UNIVERSITY OF CAPE COAST

DIFFERENCES IN EFFECT BETWEEN KEY SOAP AND NEW OMO ON THE PERFORMANCE OF GTP WAX PRINTS

BARBARA OSEKRE

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BY

NAME: BARBARA OSEKRE

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ABSTRACT

The purpose of the current research was to examine the effects of soap (key soap) and soapless detergent (new omo) on the colour change, dimensional stability and tensile strength of GTP wax prints. This is to find out if the rebranded omo has the same effect on printed fabrics as key soap to inform and increase consumers' confidence in using new omo in taking proper care of their printed fabrics. This research used two wax prints fabrics (Adepa Dumas and Nustyle). The samples were bought from accredited distributors from the market and selected based on the differences in their brands and prices. A 2×2×5 factorial experimental research design using the laboratory method was employed. Data were collected using GSA premises and standards. The findings show that a difference of 70.780N between key soap and new omo caused a significant effect on the weft strength of Adepa Dumas and a difference of .130% and .120% respectively caused a significant effect in warp dimension of Adepa Dumas. The study also revealed that a difference of 42.720N between key soap and new omo caused a significant effect in the weft strength of Nutyle wax print, a difference of .080 units caused a significant effect in its colour change and a difference of .042% and .066% caused a significant change in the warp and weft dimensions respectively. The findings also revealed a significant interaction effect between washing soaps and their washing periods on the weft strength, the colour change, the warp and weft dimensions of Adepa Dumas and Nustyle after five washing periods. Therefore, it is recommended that more awareness should be created by Unilever Ghana Limited on the reliable use of the rebranded omo (new omo)

on wax printed fabrics since most wax prints' users have the assumption that omo will destroy their prints.

KEY WORDS

Washing

Soap

Detergent

Wax prints

Colour change

Tensile strength

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DEDICATION

To my daughters: Bethel and Benita Ankrah and my late Husband Paul Kodjo Ankrah.

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CHAPTER ONE

INTRODUCTION

The use of soaps for washing wax prints has been universally accepted and embraced by all, but the same cannot be said about soapless detergent. In Ghana, most consumers prefer the use of soaps to soapless detergents in washing their wax prints. This is because it is believed that soapless detergents may weaken prints and cause their colour to fade. Therefore, this study compares soap and soapless detergent's effects on real wax printed fabrics to examine their differences.

Background to the Study

Wax prints are cotton fabrics with printed motifs that are used as a form of non-verbal communication among African women. The prints are usually named after personalities, cities, buildings, sayings, occasions, events, among others, to tell a story. The use of wax prints in Ghana has become prevalent among the young and the old since the government's campaign in 2004 to get people into National Dress on Fridays. This has led to the production of unique colours and designs of the local prints and has made many Ghanaians and foreigners develop an interest in Ghanaian real wax prints. The campaign for the use of wax prints has also made it possible for both the average Ghanaian and the affluent in the society to adorn themselves in different designs. These designs are sewn in different styles for parties, outdooring, traditional marriages, weddings, funerals, etc.

In Ghana, wax prints are produced by four major textile manufacturing companies, namely, Akosombo Textile Limited (ATL), Ghana Textile Manufacturing Company (GTMC), Printex and Tex Styles Ghana Limited, formally known as Ghana Textile Prints (GTP) (Quartey, 2006). Ghanaian wax prints are also known as real prints, and examples of real prints are tie and dye, real wax, batik, real java and fancy prints, which are extensively used for clothing and other purposes. During the care of these wax prints, consumers may have preferences to the type of soap or detergent to use. Irrespective of the choice made, consumers would want to use a washing soap or detergent that would prolong their print quality. According to Marshall, Jackson & Stanley (2012), some factors tend to influence the performance of fabrics during washing, which includes the kind of detergent or soap, the type of water used and its temperature, laundry additives, and others.

For consumers to obtain maximum satisfaction with their wax prints, there is the need to evaluate their performances during care. A better way to know the fabric's performance is to measure how the fabric performs in terms of, appearance retention, colourfastness and weather resistance on the fabric (Kadolph, 2007). Among all the standardised soaps in Ghana, Key Soap, as indicated by Fianu & Adams (1998), is considered a traditional soap that has long been used to wash wax prints and is still being used. However, much work has not been done on the effects of the various detergents found on the Ghanaian markets, even though they are being used to wash all types of fabrics.

Statement of the Problem

Knowing the different washing products and their ingredients help select the suitable soap or detergent for washing. The type of soap or detergent used in washing can affect some performance characteristics of the fabric, such as colourfastness, dimensional stability, tensile strength, among others.

Many studies have revealed different outcomes concerning the use of soap on the performance of wax prints. For instance, Kwame's (2012) study on the effect of Key Soap and Azumah Blow soap on some selected African prints found that Azuma blow soap had more effect on the colour and strength of the fabrics used in the study than key soap. In a study by Amankrah (2013), he also observed that the use of key soap on her sampled fabrics had a lesser effect on the colour and tensile strength as compared to the effect of sunlight on the same fabrics. Thus, the effects from both studies might have occurred due to differences in the ingredients used in producing these soaps.

The manufacturing of soaps and detergents has increased in recent times, and as a result, many detergent industries have been established in Ghana (Amenumey, 2008). Unilever Ghana Limited and PZ Cussons Limited are the major factories that produce standard washing soaps and detergents in Ghana. New Omo is a rebranded washing detergent produced by Unilever Ghana Limited, the same producer of Key soap. The effects of New Omo on printed fabrics have not been investigated, but since it is the same company that produces Key soap, it is anticipated that New Omo is a quality washing detergent just as Key soap. The commercial slogan for New Omo has it that it makes white whiter and coloured brighter. This information and perception about the rebranded Omo may appeal to individuals' interest and may prefer New Omo in washing their wax prints. Therefore, it is prudent that a thorough and scientific investigation is carried out to examine the effect of New Omo alongside Key soap on the performance attributes of relatively two new wax prints on the market; GTP Adepa Dumas and GTP Nustyle.

Purpose of the Study

This study sought to examine the effect of Key Soap and New Omo detergent on the colourfastness, tensile strength and dimensional stability of GTP Adepa Dumas and GTP Nustyle wax prints.

Research Objectives

The objectives of the study were to;

1. analyse the effects of Key Soap and New Omo on the colourfastness, tensile strength and dimensional stability of GTP Adepa Dumas and GTP Nustyle prints.
2. explain any differences in effects between Key Soap and New Omo on the colourfastness, tensile strength and dimensional stability of GTP Adepa Dumas and GTP Nustyle prints.
3. analyse the interaction effect between the washing soaps and the washing periods on the colourfastness, tensile strength and the dimensional stability of both printed fabrics.

Research Hypotheses

1. Ho: There is no significant effect on colourfastness, tensile strength and dimensional stability of Adepa Dumas and Nustyle when washed with Key Soap after five washing periods.
2. Ho: There is no significant effect on colourfastness, tensile strength and dimensional stability of Adepa Dumas prints and Nustyle when washed with New Omo after five washing periods.
3. H_O: There is no significant difference in the effect between Key Soap and New Omo in terms of colourfastness, tensile strength and

dimensional stability of Adepa Dumas and Nustyle after five washing periods.

4. H_O: There is no significant interaction effect between soaps and the washing periods in terms of colourfastness, tensile strength and dimensional stability of Adepa Dumas and Nstyle after five washing periods.

Significance of the Study

The importance of the study will be realized as follows:

The study will help generate knowledge about the effect the rebranded omo has on wax prints.

Secondly the study would be a source of knowledge to consumers by appreciating the differences in the effect between Key Soap and New Omo detergent on wax prints.

Thirdly, the study will serve as a soure of added knowledge to both soaps and textiles manufacturers to improve the quality of their products.

Finally, the study would serve as existing literature for teaching and outreach activities and would also serve as a reference point for providing data for further research in similar areas.

Delimitation

The scope of the study is narrowed to cover only GTP Adepa Dumas and GTP Nustyle prints of similar colours and two cleaning agents (Key Soap and New Omo detergent) from Unilever Ghana Limited. GTP Adepa Dumas and GTP Nustyle are used because GTP is a household name that is percieved to be the foremost indigenous Ghanaian wax print company noted for its high-quality textiles brand. Also, Adepa Dumas and Nustyle are new brands on the market and the effect of Key Soap and New Omo on their performance to the colourfastness, tensile strength and dimensional stability when subjected to washing are unknown. Key Soap and New Omo detergent are used because they are both from the same manufacturing company and Ghanaians believe that Key Soap has been a trusted traditional soap that has been in existence for a long time. Specimens would be subjected to two washing cycles for five washing periods to ensure a thorough effects of the washing soaps on the prints.

There are several fabric performance indicators. However, this study would narrow itself to determine the colourfastness, tensile strength and dimensional of the two brands of GTP wax prints. In measuring the three performance indicators of interest, only the following would be assessed: weave type, yarn count and fabric weight.

Limitations

Generalization cannot be made for all brands of GTP wax prints, all soaps and detergents manufactured from Uniliver Ghana Limited and for all performance indicators of textile fabrics.

Organisation of the Study

The study is organised into four chapters. The second chapter is a review of related literature relevant to the study. The third chapter describes the research methods that was adopted for the study. This covers the research design, study area, materials, instruments used for the study, selection of specimens, experimental procedures, data collection instruments, data collection procedures and data processing analysis. The fourth chapter presents the results and discussion of the results. Chapter Five, is devoted to the summary, conclusions and recommendations.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

This research investigates the differences in effect between the use of Key Soap and New Omo detergent on the colourfastness, tensile strength and dimensional stability of selected GTP Real Wax prints. This chapter reviews literature related to the topic under study. The literature is presented under the following headings:

Empirical Review

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    a. Component of soaps and their importance
    b. Component of detergents and their importance
2. Washing process
3. Real wax prints
    a. Structural elements
        i. Fibre
        ii. Yarn count
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        i. Colour change to washing
        ii. Dimensional stability to washing
        iii. Tensile strength to washing
4. Conceptual Framework

Empirical Review

Concept of Soaps and Detergents

According to Brady, Russell, & Holum (2000), the discovery of soap dates back to around 2800 B.C., when cylinders with inscriptions for making soap were discovered during excavations in ancient Babylon. Later documents from ancient Egypt (1500 B.C.) revealed how animal and vegetable oils were combined with alkaline salts to manufacture soap. Brady et al. (2000) asserted that soap gained its name from Mount Sapo, where animals were sacrificed according to the Roman tradition. When it rained, it washed the fat from the sacrificed animals combined with alkaline timber ashes from the sacrificial fires into the Tiber River, where people found the mixture helpful in cleaning. This became a soap-making recipe. Since the mid-nineteenth century, the process of creating soap has been marketed, and soap has become widely available in every local market as a helpful product for cleaning both bodies and goods (Brady et al, 2000).

Brady, James E., Russell, Joel W, Holum & John R. (2000) went on to say that as excellent as soaps are, they are not perfect because they do not operate well in calcium and magnesium-rich hard water. They stated that the insoluble calcium and magnesium salts found in soap tend to attach to the calcium and magnesium ions, precipitating and dropping out of the solution. Soaps, by doing so, end up dirtying the surfaces they were supposed to clean.

The Soap and Detergent Association of Canada – SDAC (2019) also confirm this assertion made by Brady et al., 2000. The association explained that although soap is a good cleaning agent, its effectiveness is reduced in hard water. The presence of mineral salts such as calcium (Ca) and magnesium (Mg), as well as iron (Fe) and manganese (Mn), causes the hardness of the water (Mn). The mineral salts react with the soap to generate soap film or scum, an insoluble precipitate. Soap film is difficult to remove. It tends to stick around, leaving noticeable deposits on clothing and stiffening materials. They went on to say that even when garments are washed in soft water, the soil on the clothes introduces some hardness minerals (SDAC, 2019). As a result, soap molecules are not highly adaptable to today's diverse range of fibres, washing temperatures, and water conditions.

They also mentioned that the cleaning water has a feature known as surface tension (SDAC, 2019). Each water molecule is surrounded and drawn by other water molecules in the body of the water. However, only on the waterside are those molecules surrounded by other water molecules at the surface. As the water molecules at the surface are dragged into the body of the water, tension is created. Water beads up on surfaces like glass and fabric due to the strain, slowing the wetting of the surface and impeding the cleaning process. According to the association, surface active agents or surfactants are added to cleaning solutions to lower surface tension so that water can spread and moisten surfaces during cleaning. Surfactants, or surface-active agents, are the key constituents of today's detergents. Other key cleaning actions include loosening, emulsifying (water dispersion), and retaining soil in suspension until it can be washed away (SDAC, 2019).

Synthetic detergents with a sulfonate ($R\text{-}SO_3$) group instead of a carboxylate head (R-COO) have essentially supplanted soaps in modern cleaning solutions. Sulfonate detergents are more water-soluble and do not precipitate with calcium or magnesium ions (Brady et al., 2000). Soaps and detergents are used in washing to help remove and suspend dirt, reduce the effect of hard water, and change the surface tension of the water used in washing, according to the Soap and Detergent Association of Canada –SDAC (2019). According to Katz (2000), Soaps and detergents are similar in general structure and qualities but differ in content and some specific properties. In addition, Hedge (2015) distinguished between a detergent and a soap. A detergent, he explained, is a chemical molecule or mixture of chemicals used as a cleaning agent. In contrast, soaps are cleaning agents made up of one or more fatty acid salts. It may be determined that, despite their variations in composition, they are both chemicals that have the potential to remove filth when dissolved in water. Hedge (2015) clarified that the term "detergent" refers to a broad category of cleaning products that encompasses soaps and other cleaning agents of varied chemical compositions. As a result, for this study, the term detergent refers to cleaning agents made up of various compounds, whereas the term soap refers to products made up mostly of fatty acid salts.

Component of Soaps and their Importance

Soaps are water-soluble sodium or potassium salts of fatty acids, according to SDAC (2019). According to the association Soap and Detergent of Canada, soaps are created from fats and oils, or their fatty acids, by treating them chemically with a strong alkali. Soaps are defined by Hopkins (2010) as a solid, liquid, or powdered product formed by reacting potassium or sodium hydroxide with animal or vegetable oils. Soap is a combination of sodium salts of several naturally occurring fatty acids, according to Ohpardt (2003). Soaps are cleaning agents

made chiefly of sodium or potassium salts, fats, and oils deduced from the numerous definitions. Soaps are frequently sold in a solid, moulded form known as a bar because of their shape (New World Encyclopedia, 2015).

Fat and alkali are the basic materials for soap production, although other additives such as optical brighteners, water softeners, and abrasives are frequently used to achieve specific properties (Davidsohn, 2021). According to Kuntom (1996), the composition of fats, oils, and alkalis are as follows:

Animal or plant fats and oils are utilized in soap production. Each fat or oil contains a unique blend of several different triglycerides. Three fatty acid molecules are linked to one glycerine molecule in a triglyceride molecule. There are numerous different forms of triglycerides, each with its unique combination of fatty acids.

Animal and vegetable oils and fats or fatty acids, as well as by-products of the cellulose and paper industries, such as rosin and tall oil, are all fatty raw ingredients for soap manufacturing, according to Davidsohn (2021). According to the qualities of the soap products they produce, Davidsohn (2021) divided these essential ingredients into four groups:

- Hard fats yielding slow-lathering soaps include tallow, garbage greases, hydrogenated high-melting-point marine and vegetable oils, and palm oil. These fats generate soaps that lather up little in cold water but a lot in warm water is gentle on the skin and clean well. Tallow is an essential member of this category of fats utilized in the international soap business.

- Hard fats yielding quick-lathering soaps include coconut oil, palm kernel oil, and babassu oil. Palm-kernel oil is extracted from the kernel of the fruit of the oil palm, whereas palm oil is expressed from the pericarp or outer fleshy portion of the fruit. Because these lipids are not sensitive to electrolytes like salt, they are ideal for making marine soap, which must lather in seawater. The second most important group of soap fats, after coconut oil, is the most often utilized.
- The oils that produce soft soaps, such as olive oil, soybean oil, and groundnut (peanut) oil, are the most essential, although linseed and whale oils, as well as several semi-drying or drying oils, also fall into this category. Because these oils are susceptible to changes in air, light, and temperature, soaps manufactured with them may turn rancid and discoloured over time.
- A distinct group is Rosin and tall oil (a resinous by-product of chemical wood pulp manufacturing). Rosin is utilized in various sectors, including laundry soap, less expensive bath soaps, and speciality soaps. Tall oil is mainly utilized in the production of liquid soap.

Fatty acids are components of fats and oils used in soap production. They are weak acids that are divided into two pieces. One hydrogen (H) atom, two oxygen (O) atoms, and one carbon (C) atom, plus a hydrocarbon chain connected to the carboxylic acid group, make up a carboxylic acid group. It is made up of a long, straight chain of Carbon (C) atoms, each of which carries two Hydrogen (H) atoms. Davidsohn (2021) also stated that a hot caustic alkali solution, such as caustic soda (sodium hydroxide), reacts with natural fats or oils to form sodium fatty acid salt (soap) and glycerin (or glycerol).

Alkali is a soluble salt of an alkali metal like sodium or potassium. Initially, the alkalis used in soap production were derived from plant ashes, but they are now manufactured commercially. The term alkali now refers to a chemically-a base (opposite of an acid) that reacts with and neutralizes acids. Sodium hydroxide (NaOH), commonly known as caustic soda, and potassium hydroxide (KOH), sometimes known as caustic potash, are two typical alkalis used in soap manufacturing. Sodium soaps made from sodium hydroxide are often firmer, but potassium soaps made from potassium hydroxide are typically softer or liquid. According to Davidsohn (2021), potassium soaps are more water-soluble than sodium soaps. The primary function of alkaline in soap is to balance or neutralize the acidity of other ingredients (SDAC, 2019).

Components of Detergents and their importance

A detergent is a chemical substance or mixture of chemicals that are used to clean (New World Encyclopedia, 2015). They went on to say that the term "detergent" is used in a narrow sense to refer to synthetic cleaning chemicals found in personal hygiene, dishwashing, and laundry goods. Laundry detergent, often known as washing powder, is a cleaning chemical that comes in powder and liquid forms and is used to clean laundry (Jerzy,2019). According to the SDAC (2019), detergents are effective cleaning products since they include one or more surfactants. Surfactants used in detergents, they claimed, might be tailored to operate well under various situations due to their chemical makeup. They say that surfactants are less affected by water hardness minerals. Surfactants, builders, bleaches, enzymes, and other substances were identified as general components of detergent ingredients by the association, and they were explained as follows:

Surfactants are organic substances that affect the properties of water. They are also known as surface-active agents. They lessen water's surface tension, allowing the cleaning solution to moisten a surface more quickly, allowing the soil to be loosened and removed more easily, usually with the help of mechanical action. According to the association, surfactants emulsify oily soils and maintain them distributed and suspended so they don't settle back on the surface. They went on to say that surfactants are categorised in water based on their ionic (electrical charge) qualities, and they are:

- Anionic surfactants are utilized in laundry and hand dishwashing detergents, household cleansers, and personal cleansing products because of their outstanding cleaning capabilities. Linear alkylbenzene sulphonate, alcohol ethoxysulphates, alkyl sulphates, and soap are prevalent in anionic surfactants.
- Non-ionic surfactants are water hardness resistant and transparent to most soils well. They are commonly found in laundry detergents and rinse aids, as well as automatic dishwasher detergents. The alcohol ethoxylates are the most extensively utilized.
- Fabric softeners and fabric-softening laundry detergents also contain cationic surfactants. Some household cleaners contain cations as a disinfecting/sanitizing agent. The quaternary ammonium compounds are the most common cationic sulphates.
- Because of their mildness and stability, amphoteric surfactants are employed in personal washing and household cleaning solutions.

Depending on the pH (acidity or alkalinity) of the water, they can be anionic (negatively charged), cationic (positively charged), or non-ionic (no charge) in the solution. Imidazolines and betaines are the most common amphoteric surfactants.

Most detergents utilize a combination of different surfactants to balance their performance, although laundry detergents typically combine anionic and non-ionic surfactants, according to the organization.

Builders improve or sustain the surfactant's cleaning efficacy (SDAC, 2019). According to SDAC (2019), the major role of builders is to alleviate water hardness. This is accomplished through sequestration or chelation (which keeps hardness minerals in solution), precipitation (which creates an insoluble material), or ion exchange (which exchanges ions) (trading electrically charged particles). Complex phosphates and sodium citrate are frequent sequestering builders, whereas sodium carbonate and sodium silicate are precipitating builders, and sodium aluminosilicate (zeolite) is an ion exchange builder, according to the researchers.

According to the organisation, builders can also provide and maintain alkalinity, which aids cleaning, particularly of acid soils, keeps removed soil from resettling during washing, and emulsifies oily and greasy soils.

Bleaches are mainly used to remove oxidizable organic stains (chlorophyll, anthocyanin colours, tannins, humic acids, and carotenoid pigments) that are usually of vegetable origin (SDAC, 2019). Despite the name, contemporary bleaching chemicals do not involve home bleach; they are added (sodium hypochlorite). Laundry bleaches are primarily stable adducts of hydrogen peroxide, such as sodium perborate and sodium percarbonate, which are inert as solids but react with water to produce hydrogen peroxide, which performs the bleaching activity, according to the association. According to the researchers, bleach activators like tetraacetylethylenediamine (TAED) are becoming more popular because they react with hydrogen peroxide to form peracetic acid, which is more effective at lower temperatures (60 °C).

Enzymes; Proteins (milk, cocoa, blood, egg yolk, grass), fats (chocolate, fats, oils), starch (flour and potato stains), and cellulose (cellulose stains) all require enzymes to decompose (damaged cotton fibrils, vegetable and fruit stains). SDAC (2019) went on to say that each stain requires a separate enzyme. For example, protein stains require proteases (savinase) enzymes, grease stains require lipases enzymes, carbohydrate stains require -amylases enzymes, and cellulosic stains require cellulases enzymes (SDAC 2019).

Other ingredients: Many more compounds are added to detergents based on the expected circumstances of use, according to SDAC (2019). They went on to say that such additions change the product's foaming capabilities by stabilizing or counteracting foam, while other substances change the viscosity of the solution or solubilize other compounds. Corrosion inhibitors, for example, are added to detergent to prevent damage to washing equipment; dye transfer inhibitors are added to prevent dyes from one article from colouring other items; antiredeposition agents are added to prevent fine soil particles from reattaching to the product being cleaned. They went on to say that detergents contain a variety of substances that alter the aesthetic features of the item to be cleaned, as well as the detergent itself, before and during use. Optical brighteners (brightening agents with a specialized action that gives washed garments brilliance and freshness), fabric softeners, and colourants are examples. They went on to say that a range of scents can be found in current detergents as long as they are compatible with the other ingredients and do not change the colour of the cleaned object. Perfumes are made up of a variety of substances, including terpene alcohols (citronellol, geraniol, linalool, nerol) and their esters (linalyl acetate), aromatic aldehydes (helional, hexyl cinnamaldehyde, lilial), and synthetic musks, according to them (galaxolide).

Real Wax Prints

Wax prints, rather than woven designs, are cotton woven fabrics that have been embellished with motifs or patterns of diverse designs. According to Essel (2017), Wax print fabrics have a waxy venial effect and patchy designs due to the varied methods of wax application in the printing process of fabrics, such as cracking and splattering of the wax. He went on to say that wax prints, like batiks, produce duplex printing effects. Wax prints in Ghana are sold under several brand names by various textile manufacturing companies. Wax prints were divided into two categories by Uqalo (2015): real wax and mini wax. Real wax, he explained, is an Indonesian-inspired machine-made batik cloth with a duplex appearance, in which wax is employed as a resisting agent to prevent dye absorption and has fascinating linearity due to the wax's cracking effects. He went on to say that mini wax, also known as a fancy print, gives the impression of a computer-generated 'crack' look when only one side of the fabric is printed, and the other side is left blank when printed.

Kitenge (2017) described the basic steps involved in making wax prints. He explained that wax prints are made from raw cotton spun yarns and weaved into grey material. After being bleached white to clean and remove any impurities, the grey cloth is reinforced and stretched to the required width. He went on to say that the prints are created on a computer using CAD software in black and white. The design is then carved onto a pair of copper rollers before being printed using melting, molten pine tree resin wax on both sides of the cloth. The cloth is then immersed in an indigo dye bath, with the exposed areas coloured and the resin-covered parts resisted. This procedure, he added, can also generate naturally occurring fine fractures in the wax, allowing little amounts of colour to soak through onto the linen. The wax is then purposefully fractured with special machinery to provide the desired effect, including marbling and bubbles. According to Kitenge (2017), solid colours are added to the design either before or after the wax is scraped from the cloth using giant industrial printing machines. He also mentioned that portion of the design is sometimes hand-carved onto a wooden block and then transferred to the fabric by hand (a process known as block printing). This is where the prints get their distinctive and brilliant colours. After that, the cloth is washed to remove any remaining wax or excess dyes, ensuring that colour fastness standards are met. He went on to say that depending on the intended effect, multiple types of finishes are put to the cloth. As a result, certain textiles become more and more expensive. Due to the nature of the wax printing method, Kitenge (2017) claims that it is challenging to make each piece of cloth seem precisely the same, making them unique.

Physical Properties of Woven fabrics

According to Fibre Talk (2021), woven fabric is any textile created by weaving. Weaving is one of the most ancient and extensively used fabric production processes. Woven fabric is defined by Fibre Talk (2021) as any fabric formed by interlacing two or more threads at right angles to one another. Using the exception of triaxial fabrics, all woven fabrics, according to Kadolph (2007), are manufactured with two or more sets of yarns interwoven at right angles and are referred to as biaxial fabrics. Weaves are frequently manufactured on looms, and all woven fabrics contain warp or longitudinal threads that run vertically and weft or crosswise or filler yarns or picks that run horizontally. Unless the threads used are elastic, woven fabrics are regarded to be more robust and only stretch diagonally on the bias orientations between the warp and weft directions (Fibre Talk, 2021). They went on to say that woven material frays at the edges unless techniques like pinking shears or hemming are employed to prevent fraying. According to Textiles School (2018), the physical qualities of a fabric are the fabric's static physical dimensions. They defined the weave type and the warp and filler yarn count per linear inch as physical features of woven materials.

Weave type

The interlacement process between warp and weft strands determines the cloth weave (Saiman, Wahab &Wahit, 2014). All woven fabric is created by weaving numerous individual threads, the vertical warp threads and the horizontal weft threads, into a bigger whole on a loom, whether it be an industrial loom or a personal handloom (MasterClass staff, 2020). They stated that the structure and longevity of the fabric are determined by how these threads are knitted together.

They went on to say that any of the three basic textile weaves, plain weave, twill weave, and satin weave, can be used to create any sort of woven fabric. They go on to say that the plain weave is the simplest and most prevalent of the three fundamental forms of the weave. Plain weave, also known as a calico weave, tabby weave, or basic weave, features a pattern of straight interlacing threads passing under and over each other in right angles, comparable to a woven basket, according to MasterClass staff (2020). According to MasterClass staff 2020, plain weave textiles are very durable and reliable and may be utilized for everything from clothes to upholstery. Plain weave textiles, they added, are often quite durable, retain their shape after several washes, and do not pill. This adds to the fabric's structure, which helps it keep its shape while in use. Plain weave fabrics are not highly stretchy, so they are easy to sew without having gathers or puckers, they noted. They claim that because plain weave fabrics have a simple criss-cross pattern on both sides, there is no "wrong" side unless the fabric is printed on one side.

According to Saiman, Wahab, and Wahit (2014), plain weave is the basic reinforcing structure in textile composites, with a constant but high crimp percentage. The warp yarn and filler yarn are the primary yarn components used to manufacture plain weave fabric. The weft yarns (also known as filler yarns) are horizontal threads that are brought over and under through the taut warp strands and bunched at the bottom of the machine, according to MasterClass staff (2020). The right–angle location of the warp to the filling yarns, according to Kadolph (2010), creates more fabric hardness and rigidity than yarn configurations in knits, braids, or laces. Yarns can be ravelled from adjacent sides due to their structure. According to Teli, Khare, and Chakrabarti (2008), the warp yarn direction of fabrics is stronger and may offer more resistance to stress-related deformation than the weft yarn direction.

Yarn

A yarn is a continuous strand made up of twisted fibres suitable for fabric manufacturing (Texcoms Textiles Solution-TTS, 2019). Another definition of a yarn given by Texcoms Textiles Solution -TTS, (2019) is "groupings of fibres to form a continuous thread." A yarn is a fabric's building block, and as such, it has a substantial impact on the fabric's qualities. This means that the yarn's qualities significantly impact the fabric's performance, use, and care. (Texcoms Textiles Solution-TTS, 2019). Most staple fibres are made into yarn through a process of drawing, spinning and twisting that allows an assembly of fibres to hold together in a continuous strand.

Yarns can be classified in a variety of ways. Monofilament, multifilament, and staple or spun yarns are the most common yarn kinds. Monofilament yarns have a single filament, as the name implies. Many filaments are twisted together to make multifilament yarns, according to TTS (2019). As previously stated, staple or spun yarns are made up of staple fibres that have been spun together to form a long, continuous strand of yarn. Typical yarn formations include single fibres combined into a single yarn, ply/plied (two or more yarns twisted together), cabled/corded (several plied yarns twisted together), blended/compound (different fibre types combined in a yarn), core-spun (a yarn with one type of fibre, usually a filament, in the centre (core) of the yarn, which is usually covered (wrapped) by staple fibres and fancy or effect yarns (yarns with special effects or deliberate irregularities such as slubs - thicker portions) or loops occurring regularly or randomly along the length of the yarn).

Engineering a specific set of qualities can be done using a combination of various fibres and yarn architectures. Sewing threads are an example of a yarn that has been designed with a specific function in mind. Yarns are frequently given additional finishes to ensure that they are suitable for their intended use. Direct yarn numbering and indirect yarn numbering are the two primary forms of yarn numbering systems that define yarn fineness, thickness, and size. The weight or mass of a fixed length of yarn (mass per unit length) is used in the direct yarn numbering system. In contrast, the length of yarn with a set weight is used in the indirect yarn numbering system (length per unit mass). Both systems provide a measurement of the yarn's fineness (or thickness), which is critical for its use in fabric manufacturing techniques like knitting and weaving. After the yarns have been treated, they must be combined in some way to create a fabric.

Fabric Count

Fabric count, also known as fabric density, is the number of wrap and filler yarns per square inch of grey textiles, according to Kadolph (2007). (fabric as it comes from the loom). Counts may vary based on the intended usage or fabric quality. Even though yarns, not threads, are counted, it is frequently stated as a total and may be described on labels as thread count. As a result, the number of yarns per inch is counted in each direction. According to Kadolph (2007), greater numbers indicate higher-quality fabrics. During uniaxial testing, Joseph (1988) also indicated that the number of threads in a fabric impacts its resistance capacity in part. Due to shrinkage during dyeing and finishing, the count may increase. The count is written with the warp number first; for example, 80 x 76 (read as "80 by 76"), or the sum of the two,

156. The count is a measurement of fabric quality, and the higher the count, the better the fabric. A higher count may also mean less shrinking and seam edge ravelling. Catalogues and e-commerce sites, according to Kadolph (2007), contain count because the buyer must appraise product quality based on printed information rather than inspecting the product. The strength of cloth is also determined by the thread pack, weave type, and fabric weight, according to Ozdil, Ozdogan, and Oktem (2003).

Fabric count has an integral part in assessing the quality of a fabric, according to Kadolph and Ozdil et al. (2003).

Fabric Weight

Fabric weight, often known as fabric mass, refers to the amount of fabric that a specific area or length of fabric weighs. Cloth weight is essential because it determines whether a fabric is suitable for a given use and to name materials. In the textile sector, both length and area weight values are utilized. Yards per pound can be used in trade journals to determine current costs for basic fabrics, according to Kadolph (2007); however, fabric width is critical in this system. Weight is measured in ounces per square yard (oz/yd^2) in another system. g/m^2 is the metric equivalent (grams per meter square).

Fabrics are classified as lightweight or top-weight, medium weight, or heavyweight, according to Kadolph (2007). Fabrics that weigh less than 4.0 oz/yd^2 are considered lightweight or top-weight. They have a superior drape and are softer and more pleasant next to the skin. Shirts, blouses, dresses, apparel linings, bedsheets, curtains, sheer draperies, substrates for industrial items, backing fabrics for wall coverings, and bonded and quilt fabrics are all examples of top-weight fabrics. Fabrics in the medium weight range from 4.0

to 6.0 oz/yd^2. Popular uses are heavy and stiffer shirts, blouses, dresses, garment linings, winter-weight bedsheets, draperies, upholstery, wall coverings, and table linens.

Quilted and bonded fabrics and substrates for industrial products employ a lot of medium-weight fabrics. Because they are used for garment bottoms like pants and skirts and suiting, heavy-weight textiles are also known as bottom-weight or suiting-weight items. They are heavier than 6.0 oz/yd2. Outerwear, work apparel, upholstery, draperies, bedspreads, and industrial items are all made from these tough, rigid materials.

Washing Process

Because washing processes contribute more to fabric degradation than use or wear, the time of a garment's life cycle during use can be measured by the number of laundry cycles that a garment can withstand before revealing the first indications of damage (Agarwal, Koehl, Perwueltz, & Lee, 2011). According to Kadolph (2007), washing removes filth from textile products by agitating a water-detergent solution with heat from the water. Washing is also defined by Hossain, Rony, Hasan, Kawsar, Azharul, and Zhou1 (2017) as a technology for modifying garments' appearance, size, outlook, comfort ability, and fashion. They went on to say that washing is nearly always associated with important treatments targeted at eliminating insoluble matter, stuff already in solution, or an emulsion of other pollutants from the fabric. Regardless of the differing perspectives in Kadolph's (2007) and Hossain et al. (2017)'s definitions of washing, the primary mandate of both definitions is the removal of undesired substances from a textile product. According to Kadolph (2007), agitation in the washing machine gives mechanical action that aids in soil removal, while detergent and water provide chemical energy that aids in soil removal. Other compounds, she said, could be present to aid with cleaning, disinfection, or fabric softening. According to Kosikovic, Vladic, Milic, Novakovic, Milosevic, and Dedijer (2017), the washing process in a laundry machine involves many factors, including mechanical action, chemical action, temperature, and time, with the chemical action having the most significant effect on soil loosening, aside from fabric moving, water flow rate, and washing time. These claims imply that washing on a textile product results from everything that occurs during the washing process.

Water is a cleaning ingredient utilized as a solvent in washing since it is cheap and widely available; as mentioned, Water is a crucial component of washing, and although being an excellent general solvent, it has a property known as surface tension. Each molecule in a body of water is surrounded by and attracted to other water molecules. However, those molecules are surrounded by other water molecules at the surface, creating tension as the surface water molecules are dragged towards the body of the water. Water beads up on surfaces like glass and fabric due to the strain, slowing the wetting of the surface and impeding the cleaning process. As a result, water's surface tension must be reduced in order for water to spread and soak surfaces. Surface active agents, or surfactants, are chemicals that can successfully do this. It is thought that they make water "wetter." Surfactants also loosen, emulsify (disperse in water), and retain soil in suspension until it is washed away all vital cleaning actions. Alkalinity, which is vital in eliminating acidic soils, can be provided by surfactants. Surfactants, present in soaps and detergents, lower water's surface tension, allowing water molecules to moisten the surface more effectively and increasing water's capacity to remove filthy oily stains.

According to Kadolph (2007), several approaches have been devised to stimulate how a product is cared for by users. Home laundering and attempts by professional establishments such as dry cleaners and commercial launderers are examples of these techniques. When a material used in a textile product is subjected to a cleaning process, several issues might arise, including shrinkage, distortion, non-removal of soil, wrinkling, colour loss, staining, change in hue, change in hand or texture, and other changes in appearance, according to Kadolph (2007). She found that assessing a material's reaction to the cleaning process is critical since it can lead to consumer dissatisfaction with the result. She stressed that while it is important to consider how specific materials react to cleaning, goods might be made up of various elements. As a result, the interaction of the materials in the product to be cleaned is just as essential as how each material interacts with different cleaning processes, filth types, and cleaning chemicals.

According to Kadolph (2007), a good cleaning is dependent on the machine cycle, adequate storage of textiles to be cleaned in the same cycle, and the right number of chemical compounds to help with cleaning, disinfecting, and softening. Incorrect choices in any of these areas might lead to cleaning issues and unhappiness with the product's appearance. According to Kadolph (2007), the cleaning method is designed to remove only those foreign contaminants that are classified as soil. The dyes, pigments, and adhesives used to apply fusible interlinings, label print inks, and chemical finishes should be kept in their original containers. As a result, all changes should be identified and measured while examining a material's reaction to cleaning during material testing.

Colourfastness to Washing

Colourfastness refers to a textile fabric's ability to preserve its dye colour after being washed, exposed to harsh light, and gassed or rubbed (Mokhtari, Nouri and Sarli, 2011). According to Kadolph (2007), one problem in washing is poor colourfastness. She explained that new items might experience colour loss when washed for the first time because the excess colour was not rinsed off after dyeing. Kadolph (2007) further stated that, in some cases, the loss of colour is noticeable, and in other cases, the product may look the same, but a colour transfer has occurred. She explained that dye rinsed off one material binds with and stains other materials during colour transfer, although colour loss can occur when weakly attached dye molecules migrate out of the fibre. According to her, when dye molecules decay or become damaged, they lose their ability to create colour or remain linked to the fibre, reducing the overall amount of molecules colouring a material. When this loss applies to a sufficiently high percentage of dye molecules, the product looks faded.

Lilley (2011) also stated that the degree of fading and staining of dyed goods when washed is dependent on some factors, including the temperature range, which can range from 40°C to 95°C; the type and amount of detergent added to the washing bath; the rinsing, drying, or pressing methods used to restore the sample after the washing test; and the extent of mechanical action, which can be varied by changing the agitation speed in a washing machine or by adding steel balls to the

Lilley (2011) found that washing and sunlight cause the colour of Real Wax, Real Java, and Batik fabrics to fade and suggested that they be dried in the shade. Fianu and Adams (1998) found that washing and sunlight cause the colour of Real Wax, Real Java, and Batik fabrics to fade and suggested that they be dried in the shade. In another investigation, Kwame (2012) discovered that soap types had a substantial impact on the colourfastness of GTP and ATL cotton fabrics. A similar study by Obiana, Ahuwan and Abdullahi (2007) on the comparative effect of laundering using soap and synthetic detergent on the fading properties of Nigerian and Foreign made Wax Print Fabrics also concluded that synthetic detergent fades wax print fabric more than soap on both prints. Therefore, it can be deduced from both studies that colourfastness may occur as a result of the processes involved in washing as well as the type of soap used in washing.

To rate or analyze changes in the color appearance of materials, numerous methods are utilized. The use of greyscale to assess changes in the colour of textiles due to testing is one of these ways. The colour change grey scale comprises paired chips that range in colour from light to dark grey. It's a nine-step scale with half-points depicted graphically. A colour change is any colour change, whether in brightness, hue, chrome, or any combination of these, that may be seen when comparing the test specimen to an untested sample. A grayscale consists of standard grey chips; each pair represents a progressive difference in colour or contrast that corresponds to a numerical colourfastness grade. Besides assigning a numerical grade to represent colour contrast, a colour change also can be described using such terms as a shift to another hue, lightening or darkening of the colour or a change of more or less chroma. Grey scales allow for visual identification of colour change with minimal training and rating scales (Kadolph, 2007). However, for the study, the gray scale with the colour assessment chamber was used to evaluate the colour change between selected GTP wax prints.

Tensile Strength to Washing

Though one may judge fabric strength by its weight as stipulated by Ozdil *et al.* (2003), its actual strength cannot be determined by its weight alone. The fabric's strength is an important feature that determines and influences all of the fabric's other performance characteristics (Uttam & Gangwar 2006). Tensile strength is defined by Realff, Boyce, and Backer (1997) as the most significant load that a test specimen can withstand when subjected to uniaxial tensile loading. They claimed that a fabric's strength is determined not just by the strength of the yarn components but also by the fabric's structure. Uttam and Gangwar (2006) defined tensile strength as the maximum amount of tensile stress that a material can withstand before failing.

On the other hand, Tensile strength is defined by Kadolph (2007) as the strength of a material under tension and is quantified in terms of force. According to Kadolph (2007), tensile strength usually refers to fibre performance. A fabric's tensile strength is determined by force required to break it and the distance it must travel to do so. The force required to rupture a cloth is known as breaking force or strength. According to the American Society for Testing and Materials – ASTM (2005), breaking elongation is defined as the elongation that corresponds to the breaking force.). It is usually expressed as a percentage and denotes the lengthening of a certain specimen before rupturing. According to Kadolph (2007), several strength criteria are written as It is usually reported as a percentage and indicates the increase in specific specimen length that happened before to rupture. Many strength standards are written as breaking force values, according to Kadolph (2007), even if they can be characterized by the terms tensile strength or tenacity.

The tensile strength can also be defined in three ways, according to Candan, Nergis, and Iridag (2000): yield tensile strength, which is the maximum stress a material can withstand without permanent deformation; ultimate tensile strength, which is also the maximum stress a material can withstand; and breaking tensile strength, which is also the stress coordinate on the stress-strain curve at the point of rupture. According to Mukhopadhyay and Ray (2006), yield strength is the stress that causes permanent deformation of 0.2 per cent of the original dimension.

During strength testing, the cloth is subjected to forces under carefully regulated conditions (Kadolph, 2007). The energy expended to cause a given type of failure is measured by force applied to the fabric. The quantity of mass required for anything to happen is measured as a force. Because most fabrics have two-dimensional features, such as lengthwise and crosswise, warp and filling, or wale and course, many strength testing methodologies include testing of two sets of fabric specimens (Kadolph, 2007).

The lengthwise dimension is represented by one set, while the other is the crosswise dimension. The focus of woven fabrics is on two dimensions: the warp yarn (the lengthwise dimension) and the filler yarns (the crosswise dimension). Gong and Chen (1999) discovered that the strength of woven fabric originates with the impacts of the crossing points, where warp and weft threads interlace to form a fabric, leading to the ultimate tensile strength of the fabric. Tensile strength in either the warp or weft direction, according to Uttam & Gangwar (2006), is essentially a function of yarn strength, with the weave playing only a minor role. Three primary parameters influence the structural tightness of a woven fabric. These are the figures. A study by Cano-Glu, Geultelin and Yeukselo-Glu (2004) confirms the assertions made by Uttam & Gangwar (2006) and Raul (2005). They discovered that fabrics in both the weft and warp orientations had lower tensile strength values after five washings, which was most noticeable in the weft direction of the breaking strengths. Another study by Fianu, Sallah, and Ayertey (2005) refutes Uttam & Gangwar (2006) and Raul's claims (2005). Their research discovered that how clothes are cared for during the laundry process impacts fabric performance. The influence of different drying processes on the colour and strength of wax printed fabrics was investigated, and it was discovered that sunshine weakens Real Wax printed fabrics from GTP, with laundered examples losing more strength in the sun than in the shade.

Because of the way fabrics are manufactured and treated, the location from which specimens are removed from the fabric is particularly crucial when testing for tensile strength, according to Kadolph (2007). She went on to say that the fabric closest to the selvages can differ more than the fabric at the centre. As a result, specimens for strength testing are frequently limited to the fabric's centre. According to Kadolph (2007), tensile strength is measured using two conventional test methods: the grab test and the strip test. Depending on the size and preparation of the specimens, any of these can be employed. Both approaches allow for the testing of wet specimens, which may be a crucial performance consideration for some materials.

The cut strip test is not suggested for materials that can be ravelled because the force applied to the yarns along the lengthwise edges causes them to unravel during testing. Ravelled and cut strips are helpful because they explain the strength of yarns in the fabric and calculate the power necessary to break a specific width of fabric. The ravelled strips are cut on the grain, with the threads ravelled out on both long sides. Each specimen's two short edges are not ravelled and remain cut edges. Both strip tests need specimens to be put in the jaws with the long cut or ravelled edge parallel to one of the clamp edges. The machine is operated in the same way as the grab test, and the findings are recorded in the same way. As a result, the ravelled strip test was used in the study.

Dimensional Change to Washing

Laundrying repeatedly induces dimensional instability and textile distortion, resulting in mechanical properties such as increased surface roughness and particular alterations in fabric structure (Kosikovic, Vladic, Milic, Novakovic, Milosevic & Dedijer, 2017).

According to Kadolph (2007), Dimensional change is any change or modification in the dimensions of a material, component, or product during finishing, manufacture, or care. She added that it also refers either to an increase (growth) or to a decrease (shrinkage) in dimension. Some materials may shrink in one dimension and grow in another. Changes occur because tensions in some materials that are generated during yarn spinning, manufacturing, and finishing may be relieved when a material is wetted and dried without tension, according to Kadolph (2007). Relaxation shrinkage is the name for this type of shrinkage (Kadolph, 2007). Poor dimensional stability can lead to fit, size, appearance, and end-use stability issues.

Not all relaxation shrinkage problems are resolved during the first care cycle; it may be necessary to evaluate residual shrinkage, which is relaxation shrinkage that is not removed during the first care cycle. Although residual shrinkage is usually minor, a larger amount can cause customer discontent. Progressive shrinkage, which occurs with some rayon textiles and fabrics composed of softly twisted cotton yarns, is also described by Kadolph (2007). Progressive shrinkage occurs when a material shrinks a little each time it is cleaned.

Fabric density and drape are affected by inadequate dimensional stability and product fit and appearance issues. When materials shrink, they may become more compact and stiff. Dimensional stability issues may not be consistent from one part of the material to the next in length and transverse directions. As a result, to avoid exhibiting the same warp and filler yarns in two specimens, test procedures use many specimens cut from different sections of the conditioned fabric (Kadolph, 2007).

Conceptual Framework

This section presented a framework for analysed the differences in effect between Key Soap and New Omo on the tensile strength, colourfastness and dimensional stability of Adepa Dumas and Nustyle prints. Key Soap and New Omo possesses different ingredients, which may affect the performance of both prints when they are subjected to washing.

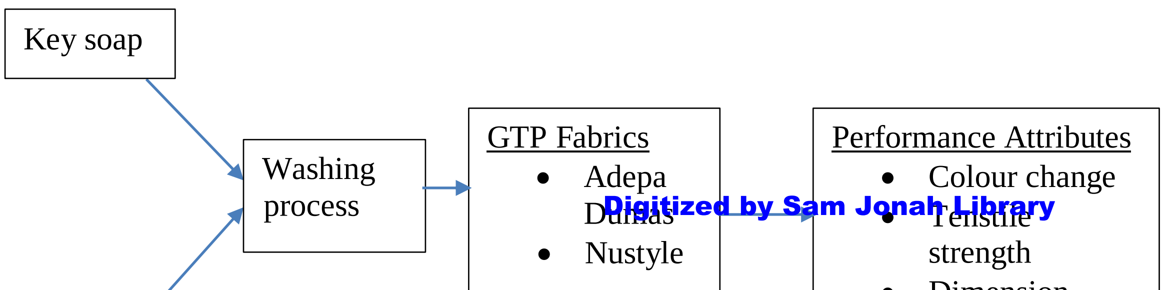


Figure 1: A Framework for Analysing the Differences in Effects between Key Soap and New Omo on the Tensile Strength, Colour Change and Dimensional Stability of Adepa Dumas and Nustyle.

Source: Author's Construct, 2020.

According to Hearle and Morton (2008), differing chemical compositions of soaps will likely have varying impacts on textile textiles. In the process of washing, fabrics are exposed to the chemical components of soaps and detergents, which in turn affect textile fabrics. Therefore, the ability of textile fabrics to resist the effects of various ingredients found in soaps and detergents plays a critical role in determining the quality of the fabric. In addition, the quality of a textile fabric also depends on the fabric's ability to resist stress. According to Mott (2002), the more fabric undergoes stress (washing), their strength and colour depreciate. This implies that as fabrics are being subjected to stress, their quality reduces. Through washing, fabrics are exposed to agitations, which is how stress is applied to textile fabrics.

The fabric's ability to withstand stress from washing and the number of times it has been washed are both important factors in assessing the fabric's quality. As a result, discrepancies in the structural aspect of wax prints in terms of fibre qualities, yarn count, weight, and weave type may influence the fabric's quality. The chemical composition, the number of washing sessions, and the structural features of both textile fabrics may explain the differences in effect between Key soap and New Omo on the colourfastness, tensile strength, and dimensional stability of GTP's wax prints.

CHAPTER THREE

RESEARCH METHODS

Introduction

The purpose of this research was to see if there are any changes in the effects of Key Soap and New Omo on the performance parameters of two different brands of Tex Styles Ghana wax prints. The study's research techniques are described in this chapter. It discusses how the experiments were carried out and why certain methodologies and strategies were used. The materials utilised in the study are also described in the chapter, which concludes with an explanation of how data was collected and analyzed.

Research Design

The study employed the experimental research design within a quantitative model. This design was used because the study was a laboratory work that involved a thorough examination of variables and a collection of numerical data to explain the various phenomena of interest. The study investigated the effects of Key Soap and New Omo on the colourfastness, tensile strength and dimensional stability of selected Tex Styles Ghana wax prints after two washing cycles for five washing periods. A 2x2x5 factorial design was employed for the study, which involved two brands of fabric, two soaps, and five washing periods.

According to Gay, Mills, and Airasian (2009), as cited by Amedahe and Gyimah (2018), a factorial design is an experimental design that permits the investigation or manipulation of two or more independent variables simultaneously to determine the main effect and interactive effect on the dependent variable. Amedahe and Gyimah (2018) further stated that there might be an interaction effect among the independent variables in a factorial design where there are two or more independent variables. This implies that the effect that one independent variable has on the dependent variables may depend on the level of the other independent variable. This study investigated the effect of three independent variables; laundry soaps, fabrics and washing periods on dependent variables; colourfastness, tensile strength and dimensional stability of the fabrics. Other parameters investigated to provide the structural descriptions of the fabrics used were weave type, yarn count and weight.

Study Area

The study was carried out in the textile laboratory of the Ghana Standards Authority (GSA), and the appropriate standard methods were used. The experimental procedures were carried out with the assistance of the technicians at the Ghana Standards Authority in a textile laboratory.

Materials

Six yards of GTP Adepa Dumas (11188) and six yards of GTP Nustyle (60706) wax prints from Tex Styles Ghana Limited were bought from the market. These fabrics were chosen because these were new brands of wax prints produced by a company that is perceived to produce good quality African prints in Ghana. GTP Adepa Dumas (11188) and GTP Nustyle (60706) were labelled as A and B, respectively.

A bar of Key Soap and 900 grams of New Omo were purchased from the market. The detergents were labelled as K and O, respectively, for the study. These brands of laundry soaps were chosen because they are also produced by the same manufacturing company, Uniliver Ghana Limited and are considered the most famous traditional laundry products in Ghana. Besides, with the introduction of New Omo for all fabrics, its effect on printed fabrics had not been scientifically proven compared to Key Soap, which was the best soap for printed fabrics (Kwame, 2012).

Sampling Procedure

A total number of two hundred and five (205) specimens were obtained from every fabric sample. In order to obtain an accurate representation of the various sections of every fabric, specimens were cut from different locations on the fabric (Figure 2). Purposive sampling was used to select the number of specimens from every fabric sample and distributed among the various experiments conducted. This sampling technique was employed because fabric specimens were cut in specific measurements and directions to meet the various specifications needed for the various test conducted.

Out of the two hundred and five (205) specimens for every fabric type, one hundred and sixty (160) specimens were used for testing tensile strength, fifteen (15) for colourfastness, fifteen (15) for dimensional stability, five (5) specimens for weight and ten (10) specimens for yarn count (Table 1).

FP	FF	FP	FF	FP	FF	FP	FF	FP	FF
FF	FP	FF	FP	FF	FP	FF	FP	FF	FP
FP	FF	FP	FF	FP	FF	FP	FF	FP	FF
FF	FP	FF	FP	FF	FP	FF	FP	FF	FP
FP	FF	FP	FF	FP	FF	FP	FF	FP	FF
FF	FP	FF	FP	FF	FP	FF	FP	FF	FP
FP	FF	FP	FF	FP	FF	FP	FF	FP	FF
FF	FP	FF	FP	FF	FP	FF	FP	FF	FP

Figure 2: Fabric sampling (FP = Fabric warp; FF = Fabric weft). Source: Authors' Construct, (2020).

Table 1: *Summary of Specimens Numbering*

	CF	DS	TS	WT	YC	Total
Test before treatment	0	0	20	10	20	50
Test after treatment	20	20	200	0	0	240
Test without treatment	10	10	100	0	0	120
						410

CF = colourfastness, DS = dimensional stability, TS = tensile strength, WT = weight, YC = yarn count.

Source: Field Survey, (2020).

Preparation of Specimens

For this study, test methods used by the Ghana Standard Authority Textiles Testing Laboratory were employed. Specimens for the various tests were prepared based on what was indicated in the test methods.

Fabric Weight

According to GS ISO 3801 (2019), to determine the weight of a specimen, an average weight measurement of at least three specimens measuring 10cm x 10cm square area should be used. Five (5) specimens measuring 10cm x10cm, were cut from every fabric sample for weight determination.

Yarn Count

Per the Ghana Standards Authority GS ISO 7211-2 (2019) standard, to determine the yarn count of a specimen, an inch square area in both the warp and the weft yarn directions should be used. Thus, five specimens measuring one-inch square area in both the warp and the weft directions were cut from different locations of every fabric sample.

Tensile Strength

According to GS ISO 13934 (2019), for testing the tensile strength of woven fabrics, the strip method is employed such that specimens for both the warp and weft yarns should have their top and bottom edges frayed leaving a measurement of 25cm x 5cm. Hence, a pattern cutter measuring 30cm x 7cm was used to cut out eighty (80) specimens in both warp and weft directions, respectively, for every fabric sample. The warp directions of specimens from every fabric sample were labelled FP for easy identification, while the weft directions were labelled FF. The top and the bottom edges of the warp and weft specimens for every specimen were frayed to achieve a measurement of 25cm × 5cm of each specimen for testing. This was to ensure that there were no cuts in the warp and weft yarns, which may distort the test.

Colour change

Fifteen (15) specimens measuring 10cm x 10cm from every fabric sample were cut with every colour in the sample fabric well represented. Without any particular measurement, a long strip of a specimen with all the colours properly represented was also cut out from every fabric sample to serve as a reference specimen to colour change.

Dimensional Stability

Per GS ISO 5077 (2019), the standard for testing dimensional stability is that with the identification of both warp and weft yarns, a 10cm x 10cm square area should be stitched along the directions of both yarns. Therefore, fifteen (15) specimens measuring 15cm x 15cm were cut from every fabric sample. An actual measurement of 10cm x 10cm square area was marked on each specimen and stitched. For easy identification, both the warp and weft yarns were labelled.

Labelling of Specimens

The labelling of the specimens was done based on the fabric types, the variables tested, and the directions of yarns in the fabric specimens for some tests. For fabric types, all GTP Adepa Dumas specimens were labelled as 'A' and all GTP Nustyle specimens were labelled as 'B'. Specimens treated with Key soap were labelled as 'K', whiles those treated with New Omo were labelled as 'O', and non-treated specimens were labelled 'N'. Variables tested were labelled as 'W' for weight, 'YC' for yarn count, 'WT' for weave type, 'CF' for colourfastness, 'ST' for tensile strength and 'DS' for dimensional stability.

Specimens from every fabric type were further categorised into four. The categories for Adepa specimens were as follows: i) Adepa before treatment (ABT), ii) Adepa key treatment (AKT), iii) Adepa Omo treatment (AOT) and iv) Adepa non-treatment (ANT). That of Nustyle specimens were as follows: i) Nustyle before treatment (BBT), ii) Nustyle Key treatment (BKT), iii) Nustyle Omo treatment (BOT), and iv) Nustyle non-treatment (BNT). (table 2).

Table 2: *Categories of specimens and their labellings according to their treatment, fabric type, test and period of washing.*

Specimen label (weight, yarn count, colour fastness, dimensional stability and tensile strength	Number of washing period
Before treatment	
ABTW	0
ABTYC	0
ABTWT	0
BBTW	0
BBTYC	0
BBTWT	0
After treatment (key)	
AKTCF	5
AKTDS	5
AKTST	5
BKTCF	5
BKTDS	5
BKTST	5
After treatment (omo)	
AOTCF	5
AOTDS	5
AOTST	5
BOTCF	5
BOTDS	5
BOTST	5
Non treatment	
ANTCF	5
ANTDS	5
ANTST	5
BNTCF	5
BNTDS	5

BNTST	5

Preparation of Soap and Detergent Solution for Washing

A stock solution of Key Soap and New Omo were prepared for washing specimens. Per the standard of the Ghana Standards Authority GS ISO 105-C10:2013, ten grams of each soap was dissolved in a litre of water to produce a soap solution. In the preparation of stocks of key soap solution, a bar of Key Soap was grated into smaller particles in a container and covered. Ten (10) grams of grated Key Soap for each stock prepared was measured and dissolved in a small amount of hot water in a beaker to get all the particles dissolved. The content was then emptied into a volumetric flask, and water was added to a quantity of two (2) litres. The mixture was then allowed to cool at room temperature for washing to be carried out.

In the preparation of the New Omo solution stocks, the same procedure used in the preparation of stocks of the Key soap solution was employed. Enough stocks of key soap and new omo detergent were readily available for washing all the specimens.

Experimental Procedures

The specimens used for the investigation were conditioned for four hours at a conditioning room before testing as indicated in GS ISO 13934 -1 (2019). This was done to ensure that all the fabric specimens had a uniform temperature for reliable results.

Washing of Specimens

Washing of specimens was done according to their treatment groups for every fabric type. All specimens washed with key soap in each fabric type were washed first, followed by New Omo and finally with water (non-treatment). The Standard Launder-Ometer (Gyrowash) (XL/A12/GWM/01) contained seven stainless steel washing cylinders. Each washing cylinder was filled with six specimens and 450ml of washing solution in every washing. Washing was done at a temperature of 30 $^{(+/-1)}$ ^{o}C for 30 minutes for two washing cycles, making a total of 60 minutes for a washing period. This was repeated for every treatment for all the washing period.

Rinsing and Drying of Specimens

Washed specimens were removed from the standard launder-ometer machine, rinsed thoroughly under running tap water and dried on a drying rack under room temperature.

Data Collection Procedure

Test for Weight and Weave type

Based on GS ISO 3801 (2019), five specimens from every fabric type were placed on an electronic balance scale, one at a time and weights recorded. The average weight values were determined and recorded in grams per metre squared (g/m^2). A hand magnifying glass was used on the same fabric specimens to observe the weave types of the fabric samples.

Test for Yarn Count

Every cut specimen for the warp yarns of every fabric type was unravelled, counted and recorded separately for five specimens. The average value was calculated and recorded in inches. The same procedure was repeated for the weft yarns for every fabric type.

Test for Tensile Strength Before and After Washing

The tensile strength testing machine was set at an applied force of 200 newtons per second (200N/s), a compensation load of 20N, and a distance of 200mm between the upper jaw and lower jaw. The breaking strength and elongation of specimens in the warp direction for every fabric sample were tested for five specimens and recorded separately. The average breaking strength and elongation values were recorded in Newtons (N) and in percentage (%), respectively. The same procedure was repeated for the weft direction of every fabric sample.

Test for Colour Change

Using a colour chamber, a geometric gray scale and a cut strip from each fabric type, the colour for each washed fabric specimen was evaluated, and gray scale values were recorded.

Test for Dimensional Stability

With the use of a tape measure, the dimensional change for each washed specimen for both warp and weft directions were determined, and any change observed was recorded.

Data Analysis

IBM SPSS version 20 was used for the analysis of the data. Means and standard deviations were employed to determine fabric's weight, yarn count and tensile strength before treatment and the colour change, tensile strength and dimensional stability after treatment. Three-way, multiple analysis of variance (MANOVA at 0.05 alpha levels) results were used to interpret the experimental data and to test the hypotheses. This was used to determine whether significant differences existed between the main effects and within the subject's effects.

Summary

Before washing, sample fabrics were tested for their weave type, weight, and yarn count. The specimen weight for every fabric sample had a dimension of 10cm x 10cm. Five specimens for every fabric sample were weighed one after the other, and the average weight was determined in g/m^2. The same specimens were used to determine the weave type by using a hand magnifier. The yarn count of specimens for both the warp and the weft yarns for every fabric sample were counted manually. With a dimension of an inch square area of the warp specimens of every fabric sample, five specimens of every fabric sample were unravelled one after the other, and the yarns were counted and recorded separately. An average yarn count of the warp yarns for every fabric sample was calculated and recorded in inches. The same procedure was repeated for the weft yarns.

After washing, rinsing, and drying specimens for every fabric sample, specimens were tested for the colour change, tensile strength, and dimensional stability. Using the gray scale, the colour assessment chamber and the unwashed specimens, the colour change of five specimens for every fabric sample was assessed through visual inspection. Specimens were assessed one after the other by two people in a well-lighted chamber (colour assessment chamber), and grades were recorded separately. An average colour change was determined for every fabric sample and recorded in units. For dimensional stability, five specimens for every fabric sample were measured on the stitched area with the aid of a tape measure one after the other. The measurements were recorded separately, and the average measurement was calculated and recorded in centimetres to determine if there had been a change in dimension. For tensile strength, the warp strength and warp elongation of five specimens of every fabric sample were tested one after the other using a tensile testing machine Hounsfield H5OKT. The strength and elongation of every specimen were recorded separately. The average strength in newton and elongation in percentage were determined for the warp yarns of every fabric sample. The same procedure was repeated for the weft yarns.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

This study investigated the effect of Key Soap and New Omo detergent on the colourfastness, tensile strength and dimensional stability of GTP Adepa Dumas and GTP Nustyle. Readings were recorded for each fabric sample of the tests identified from key soap washed, omo washed, and water washed specimens. The data obtained from the experiments were subjected to statistical analysis using IBM SPSS version 20. Means and standard deviations were used to report the details of the fabrics' selected structural and performance attributes. Inferential statistics (three-way MANOVA at 0.05 alpha levels) were used to test the hypotheses. A Bonferroni Pairwise Comparison Test was also used to determine the significant effect. The results and analysis were first presented, and the discussions followed later under the same headings.

Results and Analysis

Structural and Performance Attributes of GTP Adepa Dumas and GTP Nustyle Before wash

The importance of investigating the structural attributes of both fabrics was in accordance with Ozdil, Ozdogan and Oktem (2003) that the strength of fabric depends on the thread pack, weave type, and fabric weight. Kadolph (2007) also stated that fabric quality is based on the quality of each component used to produce and finish the fabric as well as how the various components interact. As a result, the means and standard deviations of selected structural and performance attributes of GTP Adepa Dumas and GTP Nustyle are presented in Table 3.

Table 3: *Means and standard deviations of selected structural and performance attributes of Nutysle and Adepa (Format properly)*

	Nustyle		Adepa Dumas	
	Mean	Std Dev	Mean	Std. Dev
Fabric Weight (g/m^2)	114	49.20	129	1.99
Fabric Warp yarn count	80	4.96	92	2.68
Fabric Weft yarn count	57	3.20	73	4.33
Breaking strength warp (N)	453	193	496	54.17
Elongation warp (%)	12	7.58	8	0.63
Breaking strength weft (N)	227	16.44	398	20.64
Elongation weft (%)	27	1.24	29	0.62
Fibre type	Cotton		Cottoon	
Fabric weave	Plain weave		Plain weave	

Source: Laboratory Results, (2020).

Both fabrics were 100% cotton with a plain weave of 1x1 repeat in both directions. Adepa had a higher mean yarn count of (M = 92) in the warp direction than Nustyle, with a mean yarn count of (M = 80). For the weft direction, Adepa had a higher mean yarn count of (M = 73) than Nustyle, with a mean yarn count of M = 57 (Table 3). The results show that Adepa Dumas had more yarns in both the warp and the weft directions (92 x 73) than Nustyle (81 x 57). Hosford (2005) stated that the number of threads that count partly determines the weight of fabrics.

Adepa Dumas had a higher mean weight of (M = 129g/m^2) than Nustyle with a mean weight of M = 114g/m^2 (Table 3). The results show that

Adepa Dumas is heavier than Nustyle. Regarding tensile strength, Adepa warp strength recorded a mean strength of (*M* = 496N) with an elongation of (M = 8%). On the other hand, Nustyle warp strength had a mean strength of (*M* = 452N) with an elongation of (*M* = 12%) (Table 3). For the weft direction, Adepa weft strength recorded a mean strength of (*M* = 397N) with an elongation of (*M* = 29%) whiles Nustyle weft strength recorded a mean strength of (*M* = 226N) with an elongation of (*M* = 27%) (Table 3). It could be deduced from the results that Adepa is stronger both in the warp and weft directions than Nustyle. In terms of elongation, Adepa also stretches more in the weft direction than Nustyle (Table 3).

Observation made from the results also shows that the warp directions of both fabrics were stronger than the weft directions. This confirms the claim of Cano-Glu, Geultekin, and Yeukselo-Glu, (2004) that the warp direction is the strongest part of a fabric.

Effects of Key Soap and New Omo on colour change, tensile strength and dimensional stability of Adepa Dumas and Nustyle when Washed for Five Washing Periods.

This section of the report addresses the first research objective, which focuses on assessing the effects of Key Soap and New Omo on the colour change, tensile strength and dimensional stability of GTP Adepa Dumas and GTP Nustyle for five washing periods.

The results presented addresses hypotheses 1 and 2. Table 4 shows the descriptive statistics for tensile strength, dimensional stability and colour change of GTP Adepa Dumas when washed with key soap for five washing periods.

Table 4: *Means and Standard Deviations of Selected Performance Attributes of GTP Adepa Fabric washed with Key Soap.*

Attributes	Mean Wash (*SD*)					
	Before	First	Second	Third	Fourth	Fifth
Strength Warp	496.20 (54.18)	479.80 (186.63)	557.80 (35.56)	519.60 (27.19)	512.20 (41.19)	475.40 (31.37)
Strength Weft	397.60 (20.70)	249.68 (115.14)	373.60 (46.26)	317.60 (34.69)	371.20 (36.65)	352.60 (10.45)
Colour change	5.00 (0.00)	4.20 (0.27)	4.20 (0.27)	4.30 (0.27)	4.10 (0.22)	4.00 (0.00)
Dimen Warp	10.00 (0.00)	9.86 (0.05)	9.74 (0.05)	9.78 (0.08)	9.70 (0.10)	9.72 (0.15)
Weft	10.00 (0.00)	9.82 (0.04)	9.74 (0.05)	9.82 (0.04)	9.80 (0.07)	9.78 (0.04)

Source: Laboratory Results, (2020)

Table 4 shows that after the first wash, the warp strength decreased when compared to the unwashed sample. After the second wash, it increased above the unwashed but decreased again after the third and fourth washes compared to the second wash. However, it was not below the unwashed sample. The final wash, however, decreased below the unwashed sample. The weft strength observed a fluctuating strength after every washing period but below the unwashed.

For a colour change, a colour reduction was observed after the first wash and maintained it changed after the second wash, increased after the third wash and reduced again after the fourth and fifth washes (Table 4). For dimensional stability, results in Table 4 show that in the warp dimension shrinked after the first and second washes, stretches after the third wash and shrinked again after the fourth wash and stretched again slightly after the fifth wash. The weft dimension also shrank after the first and second washes, stretched after the third wash, and shrank again after the fourth and fifth washes.

To determine whether the differences observed in the means of the attributes presented in Table 4 were significant, tests of between-fabric's effects was conducted to test hypothesis 1.

Table 5: *Tests of Between – Fabric's Effects on Selected Performance Attributes of GTP Adepa Fabric.*

Source	Dependent Variable	Df	Mean Square	F	Sig	Partia Eta Squared
Corrected Model	Strength warp	5	4621.313	0.65	0.662	0.120
	Strength weft	5	14155.649	4.59	0.004	0.489
	Colour	5	0.640	13.96	0.000	0.744
	Dimen warp	5	0.064	8.53	0.000	0.640
	Weft	5	0.041	17.37	0.000	0.784
Washing periods	Strength warp	5	4621.313	0.65	0.662	0.120
	Strength weft	5	14155.649	4.59	0.004	0.489
	Colour	5	0.640	13.96	0.000	0.744
	Dimen warp	5	0.064	8.53	0.000	0.640
	Weft	5	0.041	17.37	0.000	0.784

Source**:** Laboratory Results, (2020) Significant at P-value of 0.05

Table 5 shows the tests of between-fabric's effects. It indicated that the corrected model for Adepa warp strength was not statistically significant comparing the p-value of 0.662 to the alpha value of 0.05. This means that the use of Key Soap did not significantly affect Adepa warp strength after five washing periods. However, the corrected model also showed that the use of Key Soap had a significant effect on Adepa weft strength (p = 0.004); Adepa warp dimension ($p < 0.001$) and Adepa weft dimension ($p < 0.001$), comparing their p-values to the alpha value of 0.05.

The results from the test further show that differences in the washing periods using Key Soap had a significant effect on Adepa weft strength, colour and the warp and weft dimensions. Therefore, in order to determine the differences in the washing periods that resulted in these effects, a Bonferroni pairwise comparison test was conducted. The results obtained are presented in a Table in Appendix A.

A Bonferroni Pairwise Comparison Test on the Significant Effect of Washing Periods on Selected Perforce Attributes of GTP Adepa Dumas.

The analysis for this section was organised into three parts, namely comparison of washing periods to tensile strength, comparison of washing periods to colour change and finally, comparison of washing periods to dimensional stability.

Comparison of Washing Periods to Tensile Strength

Results from the comparison test show that differences between the first and second washing periods; and the first and fourth washing periods caused a significant effect on Adepa weft strength. Adepa weft strength after the first wash (*M*= 249.68) was significantly lower than the second (*M*= 373.60) and fourth (*M*= 371.20) washes.

Comparison of Washing Periods to Colour change

The comparison test shows that the significant effect on the colour change was not caused by differences between the washing periods but as a result of the difference between the fifth washing period and the unwashed sample. Adepa fabric after the fifth wash (M = 4.00) was significantly low.

Comparison of Washing Periods to Dimensional Stability

The test shows that no significant differences between the washing periods caused a significant effect on both the warp and weft dimensions. The significant effects on both dimensions were caused by the differences between their washing periods and the unwashed samples except for the first washing periods.

Below is a graph showing the summary of the effect of key soap on selected performance attributes of Adepa fabric after five washing periods.

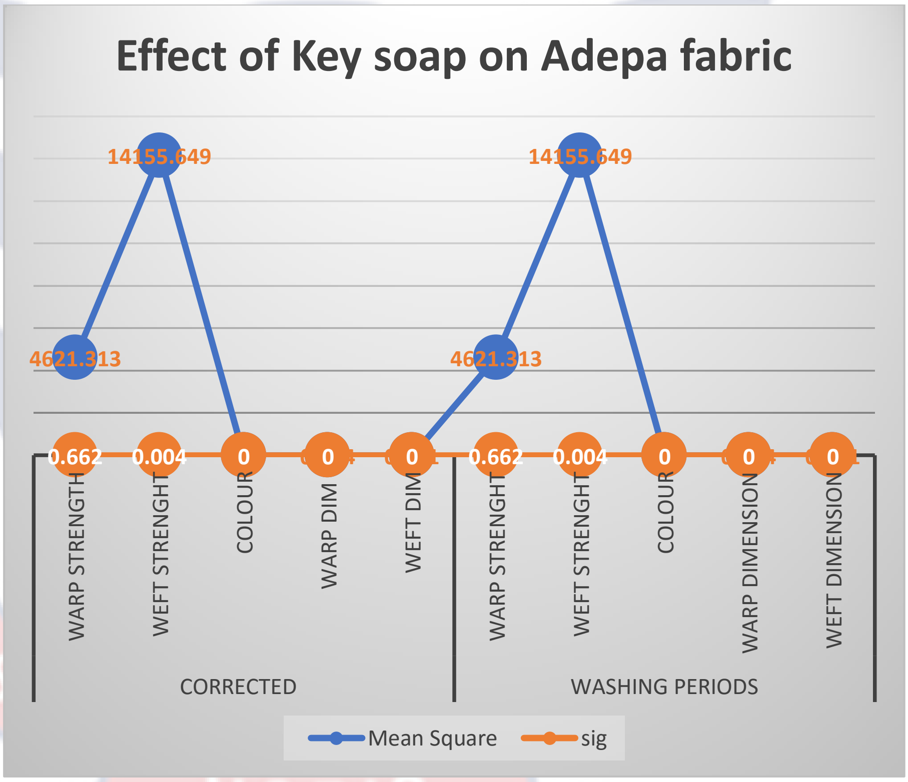


Figure 3: Effect of keysoap on Adepa fabric after five washing periods.

Table 6: *The Table Shows the Means and Standard Deviations of Selected Performance Attributes of Nustyle Fabric When Washed with Key Soap.*

GTP Nustyle	Mean Wash (*SD*)					
	Before	First	Second	Third	Fourth	Fifth
Strength	452.60	554.00	552.80	447.80	516.00	479.00
Warp	(193.58)	(55.58)	(54.83)	(47.74)	(38.07)	(14.17)
Strength	226.60	202.60	223.20	184.20	215.40	186.60
weft	(16.44)	(22.63)	(13.33)	(29.62)	(28.72)	(16.02)
Colour	5.00	4.50	4.30	4.50	4.30	4.00
change	(0.00)	(0.00)	(0.27)	(0.00)	(0.27)	(0.00)
Dimen warp	10.00	9.70	9.69	9.64	9.56	9.58
	(0.00)	(0.00)	(0.08)	(0.05)	(0.05)	(0.08)
Weft	10.00	9.68	9.64	9.72	9.72	9.62
	(0.00)	(0.13)	(0.08)	(0.08)	(0.13)	(0.08)

Source: Laboratory Results, (2020)

Table 6 shows that the warp strength of Nustyle increased after the first wash compared to the unwashed sample and reduced after the second wash though higher than the unwashed. The third wash reduced in strength below the unwashed and increased again after the fourth wash and higher than the unwashed. The final wash reduced in strength again but higher than the unwashed.

The weft strength, on the other hand, reduced in strength after the first wash compared to the unwashed but increased after the second wash below unwashed. The strength reduced again after the third wash and increased again after the fourth wash but was all below the unwashed. Final, it reduced in strength below the unwashed. Regarding colour change, the colour reduced after the first and second washes, increased colour after the third wash but of the same value as the first wash and reduced again after the fourth but of the same value as the second wash and reduced in colour again after the fifth wash.

The warp dimension of Nustyle fabric also shrinked consistently after every washing period below the unwashed. The weft dimension also shrank after the first and second washes below the unwashed sample, stretched after the third wash, maintained the same stretch after the fourth was,h and finally shrinked again below the unwashed.

The table shows that each selected attribute observed differences in their means after each washing period. Therefore, to determine if the differences observed in the means of the attributes presented in Table 6 were significant, a test of between fabric's effects was conducted to test hypothesis 1 (Table 7).

Table 7: *Tests of Between – Fabric'ts Effects on Selected Performance Attributes of GTP Nustyle.*

Source	Dependent Variable	Df	Mean Square	F	Sig	Partial Eta Squared
Corrected Model	Strength warp	5	11371.633	1.43	0.247	0.230
	Strength weft	5	1670.593	3.43	0.018	0.417
	Colour	5	0.553	22.13	0.000	0.822
	Dimen warp	5	0.128	36.44	0.000	0.884
	Weft	5	0.096	10.26	0.000	0.681
Washing periods	Strength warp	5	11371.633	1.43	0.247	0.230
	Strength weft	5	1670.593	3.34	0.018	0.417
	Colour	5	0.553	22.13	0.000	0.822
	Dimen warp	5	0.128	36.44	0.000	0.884
	Weft	5	0.096	10.26	0.000	0.681

Source: Laboratory Results, (2020) Significant P-value of 0.05.

Table 7 shows the significant effect of key soap on Nustyle fabric when washed for five periods. The between – fabric's effects test shows that the corrected model for warp strength was not statistically significant, comparing the p-value of 0.247 to the alpha value of 0.005. Hence, no significant influence was found in the washing periods on the warp strength. This means that the use of Key Soap did not significantly affect Nustyle warp strength when washed for five washing periods. However, the corrected model also shows that the use of Key Soap for five washing periods had significant influence on the weft strength weft ($p = 0.018$); colour ($p < 0.001$); warp dimension ($p < 0.001$); and weft dimension ($p < 0.001$) of Nustyle fabric comparing their p- values to the alpha value of 0.05.

The results also show that washing periods through the use of key soap had significant differences in their washing periods which had a significant effect on weft strength, colour change, warp and weft dimension of GTP Nustyle. Therefore, in order to determine the washing periods that resulted in these significant effects, a Bonferroni pairwise comparison test was conducted. The results obtained are presented in a Table in Appendix B.

A Bonferroni Pairwise Comparison Test on the Significant Effect of Washing Periods on the Selected Performance Attributes of Nustyle Fabric.

The analysis of this section was organised into three parts; namely, comparison of washing periods to tensile strength, comparison of washing periods to colour change and comparison of washing periods to dimensional stability.

Comparison of Washing Periods to Tensile Strength

The comparison test shows that no significant difference existed between the washing periods. This means that the significant effect on weft strength of GTP Nustyle was not as a result of differences between the washing periods.

Comparison of Washing Periods to Colourfastness

Results from the test show significant differences between the first and fifth washing periods; the third and fifth washing periods had a significant effect on the colour of the GTP Nustyle. The colour change after first (M = 4.5) and third (M = 4.5) washes were higher than fifth (M = 4.0) wash.

Comparison of Washing Periods to Dimensional Stability

The test also indicated that not all the washing periods had significant differences that affected the warp dimension of Nustyle fabric. Significant differences were found between the first and fourth washing periods; and the second and fourth washing periods. The warp dimension after the first wash (M = 9.7) was higher than the fourth (M = 9.5) wash, and the second wash (M = 9.6) was also higher than the fourth wash (M = 9.5) wash. On the other hand, the weft dimension did not observe significant differences among the washing periods. The significant effect was due to differences between the washing periods and the unwashed sample. The weft dimension of the unwashed (M = 10.0) was higher the first (M = 9.6), second (M = 9.6), third (M = 9.7), fourth (M = 9.7) and fifth (M = 9.6) washes.

Below is the graph showing the summary of the effect of Key soap on the selected performance attributes of Nustyle after five washing periods

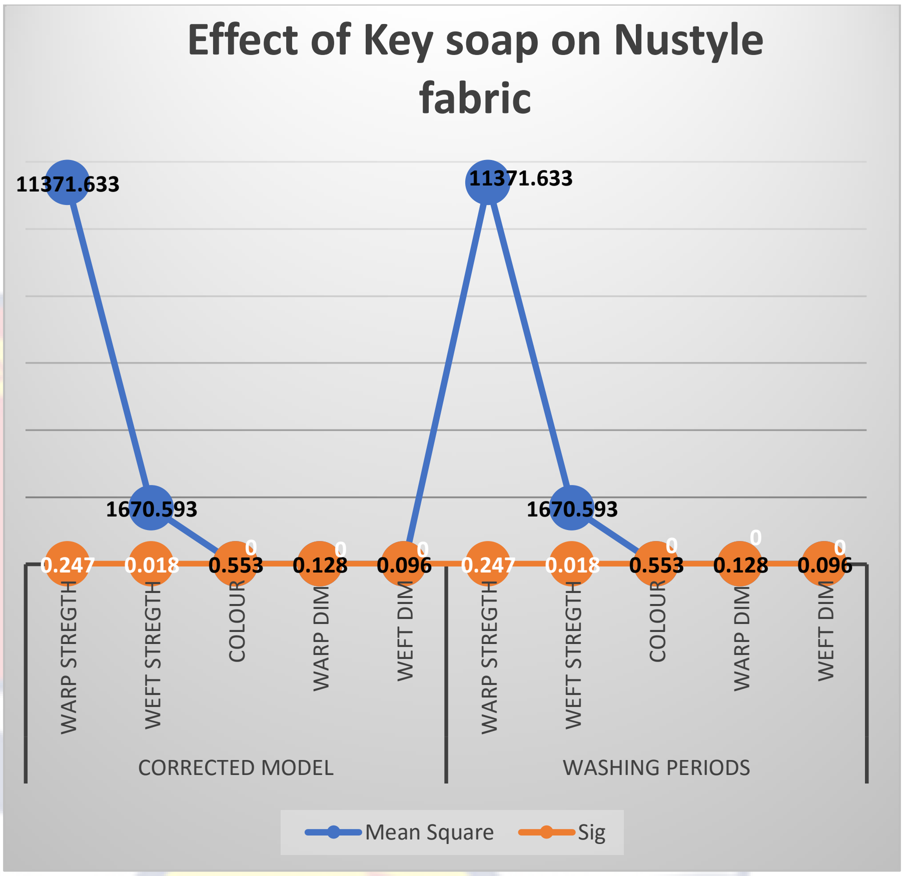


Figure 5: Efect of Key soap on Nustyle fabric

Testing of Hypothesis 1 in Tensile Strength, Colour change and Dimensional Stability of Adepa and Nustyle

Results from table 5 show that Key Soap after five washing periods had a significant effect on Adepa weft strength (p = .004); warp dimension (p < 0.001); and weft dimension (p < .001) but had no significant effect on the warp strength (p = .662). Results from table 7 also show that Key Soap had a significant effect on Nustyle weft strength (p = .018); colour (p < .001); warp dimensional (p < .001); and weft dimension (p < .001) but had no significant effect on the warp strength (p = .517) after five washing periods.

This infers that the null for the first hypothesis, which states that Key Soap has a significant effect on the tensile strength, colour change and dimensional stability of Adepa and Nustle when washed for five washing periods, fail to be rejected.

Table 8**:** *Means and Standard Deviations of Selected Performance Attributes of GTP Adepa Fabric when washed with New Omo.*

GTP Adepa	Mean Wash (*SD*)					
	Before	First	Second	Third	Fourth	Fifth
Strength	496.20	549.40	507.80	496.00	523.80	485.00
Warp	(54.18)	(44.54)	(77.15)	(43.63)	(59.94)	(51.85)
Strength	397.60	366.00	383.60	327.40	365.00	313.80
Weft	(20.70)	(32.12)	(21.13)	(64.88)	(40.49)	(38.04)
	(0.62)	(1.10)	(0.79)	(1.99)	(1.44)	
Colour	5.00	4.30	4.30	4.30	4.30	3.88
	(0.00)	(0.27)	(0.27)	(0.27)	(0.27)	(0.27)
Dimen	10.00	9.82	9.74	9.78	9.72	9.72
Warp	(0.00)	(0.08)	(0.07)	(0.04)	(0.04)	(0.04)
Weft	10.00	9.82	9.74	9.80	9.78	9.72
	(0.00)	(0.08)	(0.11)	(0.07)	(0.04)	(0.04)

Source: Laboratory Results, (2020)

Table 8 shows that after the first wash, the warp strength increased when compared to the unwashed sample. After the second and third washes, it reduced though above the unwashed but increased again after the fourth wash above the unwashed sample. The final wash, however, decreased below the unwashed sample. On the other hand, the weft strength reduced after the first wash compared to the unwashed, increased strength after the second wash but below the unwashed and reduced again after the third wash below the unwashed. The fourth wash increased strength again but below the unwashed and reduced strength again after the fifth wash below the unwashed.

After the first washing period, a colour change was observed and maintained its change to the fourth wash and reduced again after the fifth wash (Table 8). Concerning dimensional stability, results in Table 8 show that the warp dimension shrinked after the first and second washes, stretched after the third wash, shrinked again after the fourth wash, and maintained its shrinkage after the fifth wash. The weft dimension shrinked after the first and second washes, stretched after the third wash, and shrinked after the fourth and fifth washes.

The results also show differences between the means of performance attributes. Therefore, to determine if the differences in the means of the attributes presented in Table 8 were significant, a test of between fabric's effects was conducted to test hypothesis 2.

Table 9: *Test of Between – Fabric's Effects on the Selected Performance Attributes of Adepa Fabric.*

Source	Dependent Variable	Df	Mean Square	F	Sig	Partial Eta Squared
Corrected Model	Strength warp	5	2758.540	0.86	0.517	.153
	Strength weft	5	5221.660	3.40	0.018	.415
	Colour	5	.653	10.53	0.000	.687
	Dimen warp	5	.057	19.87	0.000	.805
	Weft	5	.050	10.38	0.000	.684
Washing periods	Strength warp	5	2758.540	0.86	0.517	.153
	Strength weft	5	5221.660	3.40	0.018	.415
	Colour	5	.653	10.53	0.000	.687
	Dimen warp	5	.057	19.87	0.000	.805
	Weft	5	.050	10.38	0.000	.684

Source: Laboratory Results, (2020) Significant P-value of 0.05.

Table 9 shows the significant effect of New Omo on Adepa fabric when washed for five periods. The test of between fabrics effects showed that the corrected model for warp strength was not statistically significant, comparing the p-value of .517 to the alpha value of 0.05. However, the corrected model from the table shows that the use of new omo had a significant effect on Adepa weft strength weft (p = .018); Adepa colour change ($p < .001$); Adepa warp dimension ($p < .001$); and Adepa weft dimension ($p < .001$) comparing their p- values to the alpha value of 0.05.

Results from the table further show that the washing periods through the use of new omo had significant differences in their washing periods which had a significant effect on Adepa weft strength, colour change and the warp and weft dimensions. Therefore, in order to determine the washing periods that resulted in these significant effects, a Bonferroni pairwise comparison test was conducted. The results obtained are presented in a Table in Appendix C.

A Bonferroni Pairwise Comparison Test on the Significant Effect of Washing Periods on the Selected Performance Attributes of GTP Adepa Dumas.

The analysis of this section was organised into three parts, thus comparing washing periods to tensile strength, comparison of washing periods to colour change and comparison of washing periods to dimensional stability.

Comparison of Washing Periods to the Tensile Strength

The comparison test shows that the significant effect on the weft strength was not caused as a result of the significant diference between the washing periods but between the before washed sample and the fifth washing period.

Comparison of Washing Periods to Colour change

The comparison test on clour change shows no significant difference between the washing periods. This implies that the significant effect on the colour change of Adepa fabric was caused by the differences between the washing periods and the unwashed sample.

Comparison of Washing Periods to Dimensional Stability

The test indicated that the significant effect on both the warp and weft dimensions was not due to differences between the washing periods but as a result of the differences between the washing periods and the unwashed sample.

Testing of Hypothesis 2 in Tensile Strength, Colour Change and Dimensional Stability

Results from table 7 show that New Omo had significant effect on the strength weft (p = .018); colour (p < .001); warp dimension (p < .001); and weft dimension (p < .001) but had no significant effect on the warp strength (p = .517) on Adepa fabric after being washed for five washing periods. The inference is that the null for the second hypothesis, which states that New Omo has a significant effect on Adepa fabric when washed for five washing periods, can neither be rejected nor fail to be rejected.

Below is the graph showing the summary of the effect of New Omo on the selected performance attributes of Adepa fabric after five washing periods.

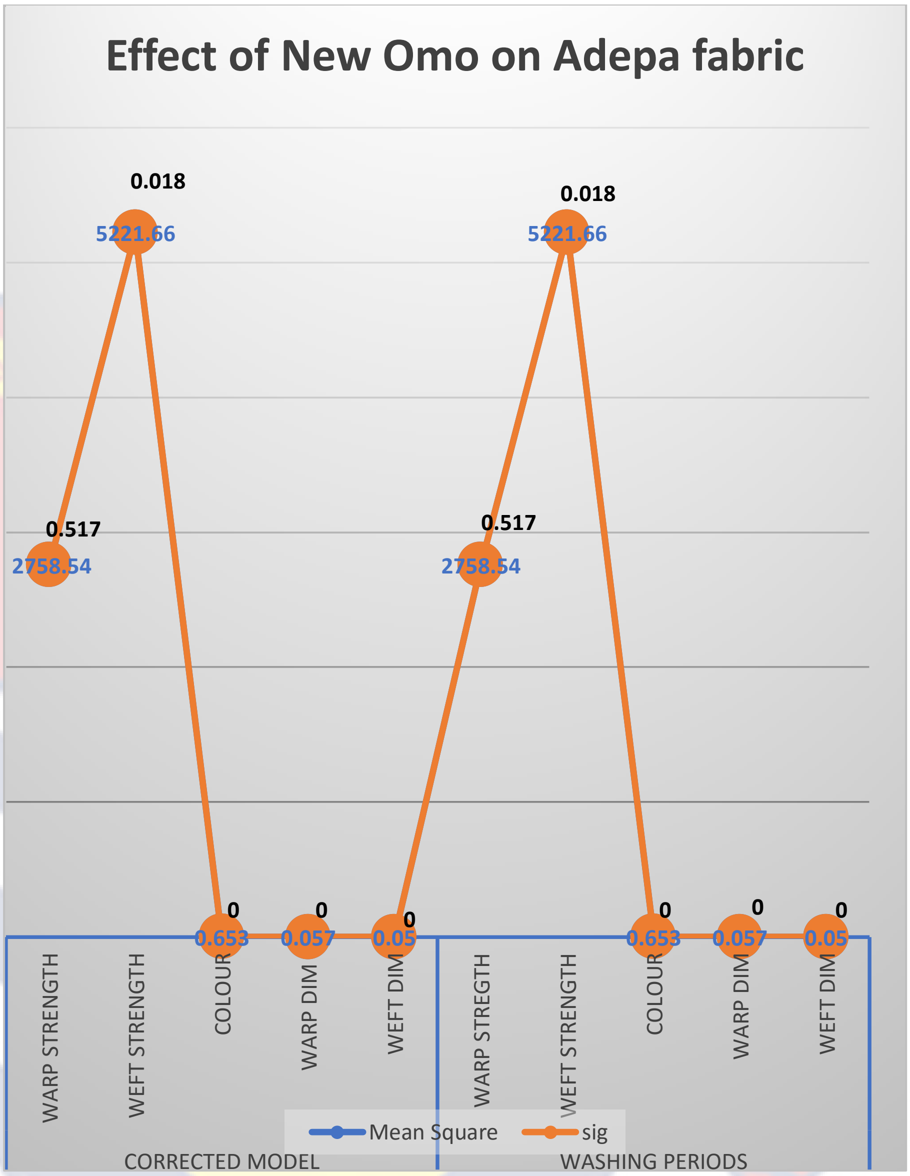


Figure 4: Effect of New Omo on the selected performance attributes of Adepa fabric.

Table 10: *Means and Standard Deviations of Selected Performance Attributes of GTP Nustyle Fabric When Washed with New Omo for five washing periods*

GTP Nustyle	Mean Wash (*SD*)					
	Before	First	Second	Third	Fourth	Fifth
Strength	452.60	538.80	476.40	505.80	530.40	532.00
Warp	(193.58)	(31.86)	(127.61)	(43.31)	(37.54)	(22.90)
Strength	226.60	226.80	350.20	210.80	217.60	220.20
Weft	(16.44)	(7.79)	(147.36)	(18.417)	(16.33)	(15.08)
Colour	5.00	4.40	4.40	4.50	4.40	4.30
	(0.00)	(0.22)	(0.22)	(0.00)	(0.22)	(0.27)
Dimen	10.00	9.72	9.70	9.66	9.56	9.74
Warp	(0.00)	(0.04)	(0.10)	(0.05)	(0.08)	(0.05)
Weft	10.00	9.80	9.71	9.80	9.76	9.64
	(0.00)	(0.07)	(0.07)	(0.00)	(0.54)	(0.13)

Source: Laboratory Results, (2020)

It can be deduced from the table that Nustyle warp strength increased after the first wash compared to unwashed and reduced strength after the second wash but above unwashed. The strength increased again after the third, fourth and fifth washes above the unwashed.

The weft strength of Nustyle fabric, on the other hand, maintained strength after the first wash compared to unwashed and increased after the second wash above unwashed. The third wash reduced the strength below the unwashed and increased again after the fourth and fifth washes but below the unwashed.

The colour of Nustyle fabric also reduced after the first wash and maintained the same colour change after the second wash. The colour increased after the third wash but below unwashed and decreased again after the fourth and fifth washes below unwashed.

The warp dimension of Nustyle fabric shrinked after the first, second, third and fourth washes below the unwashed. It stretched after the final wash but below the unwashed. The weft dimension shrank after the first and second washes, then stretched after the third wash but below the unwashed. The weft dimension shrunk again after the fourth and the fifth washes below unwashed.

The table's results also show that each selected attribute had differences in its means after each washing period. Therefore, to determine if the differences observed in the means of the performance attributes presented in Table 10 were significant, a test of between fabric's effects was conducted to test hypothesis 4 (Table 11).

Table 11: *Tests of Between – Fabirc's Effects of Selected Performance Attributes of Nustyle Fabric*

Source	Dependent Variable	Df	Mean Square	F	Sig	Partial Eta Squared
Corrected Model	Strength warp	5	6074.960	0.62	0.684	.115
	Strength weft	5	14219.473	3.72	0.012	.437
	Colour	5	.320	8.53	0.000	.640
	Dimen warp	5	.108	24.87	0.000	.838
	Weft	5	.074	14.08	0.000	.746
Washing periods	Strength warp	5	6074.960	0.622	0.684	.115
	Strength weft	5	14219.473	3.72	0.0012	.437
	Colour	5	.553	22.13	0.000	.822
	Dimen warp	5	.320	8.53	0.000	.838
	Weft	5	.074	14.08	0.000	.746

Source: Laboratory Results, (2020) Significant P-value of .05.

Results from the test show that the corrected model for Nustyle warp strength was not statistically significant, comparing the p-value of .684 to the alpha value of .005. Hence, no significant difference was found in the washing period for warp strength. This means that the use of New Omo did not influence Nustyle warp strength when washed for five washing periods. However, the corrected model shows that the use of New Omo had significant influence on weft strength (p = .012); colour (p < .001); warp dimension (p < .001); and weft dimension (p < .001) comparing their p-values to the alpha value of 0.05.

Results from the test also show that washing periods through the use of New Omo also had differences in their washing periods that affected the weft strength, colour and the warp and weft dimensions of Nustyle fabric. In order to determine the washing periods that resulted in these significant differences, a Bonferroni pairwise comparison test was conducted. The results obtained are presented in Appendix D.

A Bonferroni Pairwise Comparison Test on Selected Performance Attributes of Nustyle fabric.

Comparison of Washing Periods to the Tensile Strength

The test shows that the significant difference among the washing periods that affected the weft strength was between the second and the third, fourth and fifth washes. The weft strength after the second wash (M = 350.20) was higher than the third (M = 210.80); fourth (M = 217.60) and fifth (M = 220.20) washes.

Comparison of Washing Periods to Colour Change

The test shows that no significant difference exists among the washing periods and that the significant effect on the colour change of Nustyle resulted from the differences between the washing periods and the unwashed sample.

Comparison of Washing Periods to Dimensional Stability

The test shows that the significant difference among the washing periods that had a significant effect on the warp dimension was between the first and the fourth washes; and the second and the fourth washes. The warp dimension after the first wash (*M* = 9.72) was higher than the fourth (*M* = 9.56) wash; the second wash (*M* = 9.70) was also higher than the fourth wash (*M* = 9.56) wash. On the other hand, a significant effect on the weft dimension resulted from the differences between the first wash and the fifth washes; and the third and the fifth washes. The weft dimension after the first wash (*M* = 9.80) was higher than the fifth (*M* = 9.64) wash, and the third wash (*M* = 9.80) wash was also higher than the fifth (*M* = 9.64) wash.

Below is a graph showing the summary of New Omo on the selected performance attributes of Nustyle fabric after five washing periods.

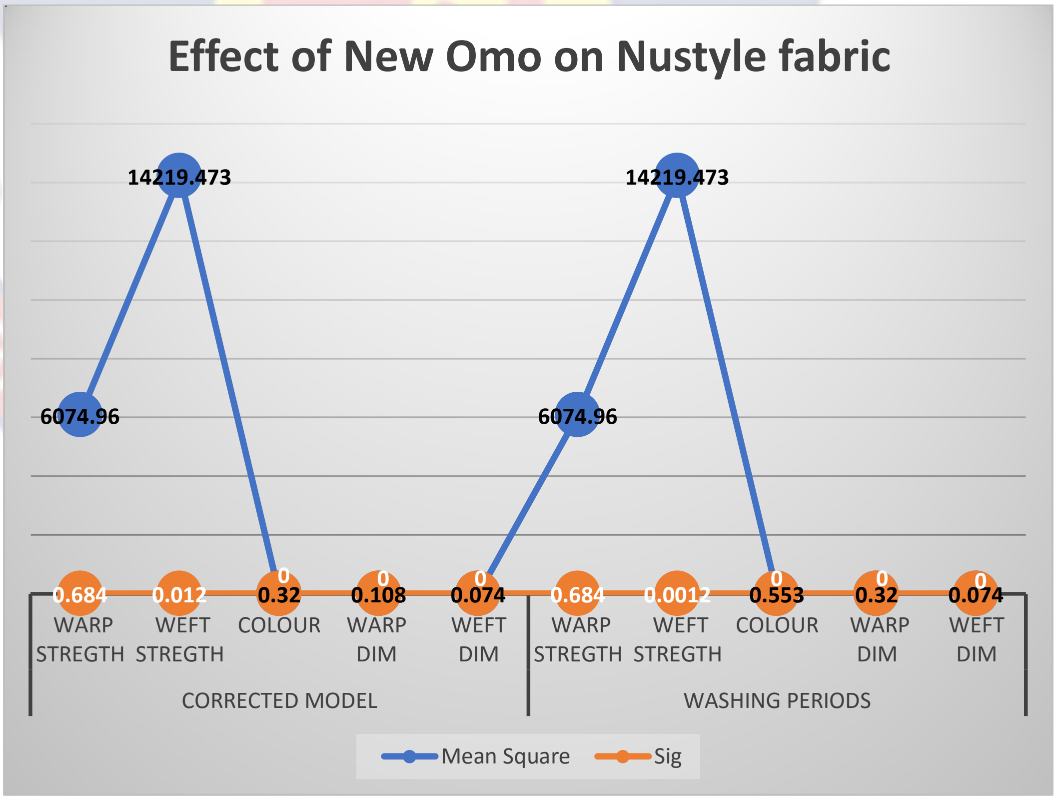


Figure 6: Effect of New Omo on Nustyle fabric

Testing of Hypothesis 2 in Tensile Strength, Colour Change and Dimensional Stability of Adepa and Nustyle

Results from table 9 show that New Omo had significant effect on the strength weft (p = 0.018); colour (p < 0.001); warp dimension (p < 0.001); and weft dimension (p < 0.001) but had no significant effect on the warp strength (p = 0.517) on Adepa fabric after being washed for five washing periods. Results from table 11also show that the use of new omo had a significant influence on the weft strength (p = .012); warp dimension (p < .001); and weft dimension (p < .001) of Nustyle fabric but had no significant effect on the warp strength (p = 0.684). The inference is that the null for the second hypothesis, which states that New Omo has a significant effect on Adepa and Nustyle fabrics when washed for five washing periods, fail to be rejected.

Differences in Effects Between Key Soap and New Omo on the Selected Performance Attributes of Adepa Dumas and Nustyle after Five Washing Periods

This report section addresses the second research objective and focuses on assessing the differences in effect between key soap and new omo on the colour change, tensile strength and dimensional stability of Adepa Dumas and Nustyle fabric after five washing periods. The report from this sub-section also addresses hypotheses three.

Table 12: *Means and Standard Deviations of the Differences in Effect Between Key Soap and New Omo on the Selected Performance Attributes of GTP Adepa Fabric When Washed for five washing periods*

GTP Nustyle	Mean Wash (*SD*)				
	First	Second	Third	Fourth	Fifth
Strength Warp	514.60 (133.07)	532.80 (62.46)	507.80 (36.45)	518.00 (48.87)	480.20 (40.71)
Strength Weft	307.84 (100.54)	378.60 (34.31)	322.50 (49.31)	368.10 (36.55)	333.20 (33.31)
Colour	4.25 (0.26)	4.25 (0.26)	4.30 (0.25)	4.20 (0.25)	3.94 (0.18)
Dimen Warp	9.84 (0.06)	9.74 (0.05)	9.78 (0.06)	9.71 (0.73)	9.72 (0.10)
Weft	9.82 (0.06)	9.74 (0.08)	9.81 (0.05)	9.79 (0.05)	9.75 (0.05)

Source: Laboratory Results, (2020)

It can be inferred from the table that the differences in effect between key soap and new omo on the warp strength of Adepa fabric increased after the second wash compared to the first wash. It reduced after the third wash below the first wash and increased again after the fourth wash but above the first wash. It was finally reduced after the fifth wash below the first wash.

The differences in effect on the weft strength, on the other hand, also increased strength after the second wash compared to the first wash and reduced after the third wash but above the first. The fourth wash increased again above the first wash and reduced again in strength above the first wash but above the first wash.

The differences in effect on the colour of Adepa fabric maintain it effect after the first and second washes. It increased in colour after the third wash compared to the first wash and reduced in colour after the fourth and fifth wash but below the first wash. A similar effect after reduced after the first wash and maintained the same colour change after the second.

The differences in effect on the warp dimension shrinked after the second wash compared to the first wash. It stretched after the third wash below the first wash. It shrunk again after the fourth wash below the first wash and stretched again after the fifth wash but below the first wash. The weft dimension, on the other hand, had a similar difference in effect as the warp dimension but shrunk after the fifth wash and below the first wash.

The table also shows that each selected attribute had differences in its effect after each washing period. Therefore, in order to determine if the differences in effect observed on the performance attributes are significant or not, a test of between fabrics effects was conducted. The results were presented in a Table in Appendix E, and this section also addresses hypothesis five.

Test of Between-Fabric's Effects on the Differences in Effect between Key Soap and New Omo on the Selected Performance Attributes Adepa Fabric.

Results from the test showed that the corrected model for warp strength was not statistically significant F (9, 40) = .704, p = .701, partial η^2 = .137; for weft strength was statistically significant F (9, 40) = 3.091, p = .007, partial η^2 = .410; for colour change was not statistically significant F (9, 40) = 1.726, p = .115, partial η^2 = .280; for warp dimension was statistically significant F (9, 40) = 2.103, p = .052, partial η^2 = .321; and for weft dimension was not statistically significant F (9, 40) = 1.597, p = .149, partial η^2 = .264. This implies that there was a significant difference in effect between key soap and new omo on the weft strength and warp dimension of Adepa fabric but not on the warp strength, colour change and weft dimension.

However, results from the intercept also show a significant effect on the differences in effect between key soap and new omo on the warp strength F (1, 40) = 2343.736, p < .001, partial η^2 = .983; weft strength F (1, 40) = 2180.733, p < .001, partial η^2 = .982; colour F (1, 40) = 13554.362, p < .001, partial η^2 = .997; warp dimension F (1, 40) = 764807.743, p < .001, partial η^2 = 1.000; and weft dimension F (1, 40) = 1112645.628, p < .001, partial η^2 = 1.000. Thus, when there is a brake away of either soaps or washing periods, there is a significant effect on the differences in effect between key soap and new omo on all the performance attributes of Adepa fabric.

Hence, results from the test on the soaps did not show any significant effect on any of the performance attributes but that of the washing periods for both Key Soap and New Omo had significant effect on the weft strength F (4, 40) = 3.397, p = .017, partial η^2 = .254; colour F (4, 40) = 3.164, p = .024, partial η^2 = .240; warp dimension F(4, 40) = 4.530, p = .004, partial η^2 = .312; and weft dimension F(4, 40) = 2.953, p = .031, partial η^2 = .228 of Adepa fabric. This implies that the significant effect from the corrected model on the weft strength and warp dimension of Adepa fabric was a result of the washing periods of both soaps and not the soaps. In order to determine the washing periods that caused the significant effect on the weft strength and warp dimension of Adepa fabric, a Bonferroni pairwise comparison test was conducted amd the results obtained are presented in Appendx E.

Comparison of Washing Periods to Weft Strength

The test shows that the washing periods that affected the weft strength was the difference between the first and second washes. After the first wash (M = 307.84), the weft strength was lower than the second wash (*M* = 378.60).

Comparison of Washing Periods to Warp Dimension

The test shows that the washing periods that significantly affected the warp dimension were the differences between the first and the fourth and fifth washes. The warp dimension after the first wash (*M* = 9.84) was higher than the fourth (*M* = 9.72) and the fifth (*M* = 9.72) washes.

Below is a summary of the significant difference between key soap and new Omo on the selected attributes of Adepa fabric.

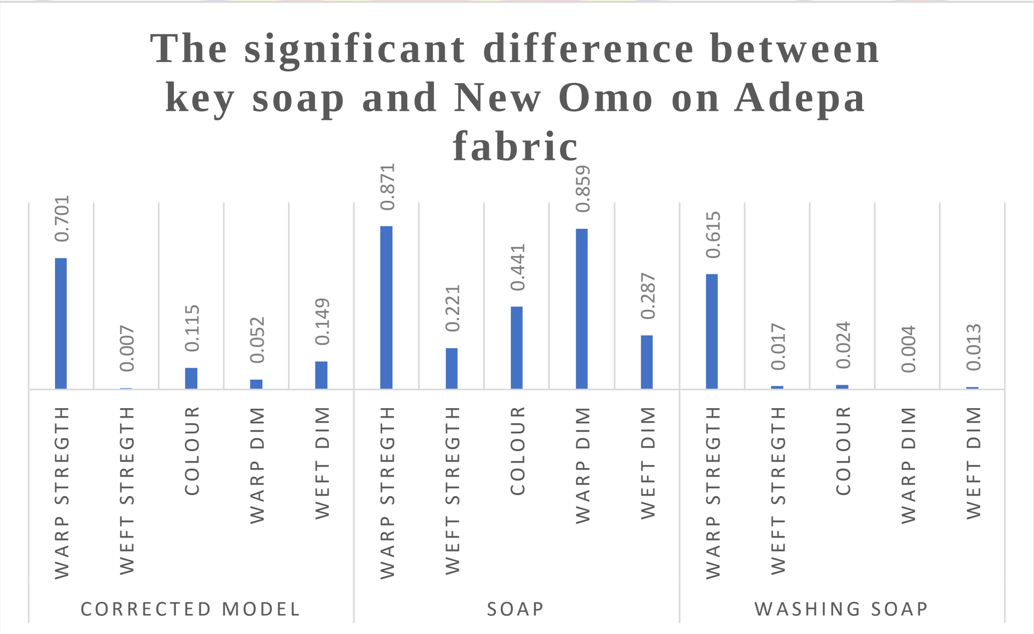


Figure 7: Significant difference between Key soap and new Omo on Adepa fabric.

Table 13: *Means and Standard Deviations of the Differences in Effect Between Key Soap and New Omo on the Selected Performance Attributes of GTP Nustyle Fabric When Washed for five washing periods*

GTP Nustyle	Mean Wash (*SD*)				
	First	Second	Third	Fourth	Fifth
Strength Warp	546.400 (43.45)	514.600 (100.97)	476.800 (52.74)	523.00 (36.44)	505.500 (60.87)
Strength Weft	214.700 (20.45)	286.700 (119.20)	197.500 (27.15)	216.500 (22.06)	203.400 (22.99)
Colour	4.450 (0.15)	4.350 (0.24)	4.500 (0.00)	4.350 (0.24)	4.150 (0.24)
Dimen Warp	9.710 (0.03)	9.695 (0.08)	9.650 (0.05)	9.560 (0.69)	9.660 (0.10)
Weft	9.740 (0.11)	9.675 (0.08)	9.760 (0.06)	9.740 (0.09)	9.630 (0.10)

Source: Laboratory Results, (2020)

It can be observed from the table that the differences in effect between key soap and new omo on the warp strength of Adepa fabric reduced after the second and the washes compared to the first wash and increased after the fourth wash but below the first wash. It finally reduced again after the fifth wash but below the first wash.

The differences in effect on the weft strength, on the other hand, also increased strength after the second wash compared to the first wash and reduced after the third wash below the first. The fourth wash increased in strength above the first wash and reduced again after the fifth wash but below the first wash.

The differences in effect on the colour of Adepa fabric reduced after the second wash compared to the first wash, increased colour after the third wash and reduced again after the fourth and fifth washes below the first wash and reduced in colour after the fourth and fifth wash but below the first wash.

The differences in effect on the warp dimension shrinked after the second, third and fourth washes and stretched after the fifth wash but below the first wash. The weft dimension, on the other hand shrinked after the second wash compared to the first wash, stretched after the third wash above the first wash and skrinked again after the fourth but of the same value as the first wash. The fifth wash also shrinked but below the first wash.

The table also shows that each selected attribute had differences in its effect after each washing period. Therefore, in order to determine if the differences in effect observed on the performance attributes are significant or not, a test of between fabrics effects was conducted. The results were presented in a Table in Appendix F, and this section also addresses hypothesis six.

Test of Between – Fabric's Effects on the Differences in Effect between Key Soap and New Omo on the Selected Performance Attributes of Nustyle fabric.

Results from the test show that the corrected model for the warp strength was not statistically significant F (9, 40) = .2.034, *p* = .060, partial η^2 = .314; for weft strength was statistically significant F (9, 40) = 4.328, *p* = .001, partial η^2 = .493; for colour change was statistically significant F (9, 40) = 3.022, *p* = .008, partial η^2 = .405; for warp dimension was statistically significant F (9, 40) = 4.805, $p < .001$, partial η^2 = .519; and for weft dimension was statistically significant F (9, 40) = 2.393, *p* = .028, partial η^2 = .350. This implies that there was a significant difference in effect between key soap and new omo on the weft strength, colour change, warp and weft dimensions but had no significant diefference in effect on the warp strength.

Results from the test further show that the intercept also shows a significant difference in effect between key soap and new omo on all the performance attributes of Nustyle fabric. This implies that when there is a breakaway of either soaps or washing periods, there is a significant difference in effect on all the performance attributes of Nustyle fabric.

However, results from the test on soaps on Nustyle fabric also show that there was a significant effect on the weft strength F (1, 40) = 9.030, *p* = .005 ., partial η^2 = .184; warp dimension F (1, 40) = 4.691, *p* = *.036*, partial η^2 = .105; and weft dimension F (1, 40) = 6.223, *p* = .017, partial η^2 = .135 but had no significant effect on the the warp strength and the colour change.

Results from the test on washing periods for both Key Soap and New Omo on Nustyle Fabric had significant effects on the weft strength F (4, 40) = 5.146, $p = .002$, partial $\eta^2 = .340$; colour F (4, 40) = 34.800, $p = .003$, partial $\eta^2 = .324$; warp dimension F (4, 40) = 7.287, $p < .001$, partial $\eta^2 = .422$; and weft dimension F (4, 40) = 3.406, $p = .017$, partial $\eta^2 = .254$ but not the warp strength.

Therefore, it can be deduced from the results that the significant effect on the weft strength, warp and weft dimensions from the corrected model was caused by both soaps and their washing periods, but that of colour was caused by only the washing periods. In order to determine which of the soaps (key soap and new omo) caused the significant difference in effect on the weft strength and the warp and weft dimensions, a Bonferroni Pairwise Comparison Test was conducted and the result was presented in Table 14.

Table 14: *Bonferroni Pairwise Comparison on the Differences in Effect Between Key Soap and New Omo on GTP Nustyle*

Dependent Variable	(I) Soap	(J) Soap	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
						Lower Bound	Upper Bound
Strength Warp	Key Soap	Omo	-6.760	15.78	0.671	-38.659	25.139
	Omo	Key Soap	6.760	15.78	0.671	-25.139	38.659
Elong Warp	Key Soap	Omo	-1.074	0.60	0.081	-2.288	.140
	Omo	Key Soap	1.074	0.60	0.081	-.140	2.288
Strength Weft	Key Soap	Omo	-42.720*	14.21	0.005	-71.452	-13.988
	Omo	Key Soap	42.720*	14.21	0.005	13.988	71.452
ElongWeft	Key Soap	Omo	1.328	0.68	0.058	-.048	2.703
	Omo	Key Soap	-1.328	0.68	0.058	-2.703	.048
Colour	Key Soap	Omo	-.080	9.05	0.152	-.191	.031
	Omo	Key Soap	.080	0.05	0.152	-.031	.191
DimenWarp	Key Soap	Omo	-.042*	0.01	0.036	-.081	-.003
	Omo	Key Soap	.042*	0.01	0.036	.003	.081
Dimen weft	Key Soap	Omo	-.066*	0.02	0.017	-.119	-.013
	Omo	Key Soap	.066*	0.02	0.017	.013	.119

Source: Laboratory Results, (2020)

a. Based on estimated marginal means, the mean difference is significant at the 0.05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Comparison of Washing Soaps to Weft Strength

The test shows that both washing soaps had significant effects on the weft strength of Nustyle fabric, but the new omo had a higher mean difference of (42.720) while key soap had a mean difference of (-42.720).

Comparison of Washing Soaps to Warp Dimension

Again, the test shows that both washing soaps had significant effects on the warp dimension of Nustyle with a higher mean difference of (.042) for new omo while key soap had a mean difference of (- .042).

Comparison of Washing Soaps to Weft Dimension

Once more, the test shows that both washing soaps had significant effects on the weft dimension of Nustyle with a higher mean difference of (.066) for new omo while key soap had a mean difference of (- .066).

Below is the graph that shows the significant difference between key soap and new omo on Nustyle fabric.

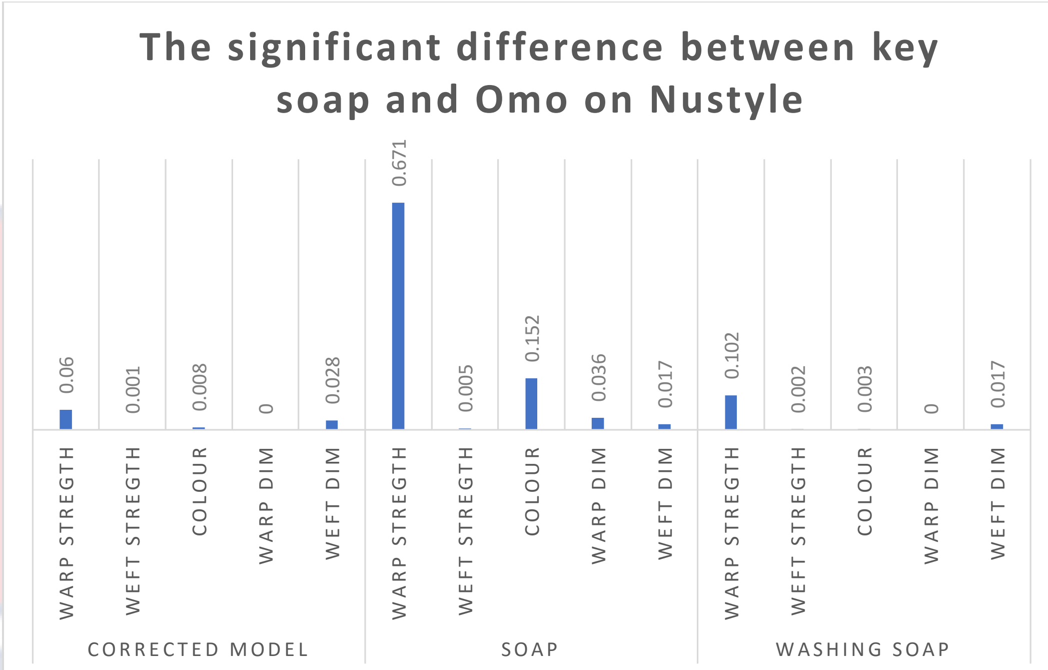


Figure 8: A graph showing the significant difference between Key soap and Omo on Nustyle fabric.

Testing of Hypothesis 3 on the Difference in Effect Between Key Soap and New Omo on Selected Performance Attributes of Adepa Dumas and Nustyle fabrics.

The null for hypothesis three which states that there is a significant difference in effect between Key Soap and New Omo on the tensile strength, colour change and dimensional stability of Adepa Dumas and Nustyle fabrics after five washing periods, fail to be rejected.

Interaction Effect Between Washing Soaps and Washing Periods in the Selected Performance Attributes of GTP Adepa Dumas and GTP Nustyle After Five Washing Periods.

This section of the report addresses the third research objective and focuses on assessing the interaction effect between washing soaps (Key Soap and New Omo) and washing periods on the colour change, tensile strength and dimensional stability of Adepa Dumas and Nustyle fabric after five washing periods. Results from the test of between fabrics effects for both Key Soap and New Omo on the selected performance attributes of Adepa and Nustyle fabrics were adopted for the analysis. The report from this sub-section also addresses hypotheses four.

Interaction Effect Between Key Soap and Washing Periods on the Selected Performance Attributes of Adepa Dumas

In examining the interaction effect between Key Soap and washing periods on Adepa Dumas when washed for five washing periods, the test of between fabric's effects shows that the corrected model for warp strength was not statistically significant, $F(5, 24) = .653$, $p = .662$, partial $\eta^2 = .120$. Hence, no significant difference was found in the washing period for the warp strength. This means that the use of Key Soap did not influence Adepa warp strength when washed for five washing periods. However, the corrected model shows that the use of Key Soap had a significant influence on the weft strength $F(5, 24) = 4.596$, $p = .004$, partial $\eta^2 = .489$; colour $F(5, 24) = 13.964$, $p < .001$, partial $\eta^2 = .744$; warp dimension $F(5, 24) = 8.533$, $p < .001$, partial $\eta^2 = .640$; and weft dimension

F(5, 24) = 17.371, $p < .001$, partial $\eta^2 = .784$. Therefore, the washing periods through the use of key soap affected the weft strength, colour, warp dimension and weft dimension of Adepa fabric. The results obtained are presented in a table in Appendix A.

Interaction Effect Between New Omo and Washing Periods on the Selected Performance Attributes of Adepa Dumas

In examining the effect of new omo on Adepa fabric when washed for five periods, the test of between fabrics effect shows that the corrected model for warp strength was not statistically significant, F (5, 24) = .869, $p = .517$, partial $\eta^2 = .153$. Hence, no significant difference was found in the washing periods. This means that the use of New Omo did not influence Adepa warp strength when washed for five washing periods. However, the corrected model show that the use of New Omo had a significant effect on the weft strength F (5, 24) = 3.405, $p = .018$, partial $\eta^2 = .415$; colour F(5, 24) = 10.538, $p < .001$, partial $\eta^2 = .687$; warp dimension F(5, 24) = 19.872, $p < .001$, partial $\eta^2 = .805$; and weft dimension F(5, 24) = 10.386, $p < .001$, partial $\eta^2 = .684$. Therefore, the washing periods through the use of new omo affected Adepa weft strength, colour, warp dimension and weft dimension. The results obtained are presented in tabular form in Appendix B.

Interaction Effect Between Soaps (Key Soap and New Omo) and Washing Periods on the Selected Performance Attributes of Nustyle

In examining the effect of Key Soap on Nustyle when washed for five periods, the test of between-subjects effects shows that the corrected model for strength warp was not statistically significant, F (5, 24) = 1.436, p = .247, partial η^2 = .230. Hence, no significant difference was found in the washing period for the strength warp. This means that the use of Key Soap did not have any influence on Nustyle strength warp when washed for five washing periods. However, the corrected model shows that the use of Key Soap had a significant influence on elongation warp F (5, 24) = 2.850, p = .037, partial η^2 = .373; strength weft F(5, 24) = 3.433, p = .018, partial η^2 = .417; elongation weft F(5, 24) = 73.826, p < .001, partial η^2 = .939; colour F(5, 24) = 22.133, p < .001, partial η^2 = .822; dimensional warp F(5, 24) = 36.443, p < .001, partial η^2 = .884; and dimensional weft F(5, 24) = 10.264, p < .001, partial η^2 = .681.

Results from the intercept also show a significant effect on force warp F (1, 24) = .948.724, p < .001, partial η^2 = .975; elongation warp F (1, 24) = 341.530, p < .001, partial η^2 = .934; force weft F(1, 24) = 2626.845, p < .001, partial η^2 = .991; elongation weft F(1, 24) = 8040.820, p < .001, partial η^2 = .997; colour F(1, 24) = 23585.333, p < .001, partial η^2 = .999;dimensional warp F(1, 24) = 805654.500, p < .001, partial η^2 = 1.000; and dimensional weft F(1, 24) = 304305.750, p < .001, partial η^2 = 1.000.

Washing periods on the other hand, have significant effect on elongation warp F (5, 24) = 2.850, p = .037, partial η^2 = .373; strength weft F (5, 24) =3.433, p = .018, partial η^2 = .417, elongation weft F (5, 24) = 73.826 , p < .001, partial η^2 = .939; colour F (5, 24) = 22.133, p < .001, partial η^2 = .822;and dimensional warp F (5, 24) = 36.443 , p < .001, partial η^2 = .884; and dimensional weft F (5, 24) = 10.264 , p < .001, partial η^2 = .681; but had no significant effect on the strength warp F (5, 24) = .1.436 , p = .247, partial η^2 = .230. The results obtained are presented in a tabular form in Appendix C.

Interactional Effect Between New Omo and Washing Periods

In examining the effect of New Omo on Nustyle fabric when washed for five periods, the test of between-subjects effects showed that the corrected model for strength warp was not statistically significant, F (5, 24) = .622, p = .684, partial η^2 = .115. Hence, no significant difference was found to exist in the washing period for strengtg warp. This means that the use of New Omo did not have any influence on the strength warp of Nustyle fabric when washed for five periods. However, the corrected model shows that the use of New Omo had a significant influence on the elongation warp F (5, 24) = 2.602, p = .051, partial η^2 = .351; strength weft F (5, 24) = 3.728, p = .012, partial η^2 = .437; elongation weft F(5, 24) = 21.601, $p < .001$, partial η^2 = .818; colour F(5, 24) = 8.533, $p < .001$, partial η^2 = .640; dimensional warp F(5, 24) = 24.877, $p < .001$, partial η^2 = .838; and dimensional weft F(5, 24) = 14.086, $p < .001$, partial η^2 = .746.

Results from the intercept also show a significant effect on strength warp F (1, 24) = 786.643, $p < .001$, partial η^2 = .970; elongation warp F (1, 24) = 233.766, $p < .001$, partial η^2 = .907; force weft F(1, 24) = 460.799, $p < .001$, partial η^2 = .987; elongation weft F(1, 24) = 1780.983, $p < .001$, partial η^2 = .987; colour F(1, 24) = 16200.000, $p < .001$, partial η^2 = .999;dimensional warp F(1, 24) = 655427.769, $p < .001$, partial η^2 = 1.000; and dimensional weft F(1, 24) = 547121.286, $p < .001$, partial η^2 = 1.000.

Results from the test also show the effect of washing periods on the selected performance attributes of Nustyle fabric. Observation from the test shows that washing periods have significant effect on elongation warp F (5, 24) = 2.602, p = .051, partial η^2 = .351; strength weft F (5, 24) =3.728, p = .012, partial η^2 = .437, elongation weft F (5, 24) = 21.601 , p < .001, partial η^2 = .818; colour F (5, 24) = 8.533, p < .001, partial η^2 = .640; dimensional warp F (5, 24) = 24.877, p < .001, partial η^2 = .838; and dimensional weft F (5, 24) = 14.086 , p < .001, partial η^2 = .746; but no significant effect was observed on the strength warp F (5, 24) = .622, p = .684, partial η^2 = .115. The results obtained are presented in a table form in Appendix D.

Testing of Hypothesis 4 in the Interaction Effect Between Washing Soaps and Washing Periods on Selected Performance Attributes of Adepa Dumas and Nustle fabrics.

The null for hypothesis four which states that there is a significant interaction effect between washing soaps and washing periods on the tensile strength, colour change and dimensional stability of Adepa Dumas and Nustle fabrics fail to be rejected.

Discussion of Results

The Effect of Key Soap and New Omo on the Tensile Strength, Colour Change and Dimensional Stability of Adepa Dumas

Results from the tests show that both washing soaps affected the weft strength, colour change and dimensional stability of Adepa Dumas after five washing periods. The effects of both washing soaps on the weft strength and not the warp strength of Adepa Dumas confirms that both set of yarns have peculiar properties that make them behave differently even under the same condition. Though both set of yarns were subjected to the same washing condition using different washing soaps, both washing soaps had the same outcomes in the strength of the yarns. This confirms what Teli, Khare & Chakrabarti (2008) stated, that the warp yarn direction of the fabric is stronger and might pose much resistance to stress-related deformation than the weft yarn direction. Another reason for the differences in the strength of the two sets of yarns could also be attributed to the differences in their thread count. The thread counts for both sets of yarns shows that the warp set of yarns had a higher mean count of (M = 92) than the weft set of yarns with a mean count of (M =73). This implies that the warp set of yarns are compacted with more yarns which explain its ability to withstand all the stress it was subjected to and still had no effect on its strength.

On the other hand, the weft set of yarns had less thread count, which could not match up with all the stress it went through, hence the significant effect on its strength for both washing soaps. This assertion also confirms what Ozdil, Ozdogan and Oktem (2003) stated that fabric strength depends on the thread pack. Despite the effect of key soap and new omo on the weft strengths of Adepa Dumas, the results, however, meet the tensile strength standards of the Ghana Standard Authority of GSISO 13934 -1, 2019.

The effect of key soap on Adepa colour change shows that after the first two washing periods, it had the same value of colour change until it finally reduced colour after the fifth washing period. New omo also experienced the same effect, but its further reduction in colour occurred after the fifth washing period. These effects from both washing soaps can be associated with the assertion made by Kadolph (2007) that new items experience colour loss when washed for the first time because the excess colour that was not rinsed off after dyeing was removed. Therefore, these effects of key soap and new omo with the same value of colour change could have been as a result of their first-time wash, which revealed their actual colours after the third and the fifth washing period, respectively. Though Adepa fabric washed with new omo experienced a change in colour from a grade of 5units to 3.88 units and that of key soap from 5units to 4units, the effect of both washing soaps passed the colourfastness test according to GS ISO105 – C10 (2019), which states that textile fabric passes the colourfastness test when it can retain at least 3-4 units of its colour on the greyscale.

The effect of key soap and new omo on the dimensional stability of Adepa fabric caused instability in both the warp and the weft dimensions after the five washing periods. The effect of key soap on the warp direction experienced more instability than the weft direction. In the case of new omo, both dimensions ended up with the same value of instability, but the warp dimension experienced an instbility hovering around the same value while the weft dimension experienced an upward and downward value of instability. It can be noted that though both the warp yarn directions from both washing soaps experienced instability, they had more stability than their weft directions. This stability in the warp directions could be because the warp yarn direction had a higher mean yarn count of (M = 92) than the weft direction with a mean yarn count of (M =73). The high yarn count in the warp direction makes that direction more dimensionally stable than the weft direction. The instability in the weft yarn direction could have been due to its lower yarn count giving the yarns the room to shift around more than in the warp direction. Although both washing soaps experienced instability in their warp and weft dimensions, their results however meet the dimensional stability standards of the Ghana Standard Authority of GSISO 5077, 2019.

The test results also show that though both washing soaps were subjected to the same washing stress on the same fabric, they performed differently under each selected performance attribute. In the case of the weft strength, new omo lost less of its weft strength compared to key soap; in terms of colour change key soap also lost less unit of colour compared to new omo, but they both experienced the same change in their warp dimensions, and with their weft dimensions, key soap experienced less shrinkage compared to new omo. Reasons for the differences in their performance attributes on the same fabric could be attributed to the differences in the component of both washing soaps. This implies that there are certain component in both washing soaps that makes them perform differently under each performance attribute on the same fabric. For instance, the rebranded omo has a component that makes it perform better in its weft strength than key soap but has something common in its components that makes them perform the same in their warp dimensions and not their weft dimensions. Likewise, key soap also has a component that makes it to lose less of its colour compared to new omo. This confirms the assertion made by Hearle and Morton (2008) that the application of soaps of different chemical compositions is likely to have different effects on textile fabrics.

The Differences in Effects Between Key Soap and New Omo on the Tensile Strength, Colour Change and Dimensional Stability of Adepa Dumas

Results from the corrected model on the differences in effect between Key Soap and New Omo after five washing periods had significant effect weft strength and warp dimension of Adepa Dumas but did not have any significant effect on the warp strength, colour change and weft dimension of Adepa Dumas. The results further show that the significant effect on the weft strength and warp dimension was not as a result of the differences in effect between the washing soaps but as a result of differences between their washing periods. This implies that the significant effects on the weft strength and warp dimension resulted from the differences in their washing periods. This could mean no difference in effect between key soap and new style on Adepa Dumas. This implies that their effect on Adepa Dumas is the same though they might have performed differently on their own. On the other, the differences between their washing periods that caused the significant effect show that the effect of washing on fabric may not necessarily be a result of the washing soaps but as a result of the series of washes the fabric went through. These effects from the differences between their washing periods on the weft strength and the warp dimension could be once again associated with the differences in the strength of the two sets of yarns which confirms the assertion made by Teli *et al.* (2008) and Ozdil, Ozdogan and Oktem (2003) on the strength of the two sets of yarns in a fabric and thread pack respectively. Though the differences between the washing periods affected the warp dimension, it experienced more stability in its dimension after many washing periods after its effect between the first and the fourth; and fifth washing periods.

The Interaction Effect between Washing Soap and their Washing Periods on Selected Performance Attributes of Adepa fabric

Results from both tests show a significant effect in the interaction between both washing soaps and their washing periods on the weft strength, colour change, and the warp and weft dimensions of Adepa fabric. It was observed that there was no significant effect in interaction between both washing soaps and their washing periods on the warp strength of Adepa fabric. This interaction effect from both washing soaps and their washing periods on Adepa fabrics confirms that it is impossible for washing to be done without the other. This implies a correlation between washing soaps and their washing periods on the effect of Adepa fabric. In addition, the non-interaction effect on the warp strength of Adepa fabric could be attributed to the strength of the warp set of yarns and the thread count in the warp direction of Adepa fabric. This effect also confirms the assertion made by Teli *et al.* (2008) that the warp direction of the fabric is stronger and, coupled with its high yarn count, will make it stronger to oppose any effect from both washing soaps their washing periods.

The Effect of Key soap and New Omo on the Tensile Strength, Colour Change and Dimensional Stability of Nustyle

Results from both tests show that both washing soaps affected the weft strength, colour change, the warp and weft dimensions of Nustyle fabric after five washing periods. It was observed that both washing soaps did not affect the warp strength of Nustyle fabric but experienced instability in the strength level of the weft strength. The difference in the strength of the two sets of yarns of Nustyle fabric could be attributed to their yarn count. It was observed that the warp direction of Nustyle had a higher mean yarn count, which made the warp direction more compact to resist the washing stress. The weft direction, on the other hand, had less yarns giving the weft direction the space for its instability in strength. It was also observed that though both washing soaps had an effect on the weft strength of Nustyle, the effect of key soap experienced more instability in strength and lost more of its strength than new omo. The differences in their effect on the weft strength of Nustyle fabric could be attributed to the differences in their component. This implies that the ingredients and the chemical component of key soap made the weft strength lose more its strength than the new omo. Likewise, the new omo also has a peculiar component, though it lost its strength, experienced some stability in its strength. Though both washing soaps affected the weft strength of Nustyle fabric, the results meet the tensile strength standards of the Ghana Standard Authority of GSISO 13934 -1, 2019.

Results from both tests also show that both washing soaps had an effect on the colour change of Nustyle fabric after five washing periods. It was observed that the effect of key soap on the colour change of Nustyle experienced a gradual reduction in its colour change but lost more of its colour after the fifth washing period. New omo, on the other hand, experienced instability in the colour change but lost less of its colour after the fifth washing period. These differences in their colour change and their colour loss could also be attributed to the differences in the component of the washing soaps. This implies that a component of the rebranded omo makes it difficult for the Nustyle fabric to lose more of its colour, which key soap does not have. This confirms the assertion made by Kwame (2012) that soap types affect the colourfastness of fabrics. Despite their differences in colour loss, they passed the colourfastness test according to GSA ISO105 – C10 (2019).

Results from both tests also show that both washing soaps affected the dimensional stability of Nustyle fabric after five washing periods. It was observed from the result that the effect of both washing soaps on the warp dimension experienced stability in their dimensions with different values, whiles the weft dimension was unstable and also shrunk with different values. These differences in their dimensions could also be attributed to the differences in their thread count. The thread count of the Nustyle fabric shows that the warp dimension has a higher mean count of 81 than the weft dimension, with a mean count of 57. This is an indication that the warp direction is compacted with more yarns making it difficult for the yarns to shift easily as compared to the weft dimension with fewer yarns creating the space for it yarns to shift easily. The results from the test of both washing soaps also show that though both washing soaps had an effect on the dimensional stability of Nustyle fabric, new omo had a lesser effect on both dimensions compared to the effect of key soap. Their differences in effect could be attributed to the differences in the washing soaps. The new omo composition makes the Nustyle fabric more dimensionally stable than key soap. Irrespective of the effect of both washing soaps on the differences instability on their warp and weft dimensions, their results however meet the dimensional stability standards of the Ghana Standard Authority of GSISO 5077, 2019.

The Differences in Effects between Key Soap and New Omo on the Selected Performance Attributes of Nustyle

The results from the corrected model from the test infer that the differences in effect between Key Soap and New Omo after five washing periods had significant effects on the weft strength, colour change, warp and weft dimensions of Nustyle fabric. The results show further that the differences between the washing periods of both washing soaps also had a significant effect on the weft strength, colour change, warp and weft dimensions of Nustyle fabric. However, the results also show that when there is a breakaway of the washing soaps from their washing periods, the differences in the washing soap only affected weft strength and warp and weft dimensions of Nustyle fabric not the colour change. The effect on the differences in their washing periods only also had an effect on the weft strength, colour change, warp and weft dimensions of Nustyle fabric, just as the results from the corrected model. This indicates that the effect on the colour change from the corrected model is a result of the effect of the differences in the washing periods and not the differences between the washing soaps.

Results from the test also show that though the differences in both washing soaps caused some effect, the difference in the effect of new omo caused more effect on the weft strength, warp and weft dimensions of Nustyle fabric. This effect could be attributed to the differences in the composition of both washing soaps. Katz (2000) confirms this by indicating that soaps and detergents are similar in their general structure and properties but different in their composition and some specific properties. In addition, this effect on Nustyle could also be attributed to the thread count and weight of the fabric. This is because comparing Nustyle and Adepa fabric, it was realized that the differences in effect between the two soaps did not affect Adepa fabric. This could be due to its higher mean yarn count of 92 x 73 and a higher mean weight of 128.80g/m^2 compared to Nustyle fabric with a mean yarn count of 81 x 57 and a mean weight of 113.70g/m^2. This also confirms the assertion made by Ozdil, Ozdogan and Oktem (2003) that the strength of fabric depends on the thread pack, weave type and fabric weight.

The Interaction Effect between Washing Soap and their Washing Periods on Selected Performance Attributes of Nustyle

The result from both tests shows that there is a significant effect in the interaction between both washing soaps and their washing periods on the weft strength, colour change, and the warp and weft dimensions of Nustyle fabric. It was observed that there was no significant effect in interaction between both washing soaps and their washing periods on the warp strength of Nustyle fabric.

This interaction effect from both washing soaps and their washing periods on Nustyle fabrics confirms that it is impossible for washing to be done without the other. This implies that there is a correlation between washing soaps and their washing periods on the effect of Nustyle fabric. However, it does not also mean that the effect of washing soap on Nustyle fabric could be as caused by the washing period. This is because though there was no significant effect in the interaction between both washing soaps and their washing periods on the warp strength of Nustyle fabric, the result from their intercept shows an effect on the warp strength, which was not as a result of the washing periods but key soap only. Therefore, there may be a correlation between washing soaps and their washing periods on fabrics but not a causative effect.

Summary of key findings

It was found that after five washing periods with key soap and new omo on Adepa and Nustyle fabrics, there were significant effects on their colour change, their weft strength and their warp and weft dimensions but had no significant effect their warp strength. It was also found that what caused the significant effect on their colour change, their weft strength and their warp and weft dimensions were as a result of some differences between their washing periods and not all the washing periods.

It was found that differences in effects between key soap and new omo had significant effect on the weft strength and warp dimension of Adepa fabric but had no significant effect on the warp strength, colour change, and warp dimension after five washing periods. It was also found that what caused the significant effect on the weft strength and warp dimension of Adepa fabric was as a result of the differences between the washing periods only and not the soap. On the other hand, differences in effect between key soap and new omo had a significant effect on the weft strength, colour, warp and weft dimensions of Nustyle fabric but had no significant on the warp dimension. It was also found that what caused the significant effect was as a result of differences in both soaps and the washing periods.

Finally, it was found that the significant effect on the weft strength, colour and the warp and weft dimensions of Adepa and Nustyle fabrics after five washing period with key soap and new omo was as a result of a significant interaction between the washing soaps (key soap and new omo) and their washing periods.

CHAPTER FIVE

SUMMARY, CONCLUSION S AND RECOMMENDATIONS

Overview of the Study

Many textile users prefer real wax prints due to their local and international recognition. Their choice of prints is mostly guided by the ability of the print to stand the test of time. What determines the durability of a wax print fabric is its ability to hold on to its colour, strength and dimension during it use and care. Due to this, care must be taken in selecting the suitable washing soap for wax print fabrics.

Studies by several researchers have revealed different outcomes concerning the use of soapless detergent and soap on printed fabrics. Some of the studies found out that the use of soapless detergent fades wax print fabrics more than soap. New Omo is a rebranded washing detergent produced by Unilever Ghana Limited, the same producer of Key soap. The commercial slogan for the rebranded Omo has it that it makes white whiter and coloured brighter. This information and perception about the New Omo may appeal to individuals' interest and may prefer New Omo in washing their wax prints. It is in line with this that this study was undertaken to investigate the difference in effect between soap and soapless detergent on the tensile strength, colourfastness and dimensional stability of wax prints fabrics for several washing periods.

Two brands of wax prints from Tes Styles Ghana Limited (GTP Adepa Dumas and GTP Nustyle) and soap and a soapless detergent from Unilever Ghana Limited (Key soap and New omo) were selected for the study. The following research hypothesis guided the study:

1. Ho_1: There is no significant effect in the colourfastness, tensile strength

and dimensional stability of Adepa Dumas and Nustyle when washed with Key Soap after five washing periods.

2. Ho_2: There is no significant effect in the colourfastness, tensile strength and dimensional stability of Adepa Dumas and Nustyle when machine washed with New Omo after five washing periods.

3. H_{O3}: There is no significant difference between Key Soap and New Omo in the colourfastness, tensile strength and dimensional stability of Adepa Dumas and Nustyle when machine washed after five washing periods.

4. $H_{O4:}$ There is no significant interaction effect between soaps and washing periods in the colourfastness, tensile strength and dimensional stability of Adepa Dumas and Nustyle after five washing periods.

A 2 x 2 x 5 experimental factorial design was used for the study. The independent variables in the study were the two brands of GTP wax prints, two washing soaps and five washing periods, whereas colour change, tensile strength and dimensional stability made up the dependent variables. There were two treatment conditions and each treatment was replicated five times. The wax prints went through five washing periods comprising 60 minutes 120 minutes. 180

minutes, 240 minutes and 300 minutes for every washing soap. A purposive sampling technique was used to sample 205 specimens from Adepa Dumas print and 205 specimens from Nustyle prints, making 410 specimens. One hundred and sixty (160) specimens were tested for tensile strength for each print, fifteen (15) specimens were tested for a colour change for each print, fifteen (15) specimens for dimensional stability for each print, five (5) specimens for weight for each print and ten (10) specimens for yarn count for each print.

Electric balance scale MN: SSLI (SN: R000100194) was used for weighing and measuring specimens as well as the required quantity of soap for the preparations of the two washing solutions. Standard Launder-Ometre (Gyrowash SN: 315/8/98/5040) was used for the laundering. The Colour Assessment chamber with a Grey Scale were also used for testing colour change in the specimens. At the same time, the tensile strength was determined using Tensile machine H50KT with a compensation load of 20N. The data collected were analysed using IBM SPSS version 20. Descriptive statistics, means and standard deviations and inferential statistics (a three-way MANOVA) were used to describe and test research hypotheses.

Summary of the Findings

1. The first hypothesis revealed that after washing Adepa Dumas with key soap for five washing periods, Adepa lost 45.00N of its weft strength, 1 unit of its colour, shrunk by .28% in it warp dimension and .22% in its weft dimension. The test also revealed that the significant effect on the weft strength occurred due to the differences between the

first and second washing periods; and, again, between the first and fourth washing periods. For a colour change, the significant effect occurred between the before wash and all washing periods. For the warp dimension, the significant effect was also between the before wash and the second, third, fourth and fifth washing periods. The significant effect on the weft dimension too occurred between the before wash and all the five washing periods. However, the key soap's significant effect on the weft strength, the colour change, the warp and weft dimensions of Adepa Dumas print after five washing periods met the GSA standard on African prints.

The effect of key soap on Nustyle fabric also revealed that Nustyle fabric lost 40.00N of its weft strength, lost 1unit of it colour and shrunk by .38% in both the warp and weft dimensions after five washing periods. The test revealed further that the significant effect on the weft strength of Nustyle was not caused by any of the differences among the washing periods. This implies that the effect from the corrected model is as a result of the soap only. For a colour change, the effect was due to the differences between the first and the fifth washing periods; and the third and the fifth washing periods. Effect on the warp dimension was also caused by the differences between the first and the fourth washing periods; and the second and the fourth washing periods. For the weft dimensions, the effect was not caused by differences between the before wash and all the washing periods.

Nevertheless, the significant effect key soap had on the weft strength, the colour change, the warp and weft dimensions of Nustyle print after five washing periods met the GSA standard for African prints.

2. The test for the second hypothesis also revealed that Adepa Dumas, when washed with new omo after five washing periods, lost 11.20N of it weft strength, lost 1.12 units of colour and shrunk by .28% in both the warp and the weft dimension. The test also revealed that the effect on the weft strength occurred only between the before wash and the fifth washing period; that of colour change was also between the before wash and all the washing periods; the effect on the warp and weft dimensions also occurred between the before wash and all the washing periods. Despite the significant effect of new omo on the weft strength, the colour change, the warp and weft dimensions of Adepa Dumas after five washing periods, it met the Ghana Standard Authority standards for African prints.

   The effect of new omo also on Nustyle print after five washing periods lost 6.40% of its weft strength, lost 0.7 units of its colour, shrunk by .26% in the warp dimension and .36% in the weft dimension. The test revealed further that the effect on the weft strength was caused by the differences between the second and the third, fourth and fifth washing periods. The effect on the colour change was due to the differences between the before wash and all the washing periods. The effect on the warp dimension was also caused by the differences between the first and the fourth washing periods, the second and the fourth washing periods, and the fourth and fifth washing periods. The effect on the weft dimension was also caused by the differences between the first and the fifth washing periods and the third and the fifth washing periods. Despite the significant effect of new omo on the weft strength, colour, warp and weft dimensions of Nustyle fabric, they met the GSA standard for African print.

3. The test for the third hypothesis revealed that the differences in effect between key soap and new omo on Adepa Dumas after five washing periods had a significant difference of -70.780N on the weft strength and it was observed between the first and the second washing period. Also, for the warp dimension. a significant difference of 0.13% was observed between the first and the fourth washing period and a difference of 0.12% was also observed between the first and the fifth washing periods.

   Also, the difference in effect between key soap and new omo on Nustyle after five washing periods also had a significant difference on the weft strength, the colour change, and the warp and weft dimensions of the print. The test revealed further that the significant difference on the weft strength, warp and weft dimensions resulted from differences in both the washing soaps and their washing periods, but that of colour change was as a result of the differences in their washing periods only. The test also disclosed that, though the differences between the washing soaps caused a significant effect on the weft strength, the warp and weft dimensions of Nustyle print, the effect of new omo was higher than key soap.

4. The test for the fourth hypothesis revealed a significant interaction effect between washing soaps (key soap and new omo) and their washing periods on the weft strength, the colour change, the warp and weft dimensions of Adepa Dumas and Nustyle after five washing periods.

Conclusions

The results of this study led to the following basic conclusions. The effects of washing soaps on the printed fabrics after washing is as a result of the type of soap used, the type of fabric used, the number of washes and the differences between the number of washes. In the case of the type of soap used, it is evident from what was observed from the study that new omo in a majority of the cases performed better than key soap. New omo lost the least of its colour, less of its weft strength and had the best stability in both the warp and weft dimensions. In case of the type of fabric used, it was observed from the study that Nustyle fabric performed better in terms of colour, lost less of its weft strength and had the best stability in its warp dimension compared to Adepa fabric.

In the case of the number of washes, not all washing periods caused an effect but the differences among the washing periods caused some effects. It was observed from the study that new omo used on Nustyle lost the least colour gradually at the end of every washing and the most colour lost occurred gradually new at end of every washing period whiles key soap used on both both fabrics lost the same units of colour at different washing periods.

It can also be noted that the difference in effect between the washing soaps is also as result of the type of fabric to receive the washes, the number washes and the differences in the number of washes. This is evident from what was observed from the study where the difference in effect between the washing soaps on Adepa fabric had effect on its weft strength and warp dimension only but on Nustyle fabric had effect on the weft strength, colour, warp and weft dimensions. It can also be noted that what caused the effect on the weft strength and warp dimension of Adepa fabric was not as a result of the difference in the soaps but as a results of the difference in the washing periods but that of Nustyle fabric was as result of the difference in both the washing soaps and the washing periods.

It can be noted that the overall performances of the two washing soaps on the performance attributes of both wax prints after five washing periods resulted from an interaction effect between the washing soaps and their washing periods. It can also be concluded that the effect of New omo on the performance attributes of both wax prints has the same effect as key soap on the performance attributes of both prints.

The current study offers a scientific basis for supporting the conventional performance of new omo on coloured fabrics. It has also brought to light the difference in performance between key soap and new omo on some performance attributes of Tex Styles Ghana Limited Wax printed fabrics. The study has added to the previous knowledge that the type of washing soap, the fabric type and the number of washes a fabric receives influence the fabric's performance. In addition, it has also provided knowledge that some soapless detergents on the Ghana market may perform better on wax printed fabrics. Finally, it has provided documentation on the effect of key soap and new omo on wax printed fabrics, the differences in their effect on wax printed fabrics and their interaction effect between the washing soaps and the number of washing periods on the wax printed fabrics which can serve as a basis for further research.

Recommendations

Based on the findings of the study, it is recommended that:

1. more awareness should be created through television and radio advertisements by Unilever Ghana Limited on the reliable use of the rebranded omo (new omo) on wax printed fabrics since most wax prints' users have the assumption that omo will destroy their prints.
2. Tex Styles Ghana Limited should indicate on the care lables of both Adepa Dumas and Nustyle prints on the reliable use of the rebranded omo detergent on the prints.
3. Tex Styles Ghana Limited should also reduced the price of Adepa Dumas or raised it quality since Nustle print performed better in most of the cases after washing with both the soapless detergent and the detergent.
4. University of Cape Coast should collaborates with both manufacturing industries to assist students financially to publish the work to educate those in academia and also serves as a reference material for students.

Suggestions for Further Studies

It is suggested that future studies should consider the difference in the effect of other soapless detergent on the colourfastness, tensile strength and dimensional stability of GTP Adepa Dumas and GTP Nustyle.

REFERENCES

A Division of the Canadian Consumer Specialty Products Association (CCSPA) (n.d). Retrieved January 15, 2019, from http://www.ccspa.org.

Agarwal G., Koehl L., Perwueltz A. & Lee K.S. (2011). Interaction of textile parameters with laundry process. *Fibres and Polymers* 12 (5), 670 – 678.

Aggor, M. (1991). The use and related problems of Ghanaian textile prints. A dissertation presented to the Home Science Department of the Specialist Training College, Winneba.

Amankrah, D. V., Koranteng, M., & Nyadroh, A. A. P. (2013). An Appraisal of Washing Cycles on the Colours of Akosombo Textile Limited and Dong Yu Textile Company Limited Kente Printed Fabrics in Ghana. *American Journal of Marketing Research,* 7(2), 17-26.

Amedahe, F. K. & Gyimah, A., (20018). *Research Methods*. Hampton Press Ltd, Cape Coast.

Amenumey, D. E. K. (2008). Ghana: A concise history from pre-colonial times to the 20th Century. Accra: Woeli Publishing Company.

ASTM D. (2005). Definition of breaking elongation. Retrieved March 11, 2019, from http://www.astm.org

Brady, James E.; Russell, Joel W.; and Holum, John R. (2000). *Chemistry: Matter and Its Changes*, 3rd edition. New York: Wiley.

Candan, C., Nergis, U. B., & Iridag, Y. (2000). Performance of open-end and ring spun yarns in weft knitted fabrics. *Textile Research Journal*, *70*(2), 177-181.

Cano-Glu, S., Geultekin, B. C. & Yeukselo-Glu, S. M. (2004). Effect of ultrasonic energy in washing of medical surgery gowns. *Ultrasonics*, 42, 113-119.

El-Bayouni, A. A. (1980). An analytical approach to the effect of laundering processes on the drape and stiffness properties of cotton woven fabrics. *Journal of Engineering for Industry*, 102, 342-346.

Fianu, G. K. D., Sallah, A. R., & Ayertey, A., (2005). Effect of sunlight and drying methods on the strength of Ghanaian Real Wax printed fabrics. *International Journal of Consumer Studies*, 35, 34 - 40.

Fibre Talk (2021). A review on different factors of woven fabric's strength. Retrieved August 13, 2018, from https://fibretalk.com

Galbraith, J. (1999). Wassily Leontief: An appreciation. *Challenge*, 3, 55-59.

Ghana Standards (GS) 124 (2019). Specification for traditional African prints. Accra: GSA.

Gong, R. H., & Chen, Y. (1999). Predicting the performance of fabrics in garment manufacturing with Artificial Neural Networks. Textile Research Journal, 69(7), 477-482.

Hedge, R. W. (n.d) The Discovery and Prehistory of Soap. Retrieved October 7, 2015, from http://www.buster.org.uk/iafsoap_hcc.html.

Hearle, J. W. S., & Morton, W. E. (2008). Physical properties of textile fibres (4th ed.). Cambridge: Woodhead Publishing Series

Hopkins, J. (2010). Knowing the components in soap making. Retrieved September 30, 2011 from http://goarticles.com.

Hossain, M., Rony, S. H., Hasan, F. M. K., Kawsar, H., Azharul, H. & Zhou1, Y. (2017). Effective Mechanical and Chemical Washing Process in Garment Industries. *American Journal of Applied Physics,* 2, 1 – 25.

History of soap (n.d.). Retrieved May 20, 2019, from http://www.chemistry explained .com

History of soap. Retrieved from Wikipedia

Hollen, N., Saddler, J., Langford, A. L., & Kadolph, J. S. (1988). *Textiles* (6^{th} ed). Macmillan publication, New York.

http://www.soaphistory.net/detergent/characteristics and uses of soap. Information about soaps and detergents. Retrieved May 16, 2019, from http://healthcleaning 101. Org

Ishtiaque, S. M., Das, B. R., Kumar, A., & Ramamoorthy, M. (2008). Static and dynamic failure mechanisms of cotton yarns. *Indian Journal Fibre Textile Research*, *33*, 111-118.

Kadolph, J. S., (2007), Quality Assurance for Textiles and Apparel. Second Edition, Fairchild Publication. New York.

Kadolph, S. J. (2007). Textiles (10^{th} ed.). New Jersey: Pearson Education, Inc.

Kadolph, S. J., & Langford, A. L. (1998). *Textiles*. New Jersey: Prentice Hall.

Kašiković, N., Vladić, G., Milić, N., Novaković, D., Milošević, R., & Dedijer, S. (2017). Colour fastness to washing of multi-layered digital prints on textile materials. *Journal of the National Science Foundation of Sri Lanka*, 46 (3), 381 – 391.

Katz, D. A. (2000). The science of soap and detergents. Illinois: AOCS Publishing.

Kitenge (2017). How African Wax Print Fabric is Produced. Retieved August 10, 2017 from https://www.pintetrest.com

Kuntom, A., (1996). Chemical and physical characteristics of soap made from distilled fatty acids of palm oil and kernel oil. *Journal of the American oil chemistry's society*, 105-108.

Kwame, S. A., 2012, Effects of Locally Manufactured Soaps On Colour, Strength And Elongation Of Some Selected Ghanaian Printed Cotton Fabrics. Retrieved May 16, 2019, from https://conference.kstu.edu.gh

Lilley, K. (2011). Colour and light fastness. Retrieved August 15, 2019, from http://www.nzexplorer.co.nz/design_scope/colour_light_fastness.php

MasterClass 2020. Retrieved Audust 7, 2021, from https://www.masterclass.com

Marshall, S., Jackson, H., & Sue Stanley, M. (2012). Individuality in clothing selection and personal appearance (7th ed).

Mokhtari, J., Nouri, M., & Sarli, M. A. (2011). Dyeing of cotton/polyester fabric with selected reactive/disperse dyes under neutral condition. Journal of Colour Sciences and Technology, 4, 143-148.

Mukhopadhyay, A. R., & Ray, S. (2006). Reduction of yarn packing defects using six sigma methods: A case study. *Quality Engineering*, *18*(2), 189-206.

Murthy, H. V. S. (2015). Introduction to Textile Fibres. Woodhead Publishing India in textiles (WPI), India.

Ohpardt, C. E. (2003). Soaps. Retrieved September 24, 2019 from http://www.elmhurst.edu/ soaps.

Ozdil, N., Ozdogan, E., & Oktem, T. (2003). Effect of enzymatic treatment on various spun yarn fabrics. F*ibres and Textiles in Eastern Europe*, *11*(4), 58-61.

Quartey, P., (2006) The Textiles and Clothing Industry in Ghana. Retrieved May 16, 2019, from https:www.google.com/search.

Raul, J. (2005). Textile testing. New Dehli: APH Publication Corporation

Realff, M. L., Boyce, M. C., & Backer, S. (1997). A micro-mechanical model of the tensile behaviour of woven fabric. *Textile Research Journal*, *67*(6), 445-459.

Realff, M. L., Seo, M., Boyce, M. C., Schwartz, P., & Backer, S. (1991). Mechanical properties of fabric woven from yarn produced by different spinning technologies: Yarn failure as a function of gauge length. *Textile Research Journal*, *61*, 517-530.

Singh, P., Singh, V. V., & Waghmare, V. N. (1996). Naturally-coloured cotton. Nagpur: Central Institute for Cotton Research.

Soap chemistry (n.d.) Retrieved June 16, 2019, from http://www.chemistryexplained.com/Ru-Sp/Soap.html#ixzz5saGdomkes

Soap and Detergent Association of Canada (n.d.). Retrieved May 13, 2019, from http://www.healyhycleaning101.org/english/SDAC.html.

Teli, M. D., Khare, A. R., & Chakrabarti, R. (2008). Dependence of yarn and fabric strength on the structural parameters. *AUTEX Research Journal*, *8*(3), 63-67.

Texcoms Textile Solutions (2019). Textile Fibres. Textile Technology knowledge series Volume I.

TextileGlossary.com (2010). What is colourfastness – Definition and explanation. Retrieved May 16, 2019, from http://www.Textile glossary.com/terms/color-fastness.html.

Textiles School (n.d). Physical Properties and Characteristics of Fabrics. Retrieve from https://www.textilesschool.com

Top 5 African print trends in Ghana (n.d.). Retrieved May 16, 2019, from myjoyonline.com.

Types of Soaps – Differences between Soaps. Retrieved May 6, 2019, from http://www.soaphistory.net/privacypolicy

Uttam, M., & Gangwar, A. K. S. (2006). Effect of single yarn strength on tensile strength of cotton fabric. *Man-made Textiles in India*, *49*(1), 30-34.

Yoruba, E. (2008). African fabrics: The history of Dutch wax prints. Retrieved September 25, 2011, from http://www.beyondvictoriana.com /2011/04/10/African-fabrics-the-history-of-dutch-wax-prints-guest

Wendren, W. (2008). The story behind African wax print cotton. Retrieved September 25, 2011 from http://www.thewrendesign.com.

APPENDICES

APPENDIX A

Tests of Between- Subjects Effects on the Effect of Key Soap on GTP Adepa Dumas

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Force Warp	23106.567[a]	5	4621.313	.653	.662	.120
	Elong Warp	144.681[b]	5	28.936	42.480	.000	.898
	Force Weft	70778.247[c]	5	14155.649	4.596	.004	.489
	Elong Weft	893.068[d]	5	178.614	71.716	.000	.937
	Colour	3.200[e]	5	.640	13.964	.000	.744
	Dimen Warp	.320[f]	5	.064	8.533	.000	.640
	Dimen weft	.203[g]	5	.041	17.371	.000	.784
Intercept	Force Warp	7706400.833	1	7706400.83	1089.22	.000	.978
	Elong Warp	2763.072	1	2763.072	4056.31	.000	.994
	Force Weft	3544165.665	1	3544165.67	1150.67	.000	.980
	Elong Weft	20797.014	1	20797.014	8350.35	.000	.997
	Colour	554.700	1	554.700	12102.55	.000	.998
	Dimen Warp	2881.200	1	2881.200	384160.00	.000	1.000
	Dimen weft	2896.901	1	2896.901	1241529.14	.000	1.000
Washing Periods	Force Warp	23106.567	5	4621.313	.653	.662	.120
	Elong Warp	144.681	5	28.936	42.480	.000	.898
	Force Weft	70778.247	5	14155.649	4.596	.004	.489
	Elong Weft	893.068	5	178.614	71.716	.000	.937
	Colour	3.200	5	.640	13.964	.000	.744
	Dimen Warp	.320	5	.064	8.533	.000	.640
	Dimen weft	.203	5	.041	17.371	.000	.784
Error	Force Warp	169803.600	24	7075.150			
	Elong Warp	16.348	24	.681			
	Force Weft	73922.448	24	3080.102			
	Elong Weft	59.773	24	2.491			
	Colour	1.100	24	.046			
	Dimen Warp	.180	24	.008			
	Dimen weft	.056	24	.002			
Total	Force Warp	7899311.000	30				
	Elong Warp	2924.102	30				
	Force Weft	3688866.360	30				
	Elong Weft	21749.855	30				
	Colour	559.000	30				
	Dimen Warp	2881.700	30				
	Dimen weft	2897.160	30				

Corrected Total	ForceWarp	192910.167	29
	ElongWarp	161.029	29
	ForceWeft	144700.695	29
	ElongWeft	952.842	29
	Colour	4.300	29
	DimenWarp	.500	29
	Dimenweft	.259	29

Bonferroni Pairwise Comparison test on the washing periods of the effect of Key Soap on GTP Adepa Dumas

Dependent Variable	(I) Washing Periods	(J) Washing Periods	Mean Difference (I-J)	Std. Error	Sig.
ForceWarp	Before Wash	First Wash	16.4000	53.19831	1.000
		Second Wash	-61.6000	53.19831	1.000
		Third Wash	-23.4000	53.19831	1.000
		Fourth Wash	-16.0000	53.19831	1.000
		Fifth Wash	20.8000	53.19831	1.000
	First Wash	Before Wash	-16.4000	53.19831	1.000
		Second Wash	-78.0000	53.19831	1.000
		Third Wash	-39.8000	53.19831	1.000
		Fourth Wash	-32.4000	53.19831	1.000
		Fifth Wash	4.4000	53.19831	1.000
	Second Wash	Before Wash	61.6000	53.19831	1.000
		First Wash	78.0000	53.19831	1.000
		Third Wash	38.2000	53.19831	1.000
		Fourth Wash	45.6000	53.19831	1.000
		Fifth Wash	82.4000	53.19831	1.000
	Third Wash	Before Wash	23.4000	53.19831	1.000
		First Wash	39.8000	53.19831	1.000
		Second Wash	-38.2000	53.19831	1.000
		Fourth Wash	7.4000	53.19831	1.000
		Fifth Wash	44.2000	53.19831	1.000
	Fourth Wash	Before Wash	16.0000	53.19831	1.000
		First Wash	32.4000	53.19831	1.000
		Second Wash	-45.6000	53.19831	1.000
		Third Wash	-7.4000	53.19831	1.000
		Fifth Wash	36.8000	53.19831	1.000
	Fifth Wash	Before Wash	-20.8000	53.19831	1.000
		First Wash	-4.4000	53.19831	1.000
		Second Wash	-82.4000	53.19831	1.000

		Third Wash	-44.2000	53.19831	1.000
		Fourth Wash	-36.8000	53.19831	1.000
ElongWarp	Before Wash	First Wash	-2.2080*	.52199	.004
		Second Wash	-3.8480*	.52199	.000
		Third Wash	-3.1380*	.52199	.000
		Fourth Wash	-2.7980*	.52199	.000
		Fifth Wash	2.5420*	.52199	.001
	First Wash	Before Wash	2.2080*	.52199	.004
		Second Wash	-1.6400	.52199	.066
		Third Wash	-.9300	.52199	1.000
		Fourth Wash	-.5900	.52199	1.000
		Fifth Wash	4.7500*	.52199	.000
	Second Wash	Before Wash	3.8480*	.52199	.000
		First Wash	1.6400	.52199	.066
		Third Wash	.7100	.52199	1.000
		Fourth Wash	1.0500	.52199	.834
		Fifth Wash	6.3900*	.52199	.000
	Third Wash	Before Wash	3.1380*	.52199	.000
		First Wash	.9300	.52199	1.000
		Second Wash	-.7100	.52199	1.000
		Fourth Wash	.3400	.52199	1.000
		Fifth Wash	5.6800*	.52199	.000
	Fourth Wash	Before Wash	2.7980*	.52199	.000
		First Wash	.5900	.52199	1.000
		Second Wash	-1.0500	.52199	.834
		Third Wash	-.3400	.52199	1.000
		Fifth Wash	5.3400*	.52199	.000
	Fifth Wash	Before Wash	-2.5420*	.52199	.001
		First Wash	-4.7500*	.52199	.000
		Second Wash	-6.3900*	.52199	.000
		Third Wash	-5.6800*	.52199	.000
		Fourth Wash	-5.3400*	.52199	.000
ForceWeft	Before Wash	First Wash	147.9200*	35.10044	.005
		Second Wash	24.0000	35.10044	1.000
		Third Wash	80.0000	35.10044	.478
		Fourth Wash	26.4000	35.10044	1.000
		Fifth Wash	45.0000	35.10044	1.000
	First Wash	Before Wash	-147.9200*	35.10044	.005
		Second Wash	-123.9200*	35.10044	.026
		Third Wash	-67.9200	35.10044	.973
		Fourth Wash	-121.5200*	35.10044	.030
		Fifth Wash	-102.9200	35.10044	.109
	Second Wash	Before Wash	-24.0000	35.10044	1.000
		First Wash	123.9200*	35.10044	.026
		Third Wash	56.0000	35.10044	1.000
		Fourth Wash	2.4000	35.10044	1.000

		Fifth Wash	21.0000	35.10044	1.000
	Third Wash	Before Wash	-80.0000	35.10044	.478
		First Wash	67.9200	35.10044	.973
		Second Wash	-56.0000	35.10044	1.000
		Fourth Wash	-53.6000	35.10044	1.000
		Fifth Wash	-35.0000	35.10044	1.000
	Fourth Wash	Before Wash	-26.4000	35.10044	1.000
		First Wash	121.5200*	35.10044	.030
		Second Wash	-2.4000	35.10044	1.000
		Third Wash	53.6000	35.10044	1.000
		Fifth Wash	18.6000	35.10044	1.000
	Fifth Wash	Before Wash	-45.0000	35.10044	1.000
		First Wash	102.9200	35.10044	.109
		Second Wash	-21.0000	35.10044	1.000
		Third Wash	35.0000	35.10044	1.000
		Fourth Wash	-18.6000	35.10044	1.000
ElongWeft	Before Wash	First Wash	3.0360	.99811	.084
		Second Wash	-1.2040	.99811	1.000
		Third Wash	.8160	.99811	1.000
		Fourth Wash	-.1640	.99811	1.000
		Fifth Wash	14.7160*	.99811	.000
	First Wash	Before Wash	-3.0360	.99811	.084
		Second Wash	-4.2400*	.99811	.004
		Third Wash	-2.2200	.99811	.537
		Fourth Wash	-3.2000	.99811	.057
		Fifth Wash	11.6800*	.99811	.000
	Second Wash	Before Wash	1.2040	.99811	1.000
		First Wash	4.2400*	.99811	.004
		Third Wash	2.0200	.99811	.814
		Fourth Wash	1.0400	.99811	1.000
		Fifth Wash	15.9200*	.99811	.000
	Third Wash	Before Wash	-.8160	.99811	1.000
		First Wash	2.2200	.99811	.537
		Second Wash	-2.0200	.99811	.814
		Fourth Wash	-.9800	.99811	1.000
		Fifth Wash	13.9000*	.99811	.000
	Fourth Wash	Before Wash	.1640	.99811	1.000
		First Wash	3.2000	.99811	.057
		Second Wash	-1.0400	.99811	1.000
		Third Wash	.9800	.99811	1.000
		Fifth Wash	14.8800*	.99811	.000
	Fifth Wash	Before Wash	-14.7160*	.99811	.000
		First Wash	-11.6800*	.99811	.000
		Second Wash	-15.9200*	.99811	.000
		Third Wash	-13.9000*	.99811	.000
		Fourth Wash	-14.8800*	.99811	.000

Colour	Before Wash	First Wash	.8000*	.13540	.000
		Second Wash	.8000*	.13540	.000
		Third Wash	.7000*	.13540	.000
		Fourth Wash	.9000*	.13540	.000
		Fifth Wash	1.0000*	.13540	.000
	First Wash	Before Wash	-.8000*	.13540	.000
		Second Wash	.0000	.13540	1.000
		Third Wash	-.1000	.13540	1.000
		Fourth Wash	.1000	.13540	1.000
		Fifth Wash	.2000	.13540	1.000
	Second Wash	Before Wash	-.8000*	.13540	.000
		First Wash	.0000	.13540	1.000
		Third Wash	-.1000	.13540	1.000
		Fourth Wash	.1000	.13540	1.000
		Fifth Wash	.2000	.13540	1.000
	Third Wash	Before Wash	-.7000*	.13540	.000
		First Wash	.1000	.13540	1.000
		Second Wash	.1000	.13540	1.000
		Fourth Wash	.2000	.13540	1.000
		Fifth Wash	.3000	.13540	.547
	Fourth Wash	Before Wash	-.9000*	.13540	.000
		First Wash	-.1000	.13540	1.000
		Second Wash	-.1000	.13540	1.000
		Third Wash	-.2000	.13540	1.000
		Fifth Wash	.1000	.13540	1.000
	Fifth Wash	Before Wash	-1.0000*	.13540	.000
		First Wash	-.2000	.13540	1.000
		Second Wash	-.2000	.13540	1.000
		Third Wash	-.3000	.13540	.547
		Fourth Wash	-.1000	.13540	1.000
Dimen Warp	Before Wash	First Wash	.1400	.05477	.260
		Second Wash	.2600*	.05477	.001
		Third Wash	.2200*	.05477	.008
		Fourth Wash	.3000*	.05477	.000
		Fifth Wash	.2800*	.05477	.000
	First Wash	Before Wash	-.1400	.05477	.260
		Second Wash	.1200	.05477	.576
		Third Wash	.0800	.05477	1.000
		Fourth Wash	.1600	.05477	.112
		Fifth Wash	.1400	.05477	.260
	Second Wash	Before Wash	-.2600*	.05477	.001
		First Wash	-.1200	.05477	.576
		Third Wash	-.0400	.05477	1.000
		Fourth Wash	.0400	.05477	1.000
		Fifth Wash	.0200	.05477	1.000
	Third	Before Wash	-.2200*	.05477	.008

	Wash	First Wash	-.0800	.05477	1.000
		Second Wash	.0400	.05477	1.000
		Fourth Wash	.0800	.05477	1.000
		Fifth Wash	.0600	.05477	1.000
	Fourth Wash	Before Wash	-.3000*	.05477	.000
		First Wash	-.1600	.05477	.112
		Second Wash	-.0400	.05477	1.000
		Third Wash	-.0800	.05477	1.000
		Fifth Wash	-.0200	.05477	1.000
	Fifth Wash	Before Wash	-.2800*	.05477	.000
		First Wash	-.1400	.05477	.260
		Second Wash	-.0200	.05477	1.000
		Third Wash	-.0600	.05477	1.000
		Fourth Wash	.0200	.05477	1.000
Dimenweft	Before Wash	First Wash	.1800*	.03055	.000
		Second Wash	.2600*	.03055	.000
		Third Wash	.1800*	.03055	.000
		Fourth Wash	.2000*	.03055	.000
		Fifth Wash	.2200*	.03055	.000
	First Wash	Before Wash	-.1800*	.03055	.000
		Second Wash	.0800	.03055	.226
		Third Wash	.0000	.03055	1.000
		Fourth Wash	.0200	.03055	1.000
		Fifth Wash	.0400	.03055	1.000
	Second Wash	Before Wash	-.2600*	.03055	.000
		First Wash	-.0800	.03055	.226
		Third Wash	-.0800	.03055	.226
		Fourth Wash	-.0600	.03055	.918
		Fifth Wash	-.0400	.03055	1.000
	Third Wash	Before Wash	-.1800*	.03055	.000
		First Wash	.0000	.03055	1.000
		Second Wash	.0800	.03055	.226
		Fourth Wash	.0200	.03055	1.000
		Fifth Wash	.0400	.03055	1.000
	Fourth Wash	Before Wash	-.2000*	.03055	.000
		First Wash	-.0200	.03055	1.000
		Second Wash	.0600	.03055	.918
		Third Wash	-.0200	.03055	1.000
		Fifth Wash	.0200	.03055	1.000
	Fifth Wash	Before Wash	-.2200*	.03055	.000
		First Wash	-.0400	.03055	1.000
		Second Wash	.0400	.03055	1.000
		Third Wash	-.0400	.03055	1.000
		Fourth Wash	-.0200	.03055	1.000

APPENDIX B

Tests of Between- Subjects Effects on the Effect of Key Soap on GTP

Nustyle

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	ForceWarp	56858.167[a]	5	11371.633	1.436	.247	.230
	ElongWarp	140.043[b]	5	28.009	2.850	.037	.373
	ForceWeft	8352.967[c]	5	1670.593	3.433	.018	.417
	ElongWeft	737.120[d]	5	147.424	73.826	.000	.939
	Colour	2.767[e]	5	.553	22.133	.000	.822
	DimenWarp	.638[f]	5	.128	36.443	.000	.884
	Dimenweft	.479[g]	5	.096	10.264	.000	.681
Intercept	ForceWarp	7511004.033	1	7511004.033	948.724	.000	.975
	ElongWarp	3355.976	1	3355.976	341.530	.000	.934
	ForceWeft	1278441.633	1	1278441.633	2626.845	.000	.991
	ElongWeft	16056.847	1	16056.847	8040.820	.000	.997
	Colour	589.633	1	589.633	23585.333	.000	.999
	DimenWarp	2819.791	1	2819.791	805654.500	.000	1.000
	Dimenweft	2840.187	1	2840.187	304305.750	.000	1.000
WashingPeriods	ForceWarp	56858.167	5	11371.633	1.436	.247	.230
	ElongWarp	140.043	5	28.009	2.850	.037	.373
	ForceWeft	8352.967	5	1670.593	3.433	.018	.417
	ElongWeft	737.120	5	147.424	73.826	.000	.939
	Colour	2.767	5	.553	22.133	.000	.822
	DimenWarp	.638	5	.128	36.443	.000	.884
	Dimenweft	.479	5	.096	10.264	.000	.681
Error	ForceWarp	190006.800	24	7916.950			
	ElongWarp	235.831	24	9.826			
	ForceWeft	11680.400	24	486.683			
	ElongWeft	47.926	24	1.997			
	Colour	.600	24	.025			
	DimenWarp	.084	24	.003			
	Dimenweft	.224	24	.009			
Total	ForceWarp	7757869.000	30				
	ElongWarp	3731.850	30				
	ForceWeft	1298475.000	30				
	ElongWeft	16841.893	30				
	Colour	593.000	30				
	DimenWarp	2820.513	30				
	Dimenweft	2840.890	30				
Corrected Total	ForceWarp	246864.967	29				

ElongWarp	375.874	29
ForceWeft	20033.367	29
ElongWeft	785.046	29
Colour	3.367	29
DimenWarp	.722	29
Dimenweft	.703	29

a. R Squared = .230 (Adjusted R Squared = .070)
b. R Squared = .373 (Adjusted R Squared = .242)
c. R Squared = .417 (Adjusted R Squared = .295)
d. R Squared = .939 (Adjusted R Squared = .926)
e. R Squared = .822 (Adjusted R Squared = .785)
f. R Squared = .884 (Adjusted R Squared = .859)
g. R Squared = .681 (Adjusted R Squared = .615)

Pairwise Comparison of washing periods on the effect of Key Soap on GTP Nustyle

Dependent Variable	(I) WashingPeriods	(J) WashingPeriods	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
						Lower Bound	Upper Bound
ForceWarp	Before Wash	First Wash	-101.400	56.274	1.000	-284.763	81.963
		Second Wash	-100.200	56.274	1.000	-283.563	83.163
		Third Wash	4.800	56.274	1.000	-178.563	188.163
		Fourth Wash	-63.400	56.274	1.000	-246.763	119.963
		Fifth Wash	-26.400	56.274	1.000	-209.763	156.963
	First Wash	Before Wash	101.400	56.274	1.000	-81.963	284.763
		Second Wash	1.200	56.274	1.000	-182.163	184.563
		Third Wash	106.200	56.274	1.000	-77.163	289.563
		Fourth Wash	38.000	56.274	1.000	-145.363	221.363
		Fifth Wash	75.000	56.274	1.000	-108.363	258.363
	Second Wash	Before Wash	100.200	56.274	1.000	-83.163	283.563
		First Wash	-1.200	56.274	1.000	-184.563	182.163
		Third Wash	105.000	56.274	1.000	-78.363	288.363
		Fourth Wash	36.800	56.274	1.000	-146.563	220.163
		Fifth Wash	73.800	56.274	1.000	-109.563	257.163
	Third Wash	Before Wash	-4.800	56.274	1.000	-188.163	178.563
		First Wash	-106.200	56.274	1.000	-289.563	77.163
		Second Wash	-105.000	56.274	1.000	-288.363	78.363
		Fourth Wash	-68.200	56.274	1.000	-251.563	115.163
		Fifth Wash	-31.200	56.274	1.000	-214.563	152.163
	Fourth Wash	Before Wash	63.400	56.274	1.000	-119.963	246.763
		First Wash	-38.000	56.274	1.000	-221.363	145.363
		Second Wash	-36.800	56.274	1.000	-220.163	146.563
		Third Wash	68.200	56.274	1.000	-115.163	251.563
		Fifth Wash	37.000	56.274	1.000	-146.363	220.363

		Before Wash	26.400	56.274	1.000	-156.963	209.763
		First Wash	-75.000	56.274	1.000	-258.363	108.363
	Fifth Wash	Second Wash	-73.800	56.274	1.000	-257.163	109.563
		Third Wash	31.200	56.274	1.000	-152.163	214.563
		Fourth Wash	-37.000	56.274	1.000	-220.363	146.363
		First Wash	.790	1.983	1.000	-5.670	7.250
		Second Wash	.250	1.983	1.000	-6.210	6.710
	Before Wash	Third Wash	.760	1.983	1.000	-5.700	7.220
		Fourth Wash	1.160	1.983	1.000	-5.300	7.620
		Fifth Wash	6.300	1.983	.061	-.160	12.760
		Before Wash	-.790	1.983	1.000	-7.250	5.670
		Second Wash	-.540	1.983	1.000	-7.000	5.920
	First Wash	Third Wash	-.030	1.983	1.000	-6.490	6.430
		Fourth Wash	.370	1.983	1.000	-6.090	6.830
		Fifth Wash	5.510	1.983	.156	-.950	11.970
		Before Wash	-.250	1.983	1.000	-6.710	6.210
		First Wash	.540	1.983	1.000	-5.920	7.000
	Second Wash	Third Wash	.510	1.983	1.000	-5.950	6.970
		Fourth Wash	.910	1.983	1.000	-5.550	7.370
		Fifth Wash	6.050	1.983	.082	-.410	12.510
ElongWarp		Before Wash	-.760	1.983	1.000	-7.220	5.700
		First Wash	.030	1.983	1.000	-6.430	6.490
	Third Wash	Second Wash	-.510	1.983	1.000	-6.970	5.950
		Fourth Wash	.400	1.983	1.000	-6.060	6.860
		Fifth Wash	5.540	1.983	.151	-.920	12.000
		Before Wash	-1.160	1.983	1.000	-7.620	5.300
		First Wash	-.370	1.983	1.000	-6.830	6.090
	Fourth Wash	Second Wash	-.910	1.983	1.000	-7.370	5.550
		Third Wash	-.400	1.983	1.000	-6.860	6.060
		Fifth Wash	5.140	1.983	.240	-1.320	11.600
		Before Wash	-6.300	1.983	.061	-12.760	.160
		First Wash	-5.510	1.983	.156	-11.970	.950
	Fifth Wash	Second Wash	-6.050	1.983	.082	-12.510	.410
		Third Wash	-5.540	1.983	.151	-12.000	.920
		Fourth Wash	-5.140	1.983	.240	-11.600	1.320
		First Wash	24.000	13.953	1.000	-21.463	69.463
		Second Wash	3.400	13.953	1.000	-42.063	48.863
	Before Wash	Third Wash	42.400	13.953	.085	-3.063	87.863
		Fourth Wash	11.200	13.953	1.000	-34.263	56.663
ForceWeft		Fifth Wash	40.000	13.953	.127	-5.463	85.463
		Before Wash	-24.000	13.953	1.000	-69.463	21.463
	First Wash	Second Wash	-20.600	13.953	1.000	-66.063	24.863
		Third Wash	18.400	13.953	1.000	-27.063	63.863
		Fourth Wash	-12.800	13.953	1.000	-58.263	32.663

		Fifth Wash	16.000	13.953	1.000	-29.463	61.463
		Before Wash	-3.400	13.953	1.000	-48.863	42.063
		First Wash	20.600	13.953	1.000	-24.863	66.063
	Second Wash	Third Wash	39.000	13.953	.151	-6.463	84.463
		Fourth Wash	7.800	13.953	1.000	-37.663	53.263
		Fifth Wash	36.600	13.953	.224	-8.863	82.063
		Before Wash	-42.400	13.953	.085	-87.863	3.063
		First Wash	-18.400	13.953	1.000	-63.863	27.063
	Third Wash	Second Wash	-39.000	13.953	.151	-84.463	6.463
		Fourth Wash	-31.200	13.953	.524	-76.663	14.263
		Fifth Wash	-2.400	13.953	1.000	-47.863	43.063
		Before Wash	-11.200	13.953	1.000	-56.663	34.263
		First Wash	12.800	13.953	1.000	-32.663	58.263
	Fourth Wash	Second Wash	-7.800	13.953	1.000	-53.263	37.663
		Third Wash	31.200	13.953	.524	-14.263	76.663
		Fifth Wash	28.800	13.953	.750	-16.663	74.263
		Before Wash	-40.000	13.953	.127	-85.463	5.463
		First Wash	-16.000	13.953	1.000	-61.463	29.463
	Fifth Wash	Second Wash	-36.600	13.953	.224	-82.063	8.863
		Third Wash	2.400	13.953	1.000	-43.063	47.863
		Fourth Wash	-28.800	13.953	.750	-74.263	16.663
		First Wash	2.820	.894	.064	-.092	5.732
		Second Wash	2.660	.894	.098	-.252	5.572
	Before Wash	Third Wash	2.200	.894	.321	-.712	5.112
		Fourth Wash	2.310	.894	.244	-.602	5.222
		Fifth Wash	15.060*	.894	.000	12.148	17.972
		Before Wash	-2.820	.894	.064	-5.732	.092
		Second Wash	-.160	.894	1.000	-3.072	2.752
	First Wash	Third Wash	-.620	.894	1.000	-3.532	2.292
		Fourth Wash	-.510	.894	1.000	-3.422	2.402
		Fifth Wash	12.240*	.894	.000	9.328	15.152
		Before Wash	-2.660	.894	.098	-5.572	.252
ElongWeft		First Wash	.160	.894	1.000	-2.752	3.072
	Second Wash	Third Wash	-.460	.894	1.000	-3.372	2.452
		Fourth Wash	-.350	.894	1.000	-3.262	2.562
		Fifth Wash	12.400*	.894	.000	9.488	15.312
		Before Wash	-2.200	.894	.321	-5.112	.712
		First Wash	.620	.894	1.000	-2.292	3.532
	Third Wash	Second Wash	.460	.894	1.000	-2.452	3.372
		Fourth Wash	.110	.894	1.000	-2.802	3.022
		Fifth Wash	12.860*	.894	.000	9.948	15.772
		Before Wash	-2.310	.894	.244	-5.222	.602
	Fourth Wash	First Wash	.510	.894	1.000	-2.402	3.422
		Second Wash	.350	.894	1.000	-2.562	3.262

		Third Wash	-.110	.894	1.000	-3.022	2.802
		Fifth Wash	12.750*	.894	.000	9.838	15.662
		Before Wash	-15.060*	.894	.000	-17.972	-12.148
		First Wash	-12.240*	.894	.000	-15.152	-9.328
	Fifth Wash	Second Wash	-12.400*	.894	.000	-15.312	-9.488
		Third Wash	-12.860*	.894	.000	-15.772	-9.948
		Fourth Wash	-12.750*	.894	.000	-15.662	-9.838
		First Wash	.500*	.100	.001	.174	.826
		Second Wash	.700*	.100	.000	.374	1.026
	Before Wash	Third Wash	.500*	.100	.001	.174	.826
		Fourth Wash	.700*	.100	.000	.374	1.026
		Fifth Wash	1.000*	.100	.000	.674	1.326
		Before Wash	-.500*	.100	.001	-.826	-.174
		Second Wash	.200	.100	.854	-.126	.526
	First Wash	Third Wash	-1.110E-016	.100	1.000	-.326	.326
		Fourth Wash	.200	.100	.854	-.126	.526
		Fifth Wash	.500*	.100	.001	.174	.826
		Before Wash	-.700*	.100	.000	-1.026	-.374
		First Wash	-.200	.100	.854	-.526	.126
	Second Wash	Third Wash	-.200	.100	.854	-.526	.126
		Fourth Wash	.000	.100	1.000	-.326	.326
		Fifth Wash	.300	.100	.093	-.026	.626
Colour		Before Wash	-.500*	.100	.001	-.826	-.174
		First Wash	1.110E-016	.100	1.000	-.326	.326
	Third Wash	Second Wash	.200	.100	.854	-.126	.526
		Fourth Wash	.200	.100	.854	-.126	.526
		Fifth Wash	.500*	.100	.001	.174	.826
		Before Wash	-.700*	.100	.000	-1.026	-.374
		First Wash	-.200	.100	.854	-.526	.126
	Fourth Wash	Second Wash	.000	.100	1.000	-.326	.326
		Third Wash	-.200	.100	.854	-.526	.126
		Fifth Wash	.300	.100	.093	-.026	.626
		Before Wash	-1.000*	.100	.000	-1.326	-.674
		First Wash	-.500*	.100	.001	-.826	-.174
	Fifth Wash	Second Wash	-.300	.100	.093	-.626	.026
		Third Wash	-.500*	.100	.001	-.826	-.174
		Fourth Wash	-.300	.100	.093	-.626	.026
		First Wash	.300*	.037	.000	.178	.422
		Second Wash	.310*	.037	.000	.188	.432
	Before Wash	Third Wash	.360*	.037	.000	.238	.482
DimenWarp		Fourth Wash	.440*	.037	.000	.318	.562
		Fifth Wash	.420*	.037	.000	.298	.542
	First Wash	Before Wash	-.300*	.037	.000	-.422	-.178
		Second Wash	.010	.037	1.000	-.112	.132

		Third Wash	.060	.037	1.000	-.062	.182
		Fourth Wash	.140*	.037	.015	.018	.262
		Fifth Wash	.120	.037	.057	-.002	.242
		Before Wash	-.310*	.037	.000	-.432	-.188
		First Wash	-.010	.037	1.000	-.132	.112
	Second Wash	Third Wash	.050	.037	1.000	-.072	.172
		Fourth Wash	.130*	.037	.029	.008	.252
		Fifth Wash	.110	.037	.107	-.012	.232
		Before Wash	-.360*	.037	.000	-.482	-.238
		First Wash	-.060	.037	1.000	-.182	.062
	Third Wash	Second Wash	-.050	.037	1.000	-.172	.072
		Fourth Wash	.080	.037	.643	-.042	.202
		Fifth Wash	.060	.037	1.000	-.062	.182
		Before Wash	-.440*	.037	.000	-.562	-.318
		First Wash	-.140*	.037	.015	-.262	-.018
	Fourth Wash	Second Wash	-.130*	.037	.029	-.252	-.008
		Third Wash	-.080	.037	.643	-.202	.042
		Fifth Wash	-.020	.037	1.000	-.142	.102
		Before Wash	-.420*	.037	.000	-.542	-.298
		First Wash	-.120	.037	.057	-.242	.002
	Fifth Wash	Second Wash	-.110	.037	.107	-.232	.012
		Third Wash	-.060	.037	1.000	-.182	.062
		Fourth Wash	.020	.037	1.000	-.102	.142
		First Wash	.320*	.061	.000	.121	.519
		Second Wash	.360*	.061	.000	.161	.559
	Before Wash	Third Wash	.280*	.061	.002	.081	.479
		Fourth Wash	.280*	.061	.002	.081	.479
		Fifth Wash	.380*	.061	.000	.181	.579
Dimenweft		Before Wash	-.320*	.061	.000	-.519	-.121
		Second Wash	.040	.061	1.000	-.159	.239
	First Wash	Third Wash	-.040	.061	1.000	-.239	.159
		Fourth Wash	-.040	.061	1.000	-.239	.159
		Fifth Wash	.060	.061	1.000	-.139	.259
		Before Wash	-.360*	.061	.000	-.559	-.161
		First Wash	-.040	.061	1.000	-.239	.159
	Second Wash	Third Wash	-.080	.061	1.000	-.279	.119
		Fourth Wash	-.080	.061	1.000	-.279	.119
		Fifth Wash	.020	.061	1.000	-.179	.219
		Before Wash	-.280*	.061	.002	-.479	-.081
		First Wash	.040	.061	1.000	-.159	.239
	Third Wash	Second Wash	.080	.061	1.000	-.119	.279
		Fourth Wash	.000	.061	1.000	-.199	.199
		Fifth Wash	.100	.061	1.000	-.099	.299
	Fourth Wash	Before Wash	-.280*	.061	.002	-.479	-.081

	First Wash	.040	.061	1.000	-.159	.239
	Second Wash	.080	.061	1.000	-.119	.279
	Third Wash	.000	.061	1.000	-.199	.199
	Fifth Wash	.100	.061	1.000	-.099	.299
	Before Wash	-.380*	.061	.000	-.579	-.181
	First Wash	-.060	.061	1.000	-.259	.139
Fifth Wash	Second Wash	-.020	.061	1.000	-.219	.179
	Third Wash	-.100	.061	1.000	-.299	.099
	Fourth Wash	-.100	.061	1.000	-.299	.099

Based on estimated marginal means

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

b. Adjustment for multiple comparisons: Bonferroni.

APPENDIX C

Tests of Between- Subjects Effects on the Effect of New Omo on GTP Adepa Dumas

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Force Warp	23106.567[a]	5	4621.313	.653	.662	.120
	Elong Warp	144.681[b]	5	28.936	42.480	.000	.898
	Force Weft	70778.247[c]	5	14155.649	4.596	.004	.489
	Elong Weft	893.068[d]	5	178.614	71.716	.000	.937
	Colour	3.200[e]	5	.640	13.964	.000	.744
	Dimen Warp	.320[f]	5	.064	8.533	.000	.640
	Dimen weft	.203[g]	5	.041	17.371	.000	.784
Intercept	Force Warp	7706400.833	1	7706400.83	1089.22	.000	.978
	Elong Warp	2763.072	1	2763.072	4056.31	.000	.994
	Force Weft	3544165.665	1	3544165.67	1150.67	.000	.980
	Elong Weft	20797.014	1	20797.014	8350.35	.000	.997
	Colour	554.700	1	554.700	12102.55	.000	.998
	Dimen Warp	2881.200	1	2881.200	384160.00	.000	1.000
	Dimen weft	2896.901	1	2896.901	1241529.14	.000	1.000
Washing Periods	Force Warp	23106.567	5	4621.313	.653	.662	.120
	Elong Warp	144.681	5	28.936	42.480	.000	.898
	Force Weft	70778.247	5	14155.649	4.596	.004	.489
	Elong Weft	893.068	5	178.614	71.716	.000	.937
	Colour	3.200	5	.640	13.964	.000	.744
	Dimen Warp	.320	5	.064	8.533	.000	.640
	Dimen weft	.203	5	.041	17.371	.000	.784
Error	Force Warp	169803.600	24	7075.150			
	Elong Warp	16.348	24	.681			
	Force Weft	73922.448	24	3080.102			
	Elong Weft	59.773	24	2.491			
	Colour	1.100	24	.046			

	Dimen Warp	.180	24	.008
	Dimen weft	.056	24	.002
Total	Force Warp	7899311.000	30	
	Elong Warp	2924.102	30	
	Force Weft	3688866.360	30	
	Elong Weft	21749.855	30	
	Colour	559.000	30	
	Dimen Warp	2881.700	30	
	Dimen weft	2897.160	30	
Corrected Total	ForceWarp	192910.167	29	
	ElongWarp	161.029	29	
	ForceWeft	144700.695	29	
	ElongWeft	952.842	29	
	Colour	4.300	29	
	DimenWarp	.500	29	
	Dimenweft	.259	29	

Bonferroni Pairwise Comparison on washing periods of the effect of New Omo on GTP Adepa Dumas

Dependent Variable	(I) Washing Periods	(J) Washing Periods	Mean Difference (I-J)	Std. Error	Sig.
ForceWarp	Before Wash	First Wash	-53.200	35.643	1.000
		Second Wash	-11.600	35.643	1.000
		Third Wash	.200	35.643	1.000
		Fourth Wash	-27.600	35.643	1.000
		Fifth Wash	11.200	35.643	1.000
	First Wash	Before Wash	53.200	35.643	1.000
		Second Wash	41.600	35.643	1.000
		Third Wash	53.400	35.643	1.000
		Fourth Wash	25.600	35.643	1.000
		Fifth Wash	64.400	35.643	1.000
	Second Wash	Before Wash	11.600	35.643	1.000
		First Wash	-41.600	35.643	1.000
		Third Wash	11.800	35.643	1.000
		Fourth Wash	-16.000	35.643	1.000
		Fifth Wash	22.800	35.643	1.000
	Third	Before Wash	-.200	35.643	1.000

	Wash	First Wash	-53.400	35.643	1.000
		Second Wash	-11.800	35.643	1.000
		Fourth Wash	-27.800	35.643	1.000
		Fifth Wash	11.000	35.643	1.000
	Fourth Wash	Before Wash	27.600	35.643	1.000
		First Wash	-25.600	35.643	1.000
		Second Wash	16.000	35.643	1.000
		Third Wash	27.800	35.643	1.000
		Fifth Wash	38.800	35.643	1.000
	Fifth Wash	Before Wash	-11.200	35.643	1.000
		First Wash	-64.400	35.643	1.000
		Second Wash	-22.800	35.643	1.000
		Third Wash	-11.000	35.643	1.000
		Fourth Wash	-38.800	35.643	1.000
ElongWarp	Before Wash	First Wash	-3.308*	.347	.000
		Second Wash	-2.978*	.347	.000
		Third Wash	-3.208*	.347	.000
		Fourth Wash	-2.978*	.347	.000
		Fifth Wash	2.308*	.347	.000
	First Wash	Before Wash	3.308*	.347	.000
		Second Wash	.330	.347	1.000
		Third Wash	.100	.347	1.000
		Fourth Wash	.330	.347	1.000
		Fifth Wash	5.616*	.347	.000
	Second Wash	Before Wash	2.978*	.347	.000
		First Wash	-.330	.347	1.000
		Third Wash	-.230	.347	1.000
		Fourth Wash	.000	.347	1.000
		Fifth Wash	5.286*	.347	.000
	Third Wash	Before Wash	3.208*	.347	.000
		First Wash	-.100	.347	1.000
		Second Wash	.230	.347	1.000
		Fourth Wash	.230	.347	1.000
		Fifth Wash	5.516*	.347	.000
	Fourth Wash	Before Wash	2.978*	.347	.000
		First Wash	-.330	.347	1.000
		Second Wash	.000	.347	1.000
		Third Wash	-.230	.347	1.000
		Fifth Wash	5.286*	.347	.000
	Fifth Wash	Before Wash	-2.308*	.347	.000
		First Wash	-5.616*	.347	.000
		Second Wash	-5.286*	.347	.000
		Third Wash	-5.516*	.347	.000
		Fourth Wash	-5.286*	.347	.000
ForceWeft	Before Wash	First Wash	31.600	24.767	1.000
		Second Wash	14.000	24.767	1.000

		Third Wash	70.200	24.767	.137
		Fourth Wash	32.600	24.767	1.000
		Fifth Wash	83.800*	24.767	.037
	First Wash	Before Wash	-31.600	24.767	1.000
		Second Wash	-17.600	24.767	1.000
		Third Wash	38.600	24.767	1.000
		Fourth Wash	1.000	24.767	1.000
		Fifth Wash	52.200	24.767	.685
	Second Wash	Before Wash	-14.000	24.767	1.000
		First Wash	17.600	24.767	1.000
		Third Wash	56.200	24.767	.488
		Fourth Wash	18.600	24.767	1.000
		Fifth Wash	69.800	24.767	.143
	Third Wash	Before Wash	-70.200	24.767	.137
		First Wash	-38.600	24.767	1.000
		Second Wash	-56.200	24.767	.488
		Fourth Wash	-37.600	24.767	1.000
		Fifth Wash	13.600	24.767	1.000
	Fourth Wash	Before Wash	-32.600	24.767	1.000
		First Wash	-1.000	24.767	1.000
		Second Wash	-18.600	24.767	1.000
		Third Wash	37.600	24.767	1.000
		Fifth Wash	51.200	24.767	.745
	Fifth Wash	Before Wash	-83.800*	24.767	.037
		First Wash	-52.200	24.767	.685
		Second Wash	-69.800	24.767	.143
		Third Wash	-13.600	24.767	1.000
		Fourth Wash	-51.200	24.767	.745
ElongWeft	Before Wash	First Wash	-.754	.782	1.000
		Second Wash	.196	.782	1.000
		Third Wash	.516	.782	1.000
		Fourth Wash	1.976	.782	.277
		Fifth Wash	15.018*	.782	.000
	First Wash	Before Wash	.754	.782	1.000
		Second Wash	.950	.782	1.000
		Third Wash	1.270	.782	1.000
		Fourth Wash	2.730*	.782	.028
		Fifth Wash	15.772*	.782	.000
	Second Wash	Before Wash	-.196	.782	1.000
		First Wash	-.950	.782	1.000
		Third Wash	.320	.782	1.000
		Fourth Wash	1.780	.782	.479
		Fifth Wash	14.822*	.782	.000
	Third Wash	Before Wash	-.516	.782	1.000
		First Wash	-1.270	.782	1.000
		Second Wash	-.320	.782	1.000

		Fourth Wash	1.460	.782	1.000
		Fifth Wash	14.502*	.782	.000
	Fourth Wash	Before Wash	-1.976	.782	.277
		First Wash	-2.730*	.782	.028
		Second Wash	-1.780	.782	.479
		Third Wash	-1.460	.782	1.000
		Fifth Wash	13.042*	.782	.000
	Fifth Wash	Before Wash	-15.018*	.782	.000
		First Wash	-15.772*	.782	.000
		Second Wash	-14.822*	.782	.000
		Third Wash	-14.502*	.782	.000
		Fourth Wash	-13.042*	.782	.000
Colour	Before Wash	First Wash	.700*	.157	.003
		Second Wash	.700*	.157	.003
		Third Wash	.700*	.157	.003
		Fourth Wash	.700*	.157	.003
		Fifth Wash	1.120*	.157	.000
	First Wash	Before Wash	-.700*	.157	.003
		Second Wash	5.551E-17	.157	1.000
		Third Wash	.000	.157	1.000
		Fourth Wash	.000	.157	1.000
		Fifth Wash	.420	.157	.202
	Second Wash	Before Wash	-.700*	.157	.003
		First Wash	-5.551E-17	.157	1.000
		Third Wash	-5.551E-17	.157	1.000
		Fourth Wash	-5.551E-17	.157	1.000
		Fifth Wash	.420	.157	.202
	Third Wash	Before Wash	-.700*	.157	.003
		First Wash	.000	.157	1.000
		Second Wash	5.551E-17	.157	1.000
		Fourth Wash	.000	.157	1.000
		Fifth Wash	.420	.157	.202
	Fourth Wash	Before Wash	-.700*	.157	.003
		First Wash	.000	.157	1.000
		Second Wash	5.551E-17	.157	1.000
		Third Wash	.000	.157	1.000
		Fifth Wash	.420	.157	.202
	Fifth Wash	Before Wash	-1.120*	.157	.000
		First Wash	-.420	.157	.202
		Second Wash	-.420	.157	.202
		Third Wash	-.420	.157	.202
		Fourth Wash	-.420	.157	.202
DimenWarp	Before Wash	First Wash	.180*	.034	.000
		Second Wash	.260*	.034	.000
		Third Wash	.220*	.034	.000
		Fourth Wash	.280*	.034	.000

		Fifth Wash	.280*	.034	.000
	First Wash	Before Wash	-.180*	.034	.000
		Second Wash	.080	.034	.402
		Third Wash	.040	.034	1.000
		Fourth Wash	.100	.034	.105
		Fifth Wash	.100	.034	.105
	Second Wash	Before Wash	-.260*	.034	.000
		First Wash	-.080	.034	.402
		Third Wash	-.040	.034	1.000
		Fourth Wash	.020	.034	1.000
		Fifth Wash	.020	.034	1.000
	Third Wash	Before Wash	-.220*	.034	.000
		First Wash	-.040	.034	1.000
		Second Wash	.040	.034	1.000
		Fourth Wash	.060	.034	1.000
		Fifth Wash	.060	.034	1.000
	Fourth Wash	Before Wash	-.280*	.034	.000
		First Wash	-.100	.034	.105
		Second Wash	-.020	.034	1.000
		Third Wash	-.060	.034	1.000
		Fifth Wash	6.058E-15	.034	1.000
	Fifth Wash	Before Wash	-.280*	.034	.000
		First Wash	-.100	.034	.105
		Second Wash	-.020	.034	1.000
		Third Wash	-.060	.034	1.000
		Fourth Wash	-6.058E-15	.034	1.000
Dimenweft	Before Wash	First Wash	.180*	.044	.006
		Second Wash	.260*	.044	.000
		Third Wash	.200*	.044	.002
		Fourth Wash	.220*	.044	.001
		Fifth Wash	.280*	.044	.000
	First Wash	Before Wash	-.180*	.044	.006
		Second Wash	.080	.044	1.000
		Third Wash	.020	.044	1.000
		Fourth Wash	.040	.044	1.000
		Fifth Wash	.100	.044	.483
	Second Wash	Before Wash	-.260*	.044	.000
		First Wash	-.080	.044	1.000
		Third Wash	-.060	.044	1.000
		Fourth Wash	-.040	.044	1.000
		Fifth Wash	.020	.044	1.000
	Third Wash	Before Wash	-.200*	.044	.002
		First Wash	-.020	.044	1.000
		Second Wash	.060	.044	1.000
		Fourth Wash	.020	.044	1.000
		Fifth Wash	.080	.044	1.000

Fourth Wash	Before Wash	-.220*	.044	.001
	First Wash	-.040	.044	1.000
	Second Wash	.040	.044	1.000
	Third Wash	-.020	.044	1.000
	Fifth Wash	.060	.044	1.000
Fifth Wash	Before Wash	-.280*	.044	.000
	First Wash	-.100	.044	.483
	Second Wash	-.020	.044	1.000
	Third Wash	-.080	.044	1.000
	Fourth Wash	-.060	.044	1.000

APPENDIX D

Tests of Between-Subjects Effects on the effect of New Omo on GTP Nustyle

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	ForceWarp	30374.800[a]	5	6074.960	.622	.684	.115
	ElongWarp	219.693[b]	5	43.939	2.602	.051	.351
	ForceWeft	71097.367[c]	5	14219.473	3.728	.012	.437
	ElongWeft	882.844[d]	5	176.569	21.601	.000	.818
	Colour	1.600[e]	5	.320	8.533	.000	.640
	DimenWarp	.539[f]	5	.108	24.877	.000	.838
	Dimenweft	.370[g]	5	.074	14.086	.000	.746
Intercept	ForceWarp	7681080.000	1	7681080.000	786.643	.000	.970
	ElongWarp	3947.974	1	3947.974	233.766	.000	.907
	ForceWeft	1757404.033	1	1757404.033	460.799	.000	.950
	ElongWeft	14557.865	1	14557.865	1780.983	.000	.987
	Colour	607.500	1	607.500	16200.000	.000	.999
	DimenWarp	2840.187	1	2840.187	655427.769	.000	1.000
	Dimenweft	2872.387	1	2872.387	547121.286	.000	1.000
WashingPeriods	ForceWarp	30374.800	5	6074.960	.622	.684	.115
	ElongWarp	219.693	5	43.939	2.602	.051	.351
	ForceWeft	71097.367	5	14219.473	3.728	.012	.437
	ElongWeft	882.844	5	176.569	21.601	.000	.818
	Colour	1.600	5	.320	8.533	.000	.640
	DimenWarp	.539	5	.108	24.877	.000	.838
	Dimenweft	.370	5	.074	14.086	.000	.746
Error	ForceWarp	234345.200	24	9764.383			
	ElongWarp	405.325	24	16.889			
	ForceWeft	91531.600	24	3813.817			
	ElongWeft	196.177	24	8.174			
	Colour	.900	24	.038			

	DimenWarp	.104	24	.004			
	Dimenweft	.126	24	.005			
	ForceWarp	7945800.000	30				
	ElongWarp	4572.992	30				
	ForceWeft	1920033.000	30				
Total	ElongWeft	15636.886	30				
	Colour	610.000	30				
	DimenWarp	2840.830	30				
	Dimenweft	2872.883	30				
	ForceWarp	264720.000	29				
	ElongWarp	625.018	29				
	ForceWeft	162628.967	29				
Corrected Total	ElongWeft	1079.022	29				
	Colour	2.500	29				
	DimenWarp	.643	29				
	Dimenweft	.496	29				

a. R Squared = .115 (Adjusted R Squared = -.070)
b. R Squared = .351 (Adjusted R Squared = .216)
c. R Squared = .437 (Adjusted R Squared = .320)
d. R Squared = .818 (Adjusted R Squared = .780)
e. R Squared = .640 (Adjusted R Squared = .565)
f. R Squared = .838 (Adjusted R Squared = .805)
g. R Squared = .746 (Adjusted R Squared = .693)

Pairwise Comparisons on washing periods of the effect of New Omo on GTP Nustyle

Dependent Variable	(I) WashingPeriods	(J) WashingPeriods	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
						Lower Bound	Upper Bound
ForceWarp	Before Wash	First Wash	-86.200	62.496	1.000	-289.836	117.436
		Second Wash	-23.800	62.496	1.000	-227.436	179.836
		Third Wash	-53.200	62.496	1.000	-256.836	150.436
		Fourth Wash	-77.800	62.496	1.000	-281.436	125.836
		Fifth Wash	-79.400	62.496	1.000	-283.036	124.236
	First Wash	Before Wash	86.200	62.496	1.000	-117.436	289.836
		Second Wash	62.400	62.496	1.000	-141.236	266.036
		Third Wash	33.000	62.496	1.000	-170.636	236.636
		Fourth Wash	8.400	62.496	1.000	-195.236	212.036
		Fifth Wash	6.800	62.496	1.000	-196.836	210.436
	Second Wash	Before Wash	23.800	62.496	1.000	-179.836	227.436
		First Wash	-62.400	62.496	1.000	-266.036	141.236
		Third Wash	-29.400	62.496	1.000	-233.036	174.236
		Fourth Wash	-54.000	62.496	1.000	-257.636	149.636
		Fifth Wash	-55.600	62.496	1.000	-259.236	148.036
	Third Wash	Before Wash	53.200	62.496	1.000	-150.436	256.836
		First Wash	-33.000	62.496	1.000	-236.636	170.636
		Second Wash	29.400	62.496	1.000	-174.236	233.036
		Fourth Wash	-24.600	62.496	1.000	-228.236	179.036
		Fifth Wash	-26.200	62.496	1.000	-229.836	177.436
	Fourth Wash	Before Wash	77.800	62.496	1.000	-125.836	281.436
		First Wash	-8.400	62.496	1.000	-212.036	195.236
		Second Wash	54.000	62.496	1.000	-149.636	257.636
		Third Wash	24.600	62.496	1.000	-179.036	228.236
		Fifth Wash	-1.600	62.496	1.000	-205.236	202.036

		Before Wash	79.400	62.496	1.000	-124.236	283.036
		First Wash	-6.800	62.496	1.000	-210.436	196.836
	Fifth Wash	Second Wash	55.600	62.496	1.000	-148.036	259.236
		Third Wash	26.200	62.496	1.000	-177.436	229.836
		Fourth Wash	1.600	62.496	1.000	-202.036	205.236
ElongWarp	Before Wash	First Wash	.850	2.599	1.000	-7.619	9.319
		Second Wash	-.040	2.599	1.000	-8.509	8.429
		Third Wash	-.070	2.599	1.000	-8.539	8.399
		Fourth Wash	-2.940	2.599	1.000	-11.409	5.529
		Fifth Wash	6.090	2.599	.416	-2.379	14.559
	First Wash	Before Wash	-.850	2.599	1.000	-9.319	7.619
		Second Wash	-.890	2.599	1.000	-9.359	7.579
		Third Wash	-.920	2.599	1.000	-9.389	7.549
		Fourth Wash	-3.790	2.599	1.000	-12.259	4.679
		Fifth Wash	5.240	2.599	.827	-3.229	13.709
	Second Wash	Before Wash	.040	2.599	1.000	-8.429	8.509
		First Wash	.890	2.599	1.000	-7.579	9.359
		Third Wash	-.030	2.599	1.000	-8.499	8.439
		Fourth Wash	-2.900	2.599	1.000	-11.369	5.569
		Fifth Wash	6.130	2.599	.402	-2.339	14.599
	Third Wash	Before Wash	.070	2.599	1.000	-8.399	8.539
		First Wash	.920	2.599	1.000	-7.549	9.389
		Second Wash	.030	2.599	1.000	-8.439	8.499
		Fourth Wash	-2.870	2.599	1.000	-11.339	5.599
		Fifth Wash	6.160	2.599	.393	-2.309	14.629
	Fourth Wash	Before Wash	2.940	2.599	1.000	-5.529	11.409
		First Wash	3.790	2.599	1.000	-4.679	12.259
		Second Wash	2.900	2.599	1.000	-5.569	11.369
		Third Wash	2.870	2.599	1.000	-5.599	11.339

		Fifth Wash	9.030*	2.599	.029	.561	17.499
		Before Wash	-6.090	2.599	.416	-14.559	2.379
		First Wash	-5.240	2.599	.827	-13.709	3.229
	Fifth Wash	Second Wash	-6.130	2.599	.402	-14.599	2.339
		Third Wash	-6.160	2.599	.393	-14.629	2.309
		Fourth Wash	-9.030*	2.599	.029	-17.499	-.561
		First Wash	-.200	39.058	1.000	-127.466	127.066
		Second Wash	-123.600	39.058	.063	-250.866	3.666
	Before Wash	Third Wash	15.800	39.058	1.000	-111.466	143.066
		Fourth Wash	9.000	39.058	1.000	-118.266	136.266
		Fifth Wash	6.400	39.058	1.000	-120.866	133.666
		Before Wash	.200	39.058	1.000	-127.066	127.466
		Second Wash	-123.400	39.058	.064	-250.666	3.866
	First Wash	Third Wash	16.000	39.058	1.000	-111.266	143.266
		Fourth Wash	9.200	39.058	1.000	-118.066	136.466
		Fifth Wash	6.600	39.058	1.000	-120.666	133.866
		Before Wash	123.600	39.058	.063	-3.666	250.866
ForceWeft		First Wash	123.400	39.058	.064	-3.866	250.666
	Second Wash	Third Wash	139.400*	39.058	.023	12.134	266.666
		Fourth Wash	132.600*	39.058	.036	5.334	259.866
		Fifth Wash	130.000*	39.058	.042	2.734	257.266
		Before Wash	-15.800	39.058	1.000	-143.066	111.466
		First Wash	-16.000	39.058	1.000	-143.266	111.266
	Third Wash	Second Wash	-139.400*	39.058	.023	-266.666	-12.134
		Fourth Wash	-6.800	39.058	1.000	-134.066	120.466
		Fifth Wash	-9.400	39.058	1.000	-136.666	117.866
		Before Wash	-9.000	39.058	1.000	-136.266	118.266
	Fourth Wash	First Wash	-9.200	39.058	1.000	-136.466	118.066
		Second Wash	-132.600*	39.058	.036	-259.866	-5.334

		Third Wash	6.800	39.058	1.000	-120.466	134.066
		Fifth Wash	-2.600	39.058	1.000	-129.866	124.666
		Before Wash	-6.400	39.058	1.000	-133.666	120.866
		First Wash	-6.600	39.058	1.000	-133.866	120.666
	Fifth Wash	Second Wash	-130.000*	39.058	.042	-257.266	-2.734
		Third Wash	9.400	39.058	1.000	-117.866	136.666
		Fourth Wash	2.600	39.058	1.000	-124.666	129.866
		First Wash	2.580	1.808	1.000	-3.312	8.472
		Second Wash	5.250	1.808	.117	-.642	11.142
	Before Wash	Third Wash	1.960	1.808	1.000	-3.932	7.852
		Fourth Wash	5.200	1.808	.125	-.692	11.092
		Fifth Wash	16.698*	1.808	.000	10.806	22.590
		Before Wash	-2.580	1.808	1.000	-8.472	3.312
		Second Wash	2.670	1.808	1.000	-3.222	8.562
	First Wash	Third Wash	-.620	1.808	1.000	-6.512	5.272
		Fourth Wash	2.620	1.808	1.000	-3.272	8.512
		Fifth Wash	14.118*	1.808	.000	8.226	20.010
ElongWeft		Before Wash	-5.250	1.808	.117	-11.142	.642
		First Wash	-2.670	1.808	1.000	-8.562	3.222
	Second Wash	Third Wash	-3.290	1.808	1.000	-9.182	2.602
		Fourth Wash	-.050	1.808	1.000	-5.942	5.842
		Fifth Wash	11.448*	1.808	.000	5.556	17.340
		Before Wash	-1.960	1.808	1.000	-7.852	3.932
		First Wash	.620	1.808	1.000	-5.272	6.512
	Third Wash	Second Wash	3.290	1.808	1.000	-2.602	9.182
		Fourth Wash	3.240	1.808	1.000	-2.652	9.132
		Fifth Wash	14.738*	1.808	.000	8.846	20.630
	Fourth Wash	Before Wash	-5.200	1.808	.125	-11.092	.692
		First Wash	-2.620	1.808	1.000	-8.512	3.272

		Second Wash	.050	1.808	1.000	-5.842	5.942
		Third Wash	-3.240	1.808	1.000	-9.132	2.652
		Fifth Wash	11.498*	1.808	.000	5.606	17.390
		Before Wash	-16.698*	1.808	.000	-22.590	-10.806
		First Wash	-14.118*	1.808	.000	-20.010	-8.226
	Fifth Wash	Second Wash	-11.448*	1.808	.000	-17.340	-5.556
		Third Wash	-14.738*	1.808	.000	-20.630	-8.846
		Fourth Wash	-11.498*	1.808	.000	-17.390	-5.606
		First Wash	.600*	.122	.001	.201	.999
		Second Wash	.600*	.122	.001	.201	.999
	Before Wash	Third Wash	.500*	.122	.006	.101	.899
		Fourth Wash	.600*	.122	.001	.201	.999
		Fifth Wash	.700*	.122	.000	.301	1.099
		Before Wash	-.600*	.122	.001	-.999	-.201
		Second Wash	1.388E-017	.122	1.000	-.399	.399
	First Wash	Third Wash	-.100	.122	1.000	-.499	.299
		Fourth Wash	1.388E-017	.122	1.000	-.399	.399
		Fifth Wash	.100	.122	1.000	-.299	.499
Colour		Before Wash	-.600*	.122	.001	-.999	-.201
		First Wash	-1.388E-017	.122	1.000	-.399	.399
	Second Wash	Third Wash	-.100	.122	1.000	-.499	.299
		Fourth Wash	.000	.122	1.000	-.399	.399
		Fifth Wash	.100	.122	1.000	-.299	.499
		Before Wash	-.500*	.122	.006	-.899	-.101
		First Wash	.100	.122	1.000	-.299	.499
	Third Wash	Second Wash	.100	.122	1.000	-.299	.499
		Fourth Wash	.100	.122	1.000	-.299	.499
		Fifth Wash	.200	.122	1.000	-.199	.599
	Fourth Wash	Before Wash	-.600*	.122	.001	-.999	-.201

		First Wash	-1.388E-017	.122	1.000	-.399	.399
		Second Wash	.000	.122	1.000	-.399	.399
		Third Wash	-.100	.122	1.000	-.499	.299
		Fifth Wash	.100	.122	1.000	-.299	.499
	Fifth Wash	Before Wash	-.700*	.122	.000	-1.099	-.301
		First Wash	-.100	.122	1.000	-.499	.299
		Second Wash	-.100	.122	1.000	-.499	.299
		Third Wash	-.200	.122	1.000	-.599	.199
		Fourth Wash	-.100	.122	1.000	-.499	.299
	Before Wash	First Wash	.280*	.042	.000	.144	.416
		Second Wash	.300*	.042	.000	.164	.436
		Third Wash	.340*	.042	.000	.204	.476
		Fourth Wash	.440*	.042	.000	.304	.576
		Fifth Wash	.260*	.042	.000	.124	.396
	First Wash	Before Wash	-.280*	.042	.000	-.416	-.144
		Second Wash	.020	.042	1.000	-.116	.156
		Third Wash	.060	.042	1.000	-.076	.196
		Fourth Wash	.160*	.042	.012	.024	.296
DimenWarp		Fifth Wash	-.020	.042	1.000	-.156	.116
	Second Wash	Before Wash	-.300*	.042	.000	-.436	-.164
		First Wash	-.020	.042	1.000	-.156	.116
		Third Wash	.040	.042	1.000	-.096	.176
		Fourth Wash	.140*	.042	.039	.004	.276
		Fifth Wash	-.040	.042	1.000	-.176	.096
	Third Wash	Before Wash	-.340*	.042	.000	-.476	-.204
		First Wash	-.060	.042	1.000	-.196	.076
		Second Wash	-.040	.042	1.000	-.176	.096
		Fourth Wash	.100	.042	.366	-.036	.236
		Fifth Wash	-.080	.042	.999	-.216	.056

		Before Wash	-.440*	.042	.000	-.576	-.304
		First Wash	-.160*	.042	.012	-.296	-.024
	Fourth Wash	Second Wash	-.140*	.042	.039	-.276	-.004
		Third Wash	-.100	.042	.366	-.236	.036
		Fifth Wash	-.180*	.042	.003	-.316	-.044
		Before Wash	-.260*	.042	.000	-.396	-.124
		First Wash	.020	.042	1.000	-.116	.156
	Fifth Wash	Second Wash	.040	.042	1.000	-.096	.176
		Third Wash	.080	.042	.999	-.056	.216
		Fourth Wash	.180*	.042	.003	.044	.316
		First Wash	.200*	.046	.003	.051	.349
		Second Wash	.290*	.046	.000	.141	.439
	Before Wash	Third Wash	.200*	.046	.003	.051	.349
		Fourth Wash	.240*	.046	.000	.091	.389
		Fifth Wash	.360*	.046	.000	.211	.509
		Before Wash	-.200*	.046	.003	-.349	-.051
		Second Wash	.090	.046	.918	-.059	.239
	First Wash	Third Wash	.000	.046	1.000	-.149	.149
		Fourth Wash	.040	.046	1.000	-.109	.189
Dimenweft		Fifth Wash	.160*	.046	.028	.011	.309
		Before Wash	-.290*	.046	.000	-.439	-.141
		First Wash	-.090	.046	.918	-.239	.059
	Second Wash	Third Wash	-.090	.046	.918	-.239	.059
		Fourth Wash	-.050	.046	1.000	-.199	.099
		Fifth Wash	.070	.046	1.000	-.079	.219
		Before Wash	-.200*	.046	.003	-.349	-.051
	Third Wash	First Wash	.000	.046	1.000	-.149	.149
		Second Wash	.090	.046	.918	-.059	.239
		Fourth Wash	.040	.046	1.000	-.109	.189

		Fifth Wash	.160*	.046	.028	.011	.309
		Before Wash	-.240*	.046	.000	-.389	-.091
		First Wash	-.040	.046	1.000	-.189	.109
	Fourth Wash	Second Wash	.050	.046	1.000	-.099	.199
		Third Wash	-.040	.046	1.000	-.189	.109
		Fifth Wash	.120	.046	.226	-.029	.269
		Before Wash	-.360*	.046	.000	-.509	-.211
		First Wash	-.160*	.046	.028	-.309	-.011
	Fifth Wash	Second Wash	-.070	.046	1.000	-.219	.079
		Third Wash	-.160*	.046	.028	-.309	-.011
		Fourth Wash	-.120	.046	.226	-.269	.029

Based on estimated marginal means

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

b. Adjustment for multiple comparisons: Bonferroni.

APPENDIX E

Pairwise Comparisons of Differences in Effect Between Key Soap and New Omo on GTP Adepa Dumas

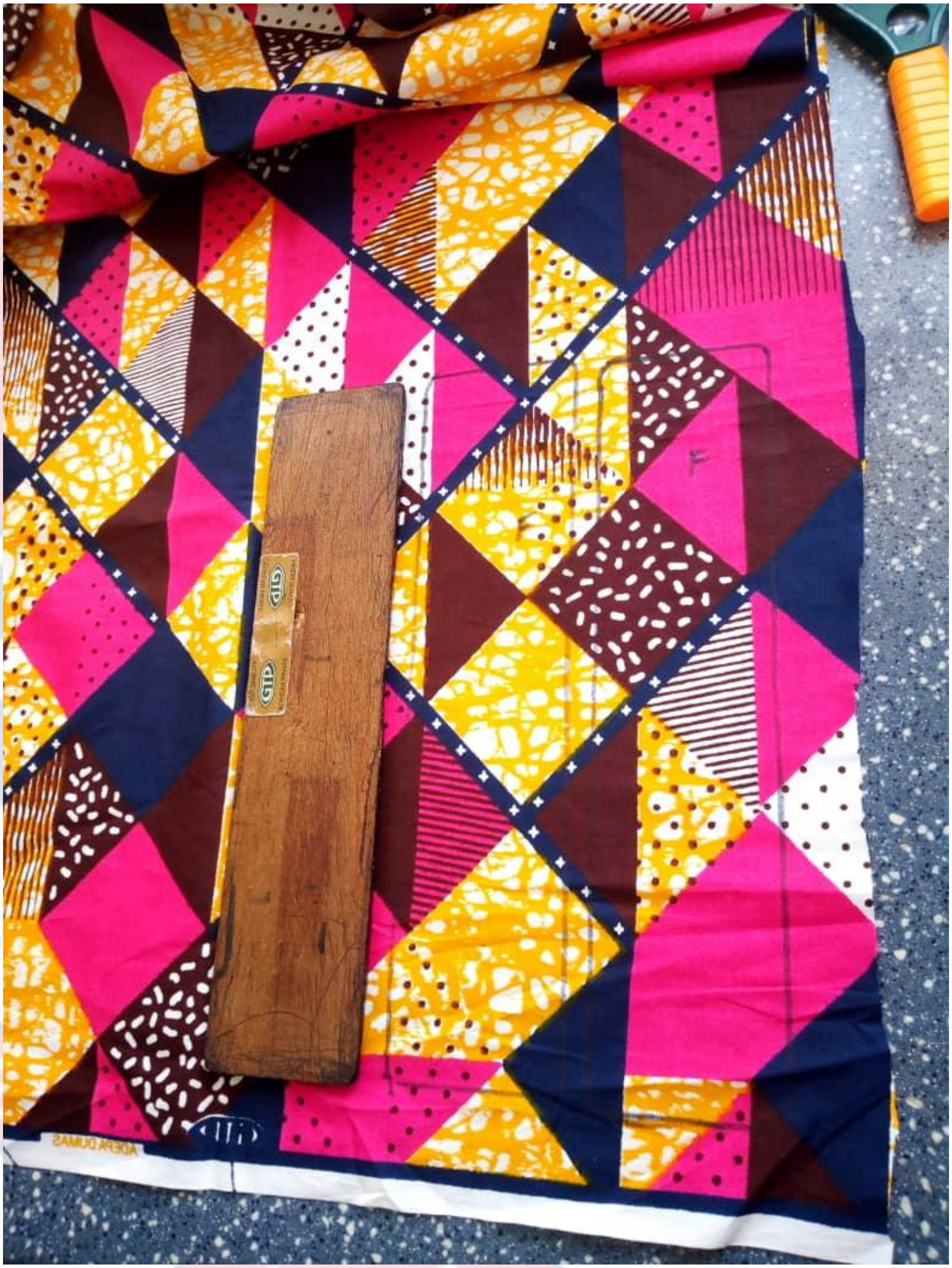
Dependent Variable	(I) Soap	(J) Soap	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
ForceWarp	Keysoap	Omo	-3.440	21.097	.871	-46.079	39.199
	Omo	Keysoap	3.440	21.097	.871	-39.199	46.079
ElongWarp	Keysoap	Omo	-.143	.202	.483	-.550	.265
	Omo	Keysoap	.143	.202	.483	-.265	.550
ForceWeft	Keysoap	Omo	-18.224	14.649	.221	-47.831	11.383
	Omo	Keysoap	18.224	14.649	.221	-11.383	47.831
ElongWeft	Keysoap	Omo	-.050	.432	.909	-.923	.824
	Omo	Keysoap	.050	.432	.909	-.824	.923
Colour	Keysoap	Omo	-.056	.072	.441	-.201	.089
	Omo	Keysoap	.056	.072	.441	-.089	.201
DimenWarp	Keysoap	Omo	.004	.022	.859	-.041	.049
	Omo	Keysoap	-.004	.022	.859	-.049	.041
Dimenweft	Keysoap	Omo	.020	.019	.287	-.017	.057
	Omo	Keysoap	-.020	.019	.287	-.057	.017

Based on estimated marginal means
a. Adjustment for multiple comparisons: Bonferroni.

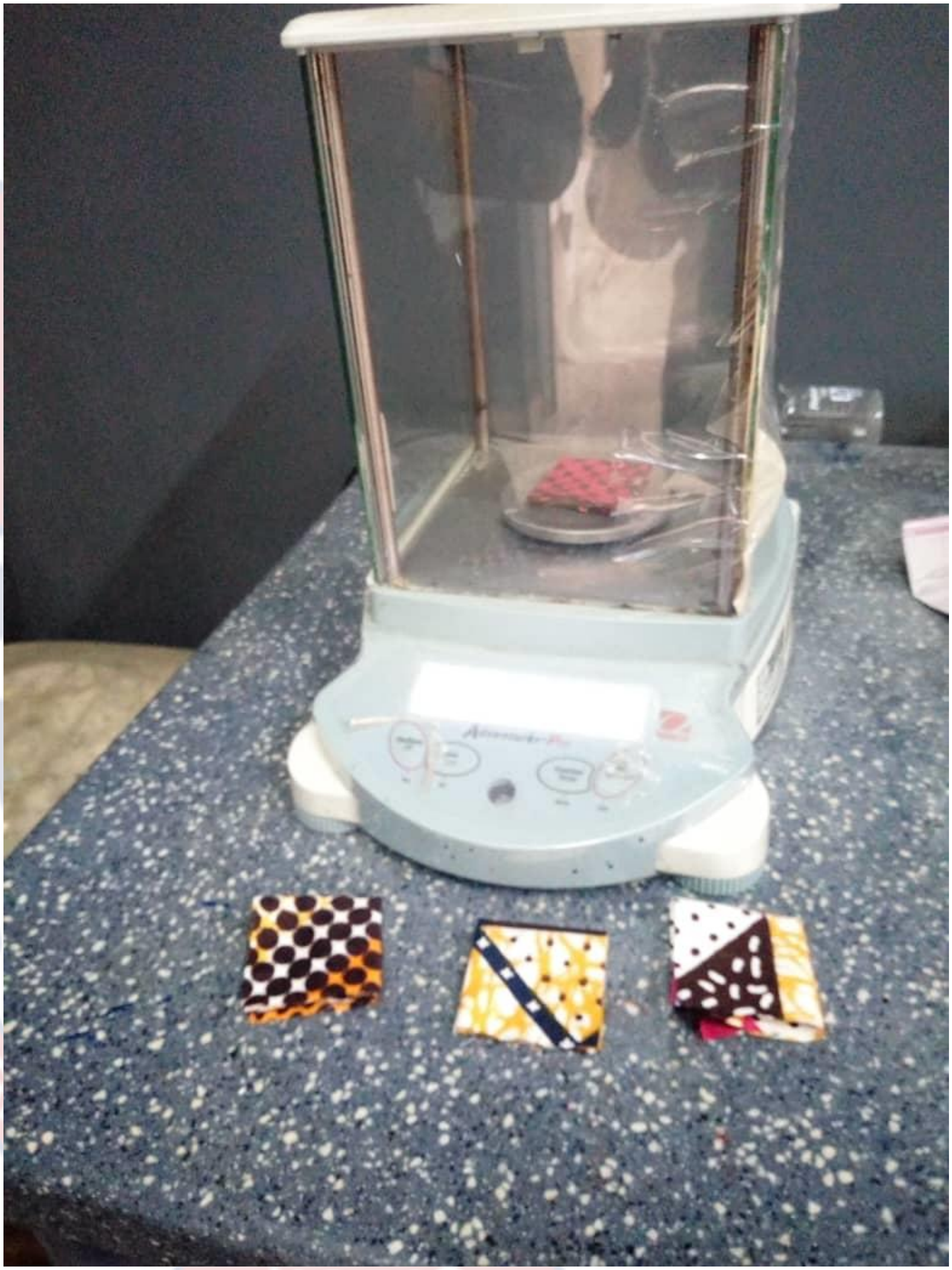
APPENDIX F

Pictures of Work Proceedings

Identifying weave type with the hand magnifying glass (eye piece)

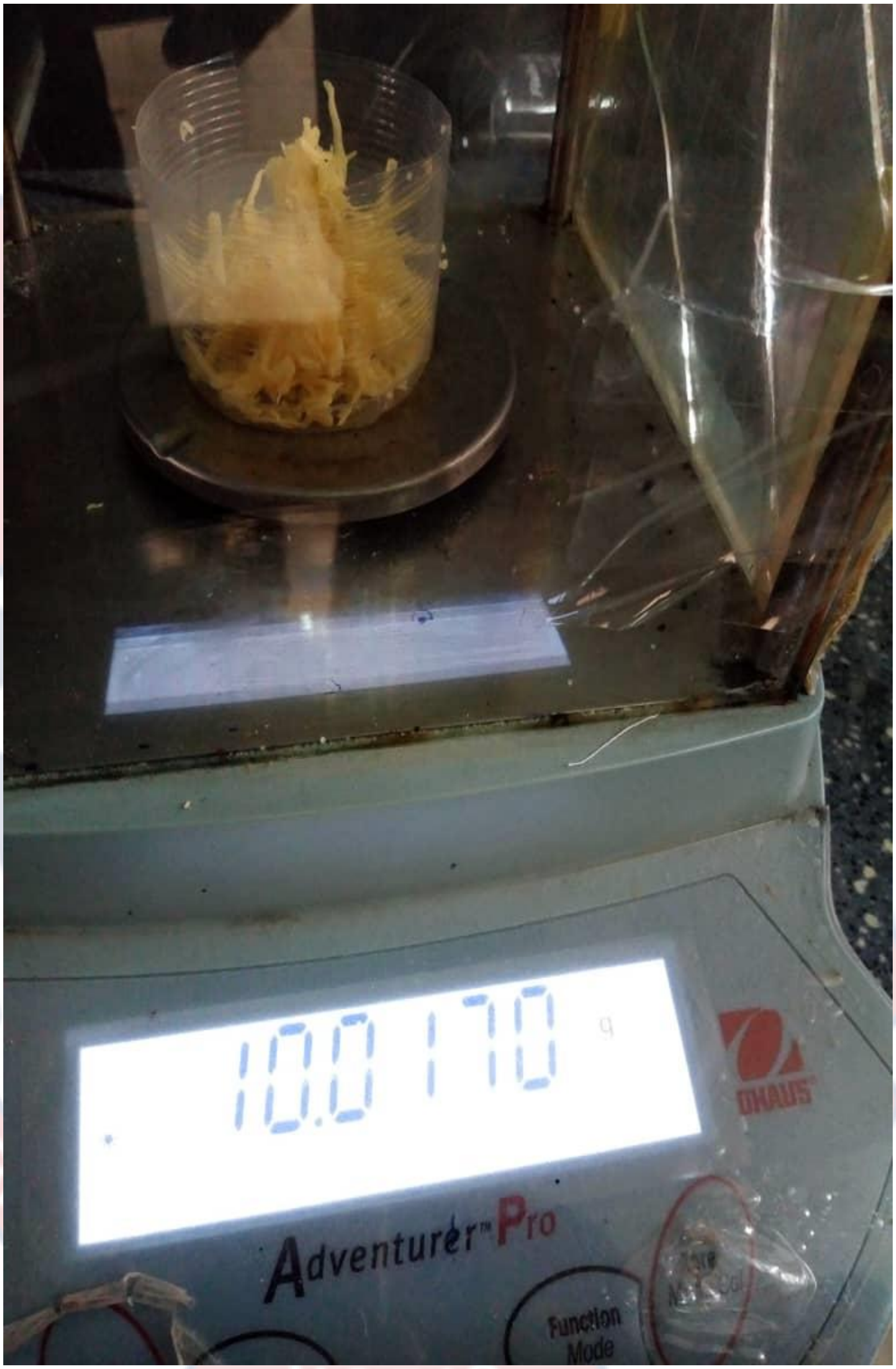


Demarcation of specimens with the pattern maker to be cut for tensile strength testing

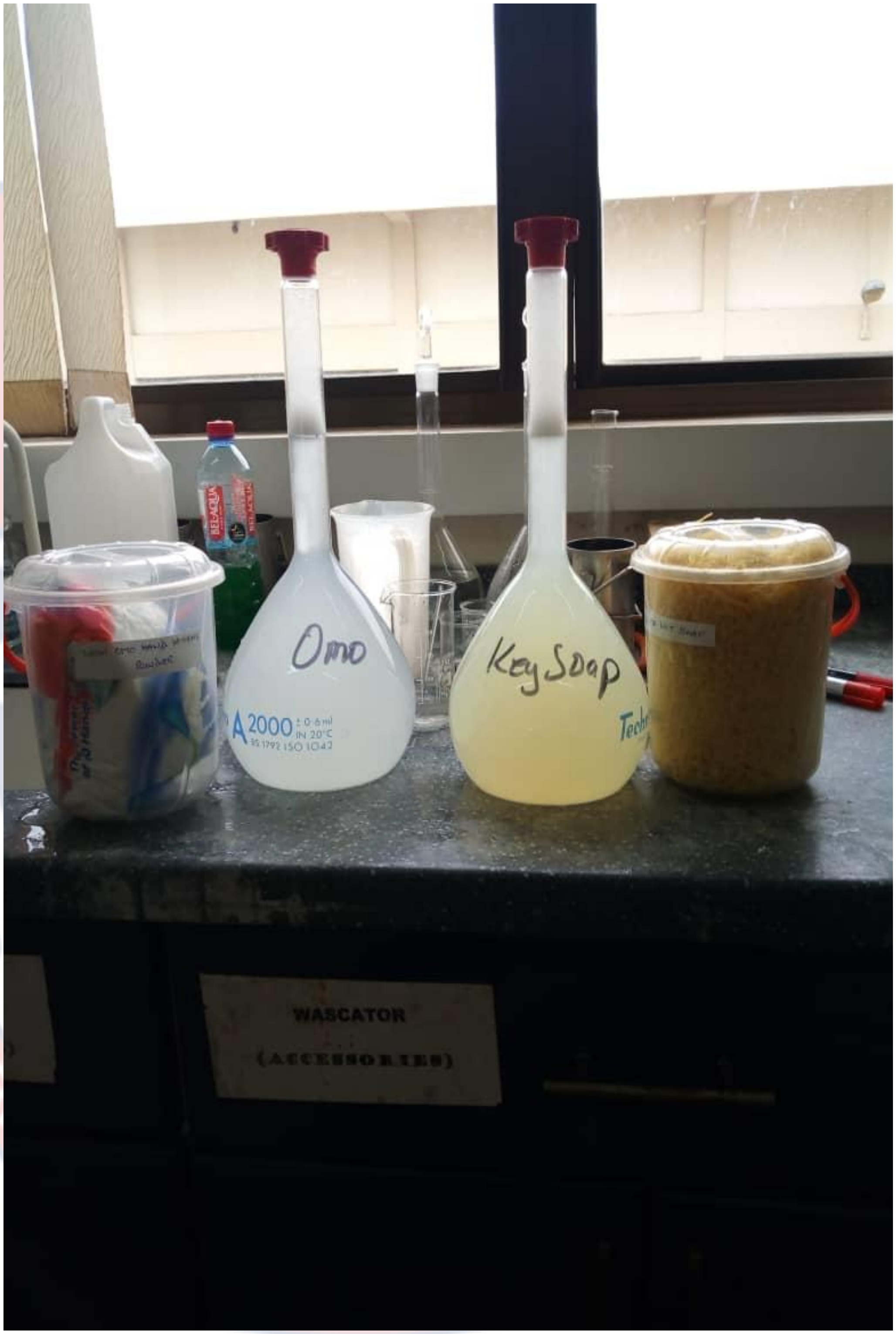


Weighing of specimens with an electronic balance scale

Yarn Count of Specimen



Weighing of soap with an electronic balance scale MN: SSLI (SN: R000100194)



Stock of Key Soap and New Omo Washing Solutions

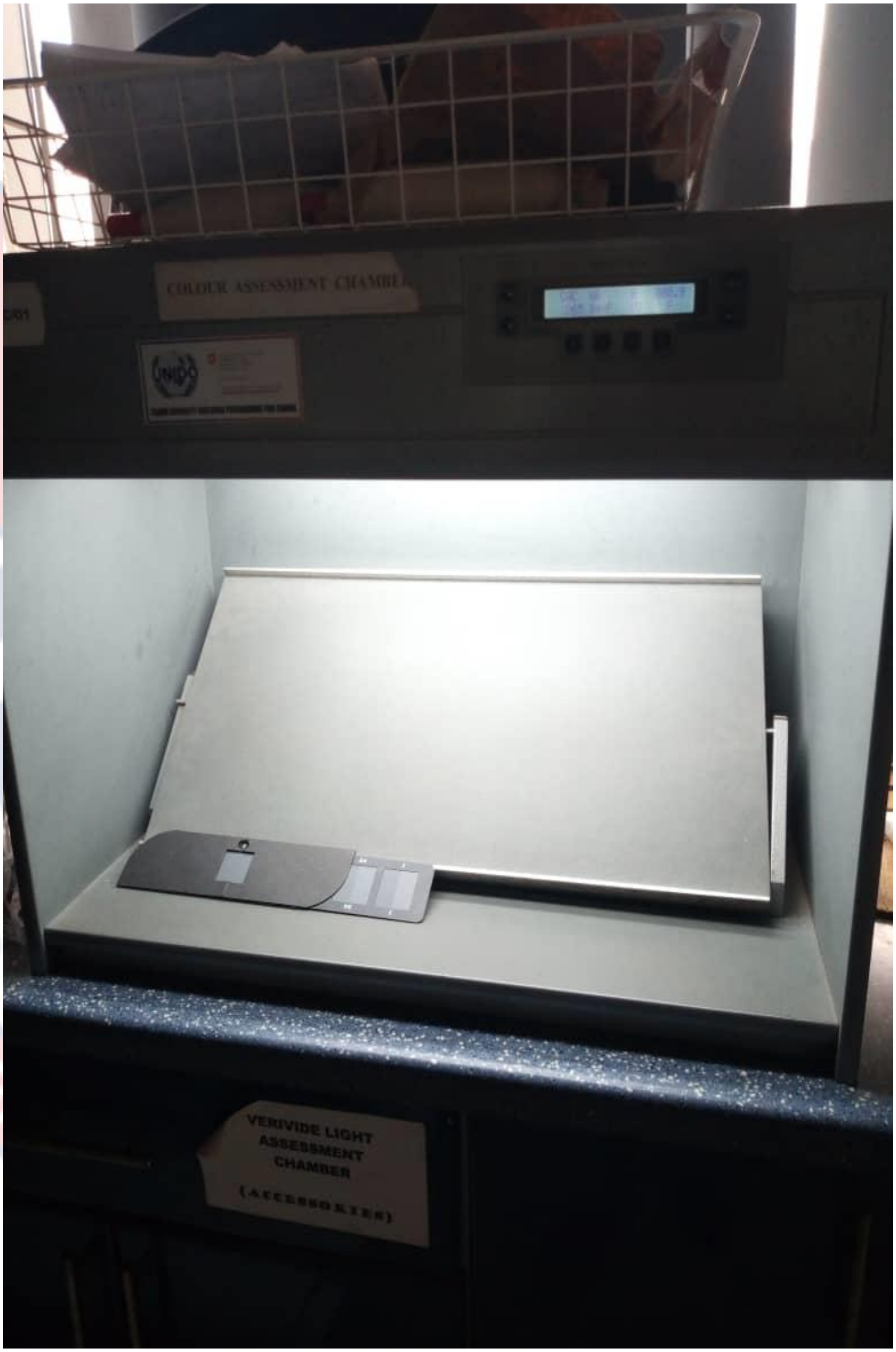
Filled Washing Cylinders with Specimens

Rinsing of Washed Specimens

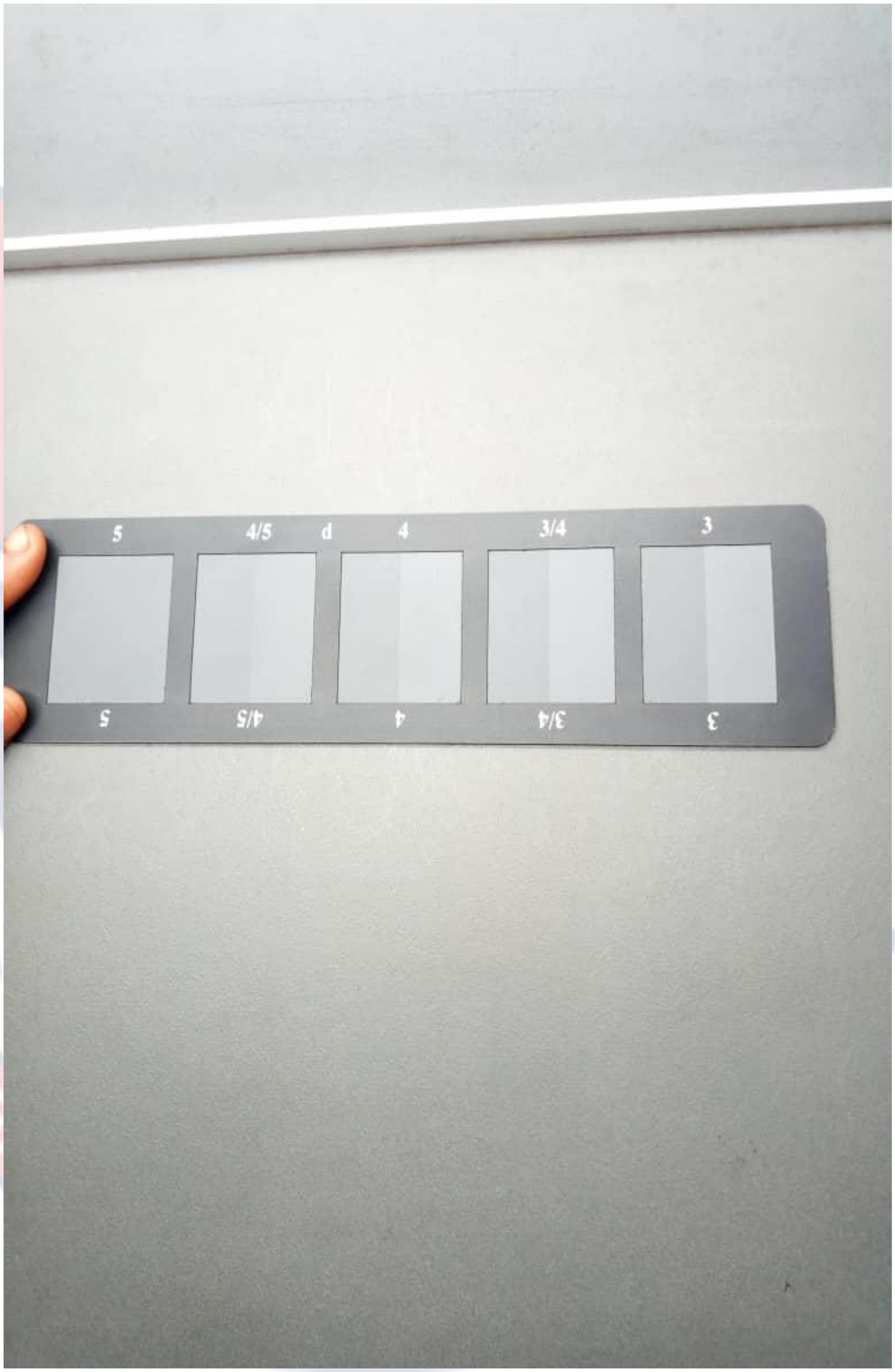
Drying of Washed Specimens on a Cloth Rack

Testing of tensile strength of specimens with Hounsfield H5OKT

Assessing the colourof specimens with the assessment colour chamber and a geometric grey scale



Colour Assessment Chamber



Geometric Grey Scale

A Standard Launder-Ometer (Gyrowash SN: 315/8/98/5040)

APPENDIX G

UNIVERSITY OF CAPE COAST

INSTITUTIONAL REVIEW BOARD SECRETARIAT

TEL: 0558093143 / 0508878309/ 0244207814
C/O Directorate of Research, Innovation and Consultancy
E-MAIL: irb@ucc.edu.gh
OUR REF: UCC/IRB/A/2016/669
YOUR REF:
OMB NO: 0990-0279
IORG #: IORG0009096

29TH MAY, 2020

Ms. Barbara Osekre
Department of Vocational and Technical Education
University of Cape Coast

Dear Ms. Osekre,

ETHICAL CLEARANCE – ID (UCCIRB/CES/2020/20)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted **Provisional Approval** for the implementation of your research protocol titled **Effect of Keysoap and New Omo on Colourfastness, Tensile Strength and Dimensional Stability of GTP Adepa Dumas and GTP Nustyle Wax Print.** This approval is valid from 29th May, 2020 to 28th May, 2021. You may apply for a renewal subject to submission of all the required documents that will be prescribed by the UCCIRB.

Please note that any modification to the project must be submitted to the UCCIRB for review and approval before its implementation. You are required to submit periodic review of the protocol to the Board and a final full review to the UCCIRB on completion of the research. The UCCIRB may observe or cause to be observed procedures and records of the research during and after implementation.

You are also required to report all serious adverse events related to this study to the UCCIRB within seven days verbally and fourteen days in writing.

Always quote the protocol identification number in all future correspondence with us in relation to this protocol.

Yours faithfully,

Samuel Asiedu Owusu, PhD
UCCIRB Administrator

ADMINISTRATOR
INSTITUTIONAL REVIEW BOARD
UNIVERSITY OF CAPE COAST