully choose the type of soap they use to wash Fabric B, as it has a significant impact on the fabric's tensile strength and dimensional stability. Different soaps may produce varying results, so selecting the right soap type is crucial for maintaining or achieving the desired fabric properties.

The number of wash cycles should also be considered, as multiple washes can significantly affect Fabric B's tensile strength and dimensional stability. Users should balance the need for cleaning with the potential impact on fabric properties.

The interactions between soap type, washed cycle, and washing blue underscore the complexity of fabric behavior during washing. Users should be aware of these interactions and may need to experiment to find the optimal washing conditions that align with their specific requirements.

In conclusion, these results highlight the importance of soap type and the number of wash cycles when considering the tensile strength and dimensional stability of Fabric B. While washing blue may not be a critical factor, the interactions between these variables should be carefully considered for effective fabric care and maintenance.

The actual measure of the fabric's tensile strength and dimensional stability which the effects are exhibited

The results presented in Tables16 highlight the effects of various interactions between soap type, washed cycle, and washing blue on the tensile strength and dimensional stability measures of Fabric B.

The interaction between soap type and washing blue significantly affected Fabric B's elongation warp. This indicates that the combination of these two factors played a role in altering the fabric's elongation properties. However, all other tensile strength and dimensional stability measures (strength warp, strength weft, shrinkage warp, shrinkage weft, elongation weft) were statistically insignificant when considering the interaction between soap type and washing blue.

Interaction Effects of Soap Type and Washed Cycle

Knowing that there was a statistically significant interaction between the soap type, washing blue and washed cycle on the Fabric B's tensile strength and dimensional stability, the study sought to find out the exact tensile strength and dimensional stability measure(s) which had been affected. In view of this, Table 15 shows the results of the test on the individual measures of tensile strength and dimensional stability.

The interaction between soap type and washed cycle had significant effects on the strength warp, strength weft, and elongation weft of Fabric B. This suggests that the combination of soap type and the number of wash cycles influenced these fabric characteristics. On the other hand, the interaction effect on shrinkage warp and elongation warp was statistically insignificant.

Interaction Effects of Washing Blue and Washed Cycle

When examining the interaction between washing blue and washed cycle, it was found to significantly impact the shrinkage weft and elongation weft of Fabric B. This implies that the combined effect of using washing blue and the number of wash cycles influenced these fabric properties. However, the fabric's strength warp, strength weft, shrinkage warp, and elongation warp remained statistically insignificant when considering this interaction.

Multiple Comparisons Tests on Fabric B based on Soap type

The combined interaction of soap type, washing blue, and washed cycles significantly affected the elongation warp and elongation weft of Fabric B. This suggests that when all three factors are considered together, they have a notable impact on these fabric properties. In contrast, the interaction effects on strength warp, strength weft, shrinkage warp, and shrinkage weft were statistically insignificant when considering these three factors simultaneously.

The results emphasize the complexity of the interactions between soap type, washing blue, and washed cycles when it comes to fabric behavior. Different combinations of these factors can have varying effects on Fabric B's tensile strength and dimensional stability. Users should be aware of these interaction effects and tailor their washing processes accordingly to achieve desired fabric characteristics. The significant effects on elongation properties (both warp and weft) suggest that users should pay particular attention to these aspects when choosing soap type, deciding on the use of washing blue, and determining the number of wash cycles. Fabric B's strength and shrinkage properties appear to be less influenced by these interactions, but users should still consider them when making decisions about fabric care and maintenance.

In summary, these results underscore the need for careful consideration of soap type, washing blue, and the number of wash cycles when aiming to maintain or modify Fabric B's tensile strength and dimensional stability, with a particular focus on elongation properties. The interactions between these factors can lead to different fabric outcomes, making informed decisions crucial for effective fabric care.

Multiple Comparisons Tests on Fabric B based on washing blue

The results presented in Tables 17 highlight the effects of various interactions between soap type, washed cycle, and washing blue on the tensile strength and dimensional stability measures of Fabric B.

The interaction between soap type and washing blue significantly affected Fabric B's elongation warp. This indicates that the combination of these two factors played a role in altering the fabric's elongation properties. However, all other tensile strength and dimensional stability measures (strength warp, strength weft, shrinkage warp, shrinkage weft, elongation weft) were statistically insignificant when considering the interaction between soap type and washing blue.

The interaction between soap type and washed cycle had significant effects on the strength warp, strength weft, and elongation weft of Fabric B. This suggests that the combination of soap type and the number of wash cycles influenced these fabric characteristics. On the other hand, the interaction effect on shrinkage warp and elongation warp was statistically insignificant.

When examining the interaction between washing blue and washed cycle, it was found to significantly impact the shrinkage weft and elongation weft of Fabric B. This implies that the combined effect of using washing blue and the number of wash cycles influenced these fabric properties.

However, the fabric's strength warp, strength weft, shrinkage warp, and elongation warp remained statistically insignificant when considering this interaction.

The combined interaction of soap type, washing blue, and washed cycles significantly affected the elongation warp and elongation weft of Fabric B. This suggests that when all three factors are considered together, they have a notable impact on these fabric properties. In contrast, the interaction effects on strength warp, strength weft, shrinkage warp, and shrinkage weft were statistically insignificant when considering these three factors simultaneously.

The results emphasize the complexity of the interactions between soap type, washing blue, and washed cycles when it comes to fabric behavior. Different combinations of these factors can have varying effects on Fabric B's tensile strength and dimensional stability. Users should be aware of these interaction effects and tailor their washing processes accordingly to achieve desired fabric characteristics. The significant effects on elongation properties (both warp and weft) suggest that users should pay particular attention to these aspects when choosing soap type, deciding on the use of washing blue, and determining the number of wash cycles.

Fabric B's strength and shrinkage properties appear to be less influenced by these interactions, but users should still consider them when making decisions about fabric care and maintenance.

In summary, these results underscore the need for careful consideration of soap type, washing blue, and the number of wash cycles when aiming to maintain or modify Fabric B's tensile strength and dimensional stability, with a particular focus on elongation properties. The interactions between these factors can lead to different fabric outcomes, making informed decisions crucial for effective fabric care.

The results presented in Tables 18 provide insights into the effects of washing blue and washing without blue on Fabric B's tensile strength, shrinkage, and elongation characteristics**.**

For tensile strength the unwashed Fabric B exhibited significantly higher tensile strength in both the warp and weft directions compared to when it was washed with or without washing blue. This suggests that washing, regardless of the presence of washing blue, had a detrimental effect on Fabric B's tensile strength. The slightly higher strength warp observed when washing with blue compared to without blue was statistically insignificant. However, this difference suggests that the presence of washing blue did not significantly impact Fabric B's tensile strength.

In view of elongation, the unwashed Fabric B had significantly lower elongation values in both warp and weft directions compared to when it was washed with or without washing blue. Washing, regardless of the presence of washing blue, increased the fabric's elongation properties.

While there were slight differences in elongation values between washing with and without blue, these differences were statistically insignificant. This suggests that washing blue had minimal to no effect on Fabric B's elongation. Users should note that washing can increase Fabric B's elongation, making it potentially more flexible. This characteristic might be desirable in certain applications but should be considered when designing products.

Users should be aware that washing, in general, can lead to a reduction in tensile strength. Fabric B's strength in both warp and weft directions should be considered when evaluating its suitability for specific applications.

Fabric B exhibited significant shrinkage in both warp and weft directions when washed, regardless of the presence of washing blue. The unwashed fabric had significantly lower shrinkage values compared to the washed counterparts. The presence of washing blue did not significantly impact fabric shrinkage, as the differences in shrinkage values between washing with and without blue were statistically insignificant. These results indicate that Fabric B is prone to shrinkage when subjected to washing. Users should expect this dimensional change and consider it when planning for garment construction or product development.

CHAPTER FIVE

SUMMARY RECOMMENDATIONS AND CONCLUSION

Introduction

The research findings are summarised in this chapter along with the conclusions, suggestions for future research directions and policy implication. The recommendations are based on the study's primary results and conclusions.

Summary of the Study

The study was to explore how 'black and white' Ghanaian cotton printed fabrics were affected by washing with two different types of soap and laundry blue. The soaps that were used in carrying out the research were ‘key’ bar soap (and laundry blue), and new ‘Omo’ detergent. The fabrics made by two Textiles Companies in Ghana were tested for colour fastness, strength, and dimensional stability after it had been washed. An experimental quantitative research design was taken into consideration for the study in order to determine any impacts of the soaps on the fabrics. Two "black and white" cotton printed fabrics: Fabric A and Fabric B, two different kinds of soaps: "key" soap plus laundry blue and new "omo," as well as three wash cycles, were the study's variables.

The testing was carried out at the Ghana Standards Authority's Textile Testing Laboratory. A total of 132 specimens were cut from each of the 6 yards of each fabric and used in laboratory testing. The instruments used for data collection included tensile testing machine (OHAUS), magnifying glass, weighing balance (Adventure Pro) and a pair of scissors (see Appendix). Washing of the specimens were washed with the standard Launder-Ometer (Gyrowash 315). The strip test method, a popular tensile test method, was used to evaluate the breaking force and elongation of textile textiles as stipulated in ISO 133934-1 2019. The information acquired from the test results was analysed using the inferential statistics multivariate analysis of variance (MANOVA)

Key Findings

1. In both fabrics A and B, there were more yarns in the warp direction than the weft. In terms of strength and elongation, Fabric A exhibited strength in the warp direction, while Fabric B has higher weft strength. Both fabrics exhibit greater elongation in the weft direction compared to the warp. For yarn counts and weight, fabric A has more warp and weft yarns, indicating a denser structure. Fabric B has fewer yarn counts, making it lighter in weight and potentially more breathable. These findings underscore the distinct structural attributes of the two fabrics, and suggest how their differences are likely to impact their performance and suitability in various use cases.
2. For colour, Fabric A demonstrated relatively good colour retention even when subjected to multiple wash cycles with the two types of soaps. This suggests that Fabric A can maintain its original color fairly well under typical laundering conditions. Fabric B experienced more significant color loss during the first wash with Key soap plus laundry blue, and remained relatively stable during subsequent washes.

3. Regarding the effects of washing with and without washing blue on Fabric A and Fabric B, both Fabric A and Fabric B experienced a significant reduction in tensile strength when subjected to washing, irrespective of the presence of washing blue. For elongation changes, washing, whether with or without washing blue, increased the elongation properties of both fabrics.
4. Both fabrics experienced a decrease in tensile strength after washing with either Key soap (plus blue) or New Omo, with Key soap generally causing a more significant reduction. Fabric B exhibited similar trends, with Key soap causing more significant reductions in both warp and weft strength.
5. Both fabrics exhibited significant shrinkage in the warp and weft dimensions when washed, indicating that they are susceptible to changes in size and dimensional instability. The presence of washing blue did not significantly influence this shrinkage. Washing with both soaps led to fabric shrinkage, indicating reduced dimensions in both Fabric A and Fabric B. Key soap (plus blue) caused more pronounced shrinkage in both warp and weft directions compared to New Omo
6. The study showed a decreasing slope in the percentage of elongation in the warp direction (warp yarns) compared to the weft, demonstrating that the fabric's elasticity in the warp also reduced with each washing cycle. The varied effect of the soaps on the fabrics did not cause the fabrics to fall short of the GSA standard of tensile strength for African cotton printed fabrics.

Conclusions

The findings of this work have shown that indeed the new Omo detergent does not cause Ghanaian cotton fabrics to fail in performance than key soap and so the notion that using this detergent to wash locally produced cotton prints should be discarded. This does also not mean that new Omo is better in performance than key soap plus blue, as the effect that was observed on the parameters did also not cause the fabrics to fall short of the GSA standard (GS 124:2019) for colourfastness, tensile strength and dimensional stability to washing in African Printed cotton fabrics.

These conclusions were then reached as a result of the study's findings:

1. Fabric structural properties such as yarn counts, yarn strength, weave structure and fabric weight are all important factors to consider when assessing a fabric's performance attributes. Although there were structural differences between the two fabrics, they both met the GSA standard (GS 124:2019) for structural properties of African prints.
2. There is anecdotal evidence among the Ghanaian populace that detergent causes a reduction in performance attributes of Ghanaian cotton-printed black and white fabrics but soaps like 'key' soap do not. However, the results of this study showed otherwise, as the detergent, new Omo used in the experiment had minimal effect on the two fabrics that were used in the experiment in comparison to the effect of key' soap plus blue.
3. New Omo and key soap plus blue did not seem to have a toll on the strength of both fabrics in the weft direction, as compared to the warp and this did not cause the fabrics to fall short of the GSA standard requirements.

4. New ‘omo’ and key soap caused the two fabrics to be dimensional unstable in the warp yarns than in the weft yarns.
5. Although there were statistically significant differences between the soap type, wash cycle and the strength and dimensions of fabric A and fabric B, the varied effect of the soaps on these fabric parameters did not cause the fabrics to be substandard as they both met the standard requirement of the GSA.

Recommendations

1. Based on the findings that new omo detergent does not cause deterioration of black and white cotton printed fabrics in terms of the parameters tested, Unilever Ghana Limited, producers of the new Omo detergent, should also raise knowledge through advertisement in the media space on the safe application of the rebranded Omo (new Omo) on Ghanaian cotton-printed ‘black and white’ fabrics.
2. Manufacturers of Ghanaian cotton printed ‘black and white’ fabrics should also recommend the use of new Omo detergent as another option in washing their fabrics by listing it on their care labels. This is because new Omo does not cause these prints to fail in performance.

Suggestions for Further Studies

The researcher suggests the following for further studying:

1. Research should be carried out to explore the impact of various washing agents beyond Key soap and New Omo on fabric properties. Different detergents and additives may have distinct effects on other performance metrics such as colour fastness to perspiration, sunshine, and hot heat pressing which could be valuable information for

consumers and producers of Ghanaian cotton printed "black and white" fabrics.

2. It is advised to increase the number of washing cycles and vary the temperature of the washing liquor in order to achieve varying results in addition to the findings of this study so that a comprehensive representation of the performance of "black and white" Ghanaian cotton printed fabric can be achieved.
3. Researchers can explore how different fabric structures, such as twill, satin, or plain weaves, influence properties like tensile and dimensional properties. This can provide more nuanced insights into the relationship between fabric construction and performance.
4. Research could also be conducted to see the environmental impact of these fabrics, especially in terms of their response to washing to assess factors such as microfiber shedding, water, and energy consumption during washing, and potential eco-friendly alternatives for fabric maintenance.
5. Consumer preferences and acceptance of fabrics with varying performance attributes can also be studied. This research could help manufacturers align fabric properties with market demands and consumer expectations.
6. There could be studies tailored to specific markets or regions in Ghana to understand how local conditions, preferences, and laundering practices affect fabric performance and suitability for various applications.

7. Interdisciplinary research that combines textile science with fields like material engineering, sustainability, and consumer behavior can be carried out to gain a comprehensive understanding of fabric properties and their broader implications.

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APPENDICES

TENSILE TESTING MACHINE

Figure 2: Tensile Testing Machine

APPENDIX B

INTRODUCTORY LETTER

UNIVERSITY OF CAPE COAST
COLLEGE OF EDUCATION STUDIES
FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF VOCATIONAL AND TECHNICAL EDUCATION

Direct: 03320-91097
Telegrams & Cables: University, Cape Coast

University of Cape Coast
Cape Coast

Our Ref: VTE/IAP/V.1/165

9th December, 2020

The Head
Material Science Department Standard Board
UCC

Dear Sir/Madam

INTRODUCTORY LETTER

We have the pleasure of introducing to you **Cynthia Agyeiwaa Kusi** who is an M.Phil student of this Department and working on the thesis topic **"The Effect of 'Key Soap' plus Laundry blue and 'New Omo' on 'Black and White' fabric".**

Currently, she is at the data collection stage of her research work and we would be most grateful if you could grant her an ethical clearance from your outfit to enable her proceed with the collection of data.

Thank you.

Yours faithfully,

Dr. Augustina Araba Amissah
HEAD OF DEPARTMENT

Figure 3: Introductory Letter