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EFFECT OF POTATO AND CORN STARCH ON PLAIN WOVEN FABRIC PRODUCTIVITY IN KTSC

Bahir Dar University

Ethiopian Institute of Textile And Fashion Technology

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EFFECT OF POTATO AND CORN STARCH ON PLAIN WOVEN FABRIC PRODUCTIVITY IN KTSC

By

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In

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Asst.Prof Ayano Koryita

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ADVISORS' APPROVAL SHEET

ETHIOPIAN INSTITUTE OF TEXTILE AND FASHION TECHNOLOGY (EiTEX) POST GRADUATE OFFICE

This is to certify that the thesis title "study the effect of potato and corn starch on productivity in KTSC'' Submitted in partial fulfillment of the requirements for the degree of masters with specialization in Textile Education the post graduate program of the Ethiopian institute of textile and fashion technology and has been carried out by Yonatan Debashu ID. No. MTT/S/015/07 under my/our supervision, therefore, I/we recommend that the student fulfilled the requirements and hence hereby can submit the thesis to the institute.

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APPROVAL PAGE

I certify that I have supervised /read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in quality and scope, as a thesis for the fulfillment of the requirements for the degree of masters of Textile Education.

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(Examination Committee Member)

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DECLARATION

I hereby declare that the thesis is submitted in the fulfillment of the Master's degree is my own work and that all contributions from any other persons or sources are properly and duly cited. I further declare that the material has not been submitted either in whole or in part, for a degree at this or any other university in making this declaration, I understand and acknowledge any breaches in this declaration constitute academic misconducts, which may result in my expulsion from the program me and/or exclusion from the award of degree.

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Date:

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ABSTRACT

Weaving efficiency is greatly affected by the warp yarns strength and other properties. To improve these warp yarn properties, sizing is done with various agents either natural or synthetic sizing materials. Most of the natural sizing agents used in the industry is made of starch. Starch used is obtained from different sources with different properties. For this reason, there is the need to compare different sources of starch with and without PVA for their competitiveness.

In this study two starches: potato and corn have been comparatively studied for their performance on sized yarn. Ring spun cotton yarn of 34 Nm was sized using the starches and its properties studied. The properties of the constructed fabric in terms of tensile strength, elongation, abrasion resistance and size removal percentage after desizing were also studied. End breakage rate on the loom was observed to check the weaving efficiency.

From the results it was seen that the tensile strength, strength gain and abrasion resistance of yarns sized with potato starches without PVA was higher. Size removal percentage of yarns sized with potato starches with PVA was higher. Corn starch without PVA showed better result on elongation at break. Corn starch with PVA sized yarns performance was lower on overall properties and end breakage rate on loom. Yarns sized with Potato starch without PVA showed better overall performance properties and it is cost effective while corn starch showed lower performance properties and it is not cost effective.

Key words: Native Starch, Potato Starch, Corn Starch, PVA, Viscosity, Sizing

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LIST OF ABBRIVATION

EITEX--------------Ethiopian institute of textiles and fashion technology

BDU----------------Bahir Dar University

GSM---------------Grams per meter square

CSC---------------Centistokes

Kg-----------------Kilograms

ASTM------------American standards for testing materials

KTSC-------------Kombolcha textile Share Company

Nacl---------------Sodium chloride

g/l-----------------Gram per litre

MLR-------------Material liquor ratio

PVA--------------Polyvinyl alcohol

CMC-------------Carboximethyl cellulose

TPm--------------Twist per meter

Kpa---------------Kilopascal

Owf ---------------own weight of fabric

EPC----------------Ends per centimeter

PPC----------------picks per centimeter

W/W---------------Weight by Weight

BOD--------------- Biological Oxygen Demand

SPSS--------------- Stastical Package for Social Sciences

CHAPTER ONE

INTRODUCTION

1.1 Background

The old adage that sizing is the heart of weaving still holds good today. This statement is all the more important in today's environment when loom speeds have increased tenfold from those used in shuttle looms. The weaving process depends upon a complexity of factors which include the material characteristics, the sizing ingredients, the sizing operation, and the yarn parameters.

Sizing is a process where film forming polymer is applied to provide temporary protection to the warp yarns from abrasive and other types of stresses generated on the weaving machine in order to reduce the warp breakages .Sizing help in forming coating which encapsulates the yarn embeds the protruding fibers and also cause some inter fiber binding by penetration(P.G. Dumitras, 2004) .The performance of warp yarn largely depend on the nature of protective coating applied and its interaction with fiber substrate(Goswami, 2004).

Starches from different botanic groups can differ in their granule shape and size, amount of amylose and amylopectin, proportion of lipids and phosphates and others. These properties can affect the physico mechanical properties of starches which in turn can affect their functional properties.

The sizing process can affect productivity of weave room. It imparts strength and improves abrasion resistance of warp yarn by coating a thin film of size ingredients so that it can withstand against several actions subjected to during weaving process i.e. cyclic strain, flexing abrasion at various loom parts and inter yarn friction (P.R.Patel, 2013).

The selection, evaluation, and performance of the warp (yarn/size system) for any specific fabric sett and the loom must be determined in the context of the developments and changes that have occurred in the spinning/winding/ warping and the slashing processes.

Starch has a long history of being used as a sizing agent in the textile industry. It has been the most popular and economic size material. Synthetic sizing materials have restrictions in use mainly because of ecological reasons therefore the natural starches are preferable ones (BK behera, 1994; Malin E. Karlsson 2007).

1.2 Justification

Scientific research and technological developments in the weaving field worldwide have always followed the fundamental goals of providing improvements in the process and product qualities and producing efficiently a great variety of products for consumption. Weaving is the most predominant method of producing cotton textile fabrics. Approximately 80% of cotton produced world wide is used in woven fabrics. In the weaving process, the warp yarns on a loom undergo extremely harsh mechanical actions of repeated stresses and strains as well as substantial abrasion due to friction. (KusumLata, 2012)

As a result yarn would develop a significant amount of hairiness (projecting fibers), which would hinder satisfactory fabric formation.

This is due to generation of lint, formation of balls in dense warps, inter fiber clinging and inter yarn entanglements, and, consequently leading to yarn breakages, loom stoppages, and, hence, production and quality interruptions. To avoid these problems during weaving, the warp yarns have always been coated with a thin strong film of a suitable adhesive, generally any ordinary or modified starch (P.G. Dumitras, 2004).

In textile processing, except for filament yarns, most warp yarns need to be sized before weaving. During weaving, warp yarns experience 3000-5000 times repeated stretching, inflection and abrasion and as a consequence are susceptible to breakage (BK behera, 1994). Breaking of warp yarns during weaving causes loom stoppages decreasing productivity and creating fabric defects.

1.3 Statement of problem

Different companies use different natural starches for warp sizing and even the same company uses different natural starches at different time. But there is no enough data about the performance of different natural starches on sized yarn and companies are challenged in selection of sizing starches. Starches are widely studied by different professionals but there is research gap regarding the performance evaluation of different starches on textile application especially on sized yarn properties. The process of evaluating sized yarns, sizing ingredients, and various size formulations by an actual weaving trial, is not practicable since it is time consuming, risky, and prohibitively expensive. Some other means of assessment and criteria ultimately linked to weaveability will have to be developed. The criteria used should yield maximal and reliable information, yet should be sufficiently quick to assess. To assess the efficiency of a variety of size formulations and the effect of slashing variables under a wide range of weaving conditions, it is imperative that a laboratory evaluation system is established(P.R.Patel, 2013).

Therefore this study is aimed at helping mainly Ethiopian textile companies and starch manufacturers by giving the right information about the performance of yarn sized with the common types of native starches keeping the other parameters constant.

1.4 Research Purpose and Objectives

1.4.1 Research Purpose

The purpose of this thesis is to explore how different sizing chemicals would affect the productivity in weaving mills.

1.4.2 General Objective

To identify natural starch that brings better sized yarn properties and performance among the common natural starches.

1.4.3 Specific Objectives

- ❖ To Study the productivity by stoppages, warp breakage per shift
- ❖ Testing rate of warp yarn breakage during weaving
- ❖ To study tensile strength and elongation of yarn and fabric sized with potato and Corn starches.
- ❖ To study abrasion resistance characteristic of fabric constructed from yarn sized with potato and Cornstarch.
- ❖ To study size removal percentage of yarn and fabric sized with potato and Corn starch.
- ❖ To analyze and study the relation between the different sized yarn properties and the type of starch used.
- ❖ Effect of sizing chemicals on the performance of yarns as well as on productivity.

1.5 Significance

Starches are the main constituents of sizing elements used in warp sizing and there are a number of sizing starches used for warp sizing. But there is a gap and no enough information about the performance of yarns sized with the different native starches. The significance of this work is giving clear information about the performance properties of warp yarn sized with maize starch and potato starch. This work is aimed at evaluating the different properties of warp yarn sized with these particular starches and evaluating their performance on loom so that the gap will be minimized.

Fulfilling this gap will benefit the following groups:

- Existing weaving mills
- New weaving mills
- Researchers in this area
- Academic institutions
- Starch manufacturers (local)

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The sizing is a process affecting productivity of weave room. It imparts strength and improves abrasion resistance of warp yarn by coating a thin film of size ingredients so that it can withstand against several actions it is subjected to during weaving process i.e. cyclic strain, flexing abrasion at various loom parts and inter yarn friction.

Sizing plays a very important role in the production of fabric during weaving process. It improves the physico mechanical parameters of warp threads. Sizing agents are used to improve or increase the stiffness, strength, and smoothness of yarns, fabrics, and other products (S. Sultana, 2014). Sizing agents are applied as an aqueous solution to yarns in order to strengthen and lubricate them, thereby increasing the efficiency of the weaving process and improving the quality of the resulting fabric. Because breaking of yarn during weaving process causes loom stoppages that decreases the productivity and creates fabric defects (Karmakar, 2014).

Selection of sizing chemicals (agent) is important because chemistry of sizing material with yarn decides in the degree of improvement in yarn strength. Adhesion of size material with fibre substrate is found to have good correlation with weave ability of sized yarns. Performance of warp yarn depends on the nature of protective coating and its interaction with fiber substrate (P.R.Patel, 2013).

The global need for sizing agents all over the world is estimated to be more than 3 million tons per year. Among the commonly used agents, the various starches make about 75% (potato and corn starch 60%; modified starch 15%; (poly) acrylates 12%; polyvinyl alcohol (PVA) 11%; and carboximethyl cellulose (CMC) and other substances 2%)(P.G.Dumitras, 2004).

The selection of sizing ingredients is very critical and complex because wide range options are available (Goswami, 2004).

The effectiveness of sizing depends on the adhesion between size and yarn, film-forming properties of the size material and the properties of yarn themselves and machine variables. The ease of size removal from fabric after weaving without environmental and ecological damage can also be considered in sizing chemical effectiveness evaluation.

Many attempts have been made to evaluate the variables that affect size performance without expensive full-scale sizing and weaving trials. During desizing of cotton yarn, aqueous sizing agent dissolves in water with elimination from the yarn and it is assumed that the yarn will behave in the similar way after the weaving (S. Sultana, 2014). For this reason an ideal sizing agent should form a film on the surface of yarn to improve tensile performance.

Requirements for size materials vary with different types of yarns. So size mixtures are composed of ingredients which have different characteristics for different types of yarns because they are required to fulfill many different conditions. Cotton sizing agents are mainly composed of starchy substances like wheat flour, corn starch, potato starch, or sago flour, cassava starch and so on.

In practical mill operation, the strength property of the yarn has always been considered the prime factor that influences the performance of warp yarn during weaving. However, in recent years the mill supervisors and textile scientists have realized that other mechanical characteristics such as elongation, elastic recovery in both wet and dry states, and physical characteristics such as abrasion resistance and moisture sorption are equally influential in performance in the loom shed.

2.2 Sizing Materials

Natural starch and its derivatives still constitute nearly 75% of the sizing agents used in the textile industry throughout the world. It will remain the predominant ingredient, in the near future, for use in the industry because it is relatively inexpensive. The need for the development of different sizing agents other than starch and its derivatives was prompted by the introduction of new spinning and weaving technologies; these include, as previously described, spinning technologies that produce types of yarn structures that are different from the ring spun yarns and the various types of high speed shuttleless looms. The use of either starch or its derivatives proved inadequate for the achievement of quality and efficiency in the weave room. In addition, the environmental concerns regarding the discharge of effluent in local streams and wastewater treatment plants have also been influential in the search for new sizing materials. Generally, the amount of starch applied to staple yarn varies anywhere up to 15% of the weight of the yarn. The introduction of the new types of polymer synthetic sizing materials such as polyacrylates, polyesters, and polyvinyl alcohols (PVAs) has helped to reduce the amount of coating required to achieve similar if not significantly better quality warps and weave room efficiencies. However, there is still a lack of enough experience and data to allow prediction with certainty how a particular size material will behave during sizing, weaving, and desizing or in recycling of the materials. Carboxymethyl cellulose (CMC) sizing has very good adhesion to cellulosic fibers, but due to the high viscosity, the concentrations used in the industry are limited to low levels. CMC sizes are combined with PVA or acrylic sizing agents to improve their performance and desizing characteristics. However, the sizes containing CMC are very difficult to recycle. PVA is sometimes combined with acrylics and acrylate type sizes.

2.3 Selection and evaluation of size materials

At the outset it may be stated that there is no single size material that meets all the requirements as far as compatibility with every yarn being processed on any specific slasher for every fabric sett and weave room conditions. Obviously the objectives to keep in mind are that the sizing material should be easy to handle and apply to the yarn (and easy to remove) and the size–yarn system offers the best performance during weaving (improved abrasion resistance of size and yarn, yarn strength and resiliency, low shedding, and no size cracking).

In recent years several advances in improving the quality of sizing materials have been made. The properties that are important and that can be easily determined are (1) the viscosity or fluidity and (2) the mechanical and moisture sorption characteristics of the size film and the adhesion of the size to various types of fibers. For example, the polyvinyl alcohol film has an adhesive strength that is more than three times that of starch to polyester fibers. Starches have been chemically modified to improve their adhesion to fibers, strength, stability, and solubility of the size material.

The size formulations used for spun yarns (including blends) also contain other ingredients such as lubricants and binders. The lubricants help to reduce the friction and abrasion between the adjacent yarns and between yarns and heddles, drop wires, shuttles, rapiers, or projectiles. The lubricants also enhance the flexibility of the size film. The lubricants are generally fats, oils, or waxes.

In addition, another ingredient, usually a binder, is used either to enhance or suppress certain interactions between the size film and the fiber. The binder materials usually tend to reduce ‘‘skinning’’ in the size box and help reduce the force required to separate the yarns at the bust rods located at the front of a slasher. Acrylics and polyesters are generally used as binders. Some of these binder materials, especially acrylics, increase the viscosity of the size bath allowing better encapsulation of the yarn, which prevents hairiness of yarns from interfering in the weaving operation. Other ingredients, such as humectants, wetting agents, and defoamers, are added to the size formulation to ease the process of size application to the yarn.

The techniques to measure the size and the processing characteristics are well established, and it is important to establish standards that will help select the proper size or size blend that will give the best results. Some of the factors that need to be considered are the fiber type, yarn structure (ring spun, open end, air jet, or continuous filament), fabric sett, the slashing equipment, and such finished fabric requirements as fabric hand, brightness of color, and texture.

2.4 Evaluation of the sizing process

Weavers have been placing very stringent requirements on the quality of warp due to higher loom speeds and the need to produce first quality fabrics with an absolute minimum in defects. If the sizing is defective, the quality of the warp will be poor, which will affect the weaving operation and consequently the quality of the fabric.

In recent years a number of developments in process controls and sensing devices have made the process of applying the size and controlling the machine factors and yarn parameters much easier. The factors that need to be monitored and controlled on the slasher are as follows:

- ✓ Size add-on control
  - -Viscosity of size formulation
  - -Yarn speed
- ✓ Size encapsulation, which may be influenced by
  - -Size temperature/viscosity
  - -Size level
  - -Amount of solids in the formulation and between different formulations
- ✓ Tension in size box
- ✓ Moisture in yarns
- ✓ Tension in the leasing section
- ✓ Tension in the creel section

2.5 Performance of sized warp yarn

In practical mill operation, the strength property of the yarn has always been considered the prime factor that influences the performance of warp yarn during weaving. However, in recent years the mill supervisors and textile scientists have realized that other mechanical characteristics such as elongation, elastic recovery in both wet and dry states, and physical characteristics such as abrasion resistance and moisture sorption are equally influential in performance of warp yarns on loom shed(Goswami, 2004; StanaKovačević, 2004). Sizing agents are used to improve or increase the stiffness, strength, and smoothness of yarns, fabrics, papers and other products (S. Sultana, 2014). The performance of warp yarns on the loom is influenced by a number of factors as it is subjected to complex deformation including abrasion, cyclic bending and tension, and impact loading. Until recently, various constituents, such as size liquor, size film, yarn characteristics, and sized yarn behavior, have been characterized by a singles measurement (Goswami, 2004). For example, the size film and sized yarns have been characterized by the tenacity and elongation. Abrasion resistance is another criterion that has been used for establishing the protection provided by the size film to the yarn during weaving.

Weavers have been placing very stringent requirements on the quality of warp due to higher loom speeds and the need to produce high quality fabrics with an absolute minimum defects. If the sizing is defective, the quality of the warp will be poor, which will affect the weaving operation and consequently the quality of the fabric. For efficient operation of the weaving room, it is important to know how the warp yarn will perform during weaving. Until recently weaving technologists believed that by determining the adhesion of size to the yarn, the ease with which the size wears or rubs off (abrasion), and the improvement in the tenacity of the yarns, the performance of warp during weaving could be predicted (Goswami, 2004)

2.6 Properties of Size Materials

There are a number of desirable properties which a warp size should possess. These are summarized in Table 2.1. A good sizing material should have most if not all of these properties; however, sizes that are deficient in some of these properties still may be used. For example, starch is a useful sizing material even though it has a high biological oxygen demand (BOD), lacks bacterial resistance, and is sensitive to over drying; cannot be recovered; and must be cooked to achieve uniform properties besides other disadvantages. Yet it is a useful size material primarily because it is inexpensive, is easily desized, is a renewable resource, has good adhesion to cellulosic fibers, and can be modified and/or derivatized to yield a wide range of size film properties. In other words the usefulness of a size material for a specific application will depend upon the nature of the fibers of yarns being sized (e.g., cellulosic, nylon, polyester, etc.), the type of yarn (ring-spun, open-end, air-jet), the type of weaving machine being employed (shuttle, air-jet, rapier, projectile, etc.), and the characteristics of the fabric being woven (style, construction, weave, twist, yarn count, etc.). For example, what may be a suitable size for a ring-spun yarn may not work for an open-end or an air-jet spun yarn, especially if a yarn is made from blends of dissimilar fibers.

The primary size materials that act as "film formers" are

1. Starch (modified and unmodified)
2. Polyvinyl alcohol
3. Carboxymethyl cellulose
4. Acrylic (various addition polymers)

Table 1.1: properties of a good sizing material

Environmentally safe (nonpolluting)	Recoverable and reusable (or treatable)
Good film former	Low static propensity
Reasonable use economics	No skimming tendency
Penetration of yarn bundle	Easily removed (desized)
Elasticity	Easily prepared
Good film flexibility	Lack of odor
Good specific adhesion	No beam blocking
Good frictional properties (lubricity)	Compatible with other ingredients
Transparency	Good abrasion resistance
Bacterial resistance (mildew)	Neutral pH
Reasonable strength	High fold endurance
Controllable viscosity (fluidity)	Insensitive to high heat (overdrying)
Water soluble or water dispersible	Low BOD
Good hygroscopicity characteristics	No build-up on dry cans
Uniformity	Reduced shedding
Clean split at bust rods	Rapid drying
Improves weaving efficiencies	No redeposition of size
No effect on drying	Insensitive to changes in relative humidity
Reasonable extensibility	

2.7 Factors Affecting Productivity in a Weaving Mill

For the last few years, productivity is the hot issue for each companies either it is textile or chemical or fertilizer, to raise the production per unit is discussed. If we see productivity is the ratio of output per unit of input. If we take the labour productivity as an example that means ratio of output per labour hour. Productivity measures in different ways like in a factory how many hours does it take to produce the product? Productivity depends on different things or factors like labour, machinery, capital, temperature, raw materials quality etc. so every factor has its own contribution.

In textile, productivity has great influence on yarn and fabric production. Optimizing the output in this sector is a big challenge; to achieve this goal the role of an individual person regarding the production department has a great importance.

A) Machinery

Productivity is greatly influenced by the machinery efficiency, if the machine has the latest model then definitely the productivity will be high, multiphase and air jet loom has the highest weft insertion rate. If the machines have proper maintenance then, the breakage of weft yarn will be low. Breakage is the important factor to optimize the productivity, less breakage of weft yarn is the guarantee of more productivity ratio. In this competitive market many types of looms are available in the market but those looms are preferred whose yield is high and has best production results.

B) Labour

Skilled labour and their capacity is also an important factor. Labour personal involvement sometimes dependent on company's production. If the labours are well trained and aware of machine operations then production rate will be high. Labours carelessness or ignorance during production process affected the production efficiency. When machine stops due to breakage or any other reason than delay of restarting the machine has an impact on production. Sometimes it happens due to negligence of workers because they don't start the machine at the right time. Furthermore, more labour on one machine cannot give the guarantee of high productivity while on the other side competent labour can give the better results.

C) Temperature

In weaving shed, temperature (humidification factor) has great impact on the production. In weaving process, the yarn faces different tensions and friction forces. So, temperature in this environment should be maintained. If the temperature is exceeded than the standard temp, then breakage will be increased and production efficiency will be decreased and as a result whole production will be disturbed. So, to overcome this situation temperature issue should be in your mind. This will provide the best operating conditions for machine operators.

D) Energy issue

In weaving, energy is used in terms of machines operations, for air conditioning, compressors and other production areas etc. Two types of energy sources are used in a weaving mill like electrical and thermal energy. For machine operations, air conditioning and for illumination electrical energy is used but for sizing thermal energy is used.

If you have old model loom then your energy consumption will be more as compare to the latest machinery. So, latest machinery can save the energy consumption and definitely improve the production rate.

E) Raw material

This is observed that raw material quality has the key importance in production process, like from where you are buying yarn and who is your supplier? If your raw material is of high quality then the chances of breakage and error would be minimum. There will be cost factor issue in this regard because for high quality raw material you have to pay more but on the other hand this will compensate in the form of high production.

2.8 Polyvinyl alcohols (PVA)

Polyvinyl alcohol (PVA) has been one of the most versatile size materials available for warp sizing formulations since it was commercialized as a textile warp sizing agent sometime around 1965 (Goswami et al., 2004). PVA is the product obtained from the alcoholysis using polyvinyl acetate under the effect of the sodium methoxide process in methanol. Alcholysis products have total alcohoysised and partially alcohoysised. The sizing properties influenced by the degree of polymerization and degree of alcoholysis of polyvinyl alcohol. Polyvinyl alcohol size has shown excellent water-solubility, adhesiveness to the fiber, especially hydrophobic fibers. PVA films have superior elasticity, abrasion, high tensile-strength and elongation. The mixtures of polyvinyl alcohol and modified starches could also provide good protection to warp yarns (Zhu and Gao, 2008).

2.9 Environmental Problems of Sizing

After weaving process, size on the fabrics should be removed, in order to ensure the quality of finishing and dyeing processes. About 40-50% of waste water released from textile plants is related to desizing. Most of the size removed during desizing is released as effluent and causes environmental problems, especially when non-biodegradable sizes such as PVA are used. PVA is reported to remain in water for up to 900 days. Though PVA is not toxic, it has a great surface activity, and can form large amounts of foam in the water, which affect the oxygen content in water body, thereby inhibit or even undermine the respiratory activity of aquatic organisms (Zhang et al., 2005).

2.10 Physical and chemical properties of starches

The physical and chemical properties are related to the structural and molecular features of the starch granules. Cellulose and starch have identical chemical constitution as indicated in Figure 2.1. They are both polymers of glucose.

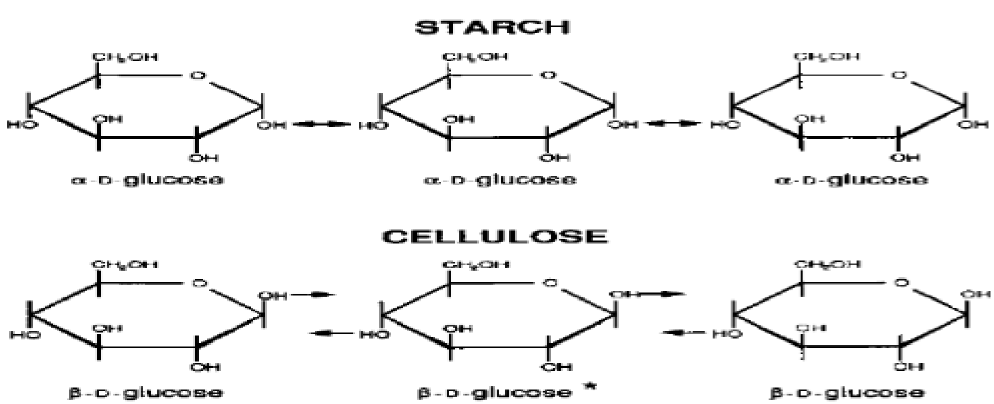

Figure 2.1 Reaction of alpha and beta anomers of glucose to form starch and cellulose (Goswami, 2004).

Plants store glucose as the polysaccharide starch. Depending on the plant, starch contains 20 to 25% amylose and 75 to 80% amylopectin. The ratio of these two strongly varies depending on the starch source. Simply put, amylose is a straight-chained, linear starch, and amylopectin is a larger, branched molecule as indicated in Figure 2.2. Amylose is primarily a linear chain of D-glucose units linked by α-1→4 linkages. However, some amylose molecules have about 0.3-0.5% of α-1→6 linkages (Goswami, 2004; Karmakar, 2014). Amylopectin is a branched polymer of glucose unit, linked with α-D-(1→4) glycosidic bond with the branching of α-D-(1→6) bond occur every 24 to 30 glucose units (AbrhamWondimu, 2014).

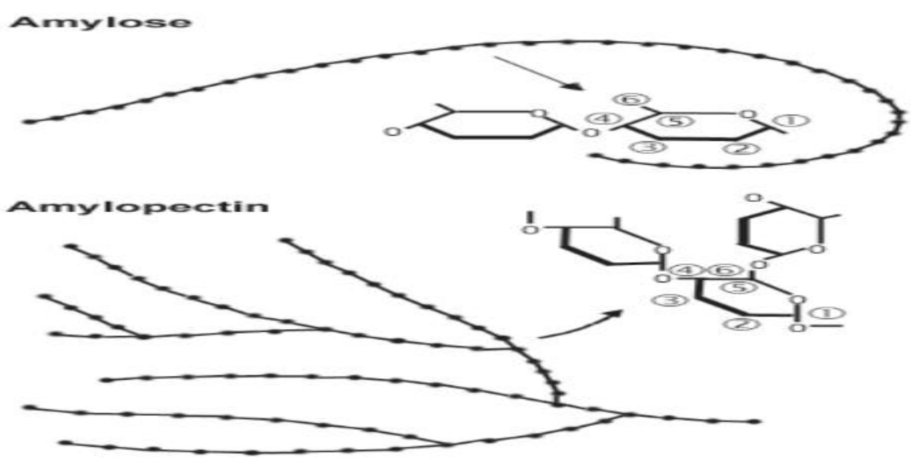

Figure 2.2: Structure of amylase and amylopectin (Goswami, 2004)

The very different structures of amylose and amylopectin account for their dissimilar properties. Small amounts of lipids and proteins are also present in the starch granules.

Physically, most native starches are having a crystallinity of about 20-40%. They are classified as semi crystalline. The amorphous regions consist of amylose and the branching points of amylopectin. The main crystalline components in granular starch are short-branched chains in the amylopectin. The crystalline regions are present in the form of double helices with a length of ~ 5 nm. Some of the parameters known to influence the granule properties are ratio of amylose to amylopectin, length of de-branched amylopectin chains, starch granule size distribution and phosphate content.

The linear nature of amylose molecules causes them to line up and associate with each other very tightly, whereas amylopectin molecules tend to be less tightly bound because the branching keeps the molecules at a greater distance from each other as it is seen in Figure 2.3.

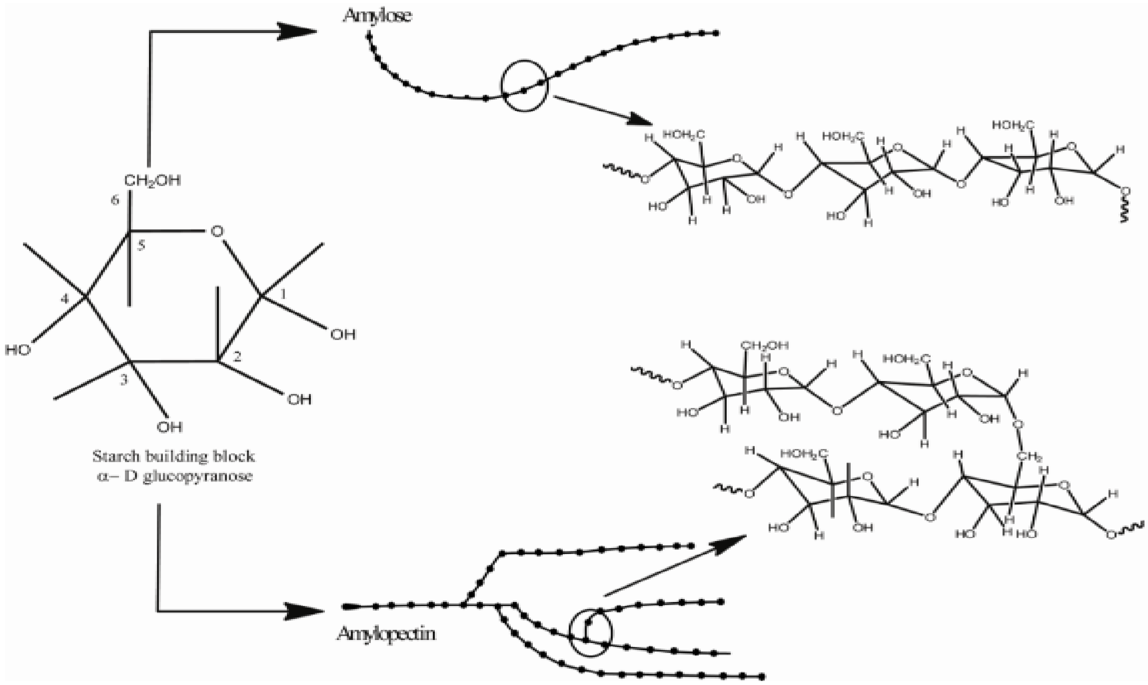

Figure 2.3: Linear and branched starch polymers (Goswami, 2004)

The length of the amylose chain is not the same for every source; it varies among different plant species but usually ranges between 102 to 104 glucose units. Amylopectin consists of short chains of, on the average, 20 to 30 α-1, 4 linked D-glucose units which are branched by α-1, 6 bonds and it usually it ranges to 104 to 105 glucose units.

Both morphology and molecular composition of starch granules vary between genotypes (Mateusz Stasiak 2013). Several properties are correlated to the granule sizes as e.g. the viscosity with corresponding influence on quality and properties of starch.

Each variety of starch is recognized by the characteristic shape and size of its granules. The granule sizes of different common starches when examined under microscope are given in Table 2.2

Table 2.2: Granule size of different native starches (KusumLata, 2012)

	Starch	Size (micrometer)
1	Rice	3-10
2	Corn	5-20
3	Wheat	22-36
4	Cassava	5-25
5	Potato	15-85

Besides the amylase and amylopectin, starches also consists other molecules like lipids While cereal starches as maize and wheat contain lipids of which the starch associated lipids are phosphorylated, potato starch granules contain no lipids and their phosphate is covalently bound to the glucose residues in the amylopectin molecules of the starch granules. The functional properties of starch are also influenced by the content of phosphate, i.e. a non-carbon component of starch. A distinction is made between phosphate which is covalently bonded in the form of monoesters to the glucose molecules of the starch and phosphate in the form of phospholipids which are associated with the starch. Potato starch granules show a unimodal size distribution. These differences have a great impact on the physical properties of the starches.

Normally, potato starch contains 20–27% amylose (w/w) of total starch depending on variety and method of determination. According to a study by Gebre-Mariam and Shimidt (Abrham Wondimu, 2014), the amylose content of Enset starch was estimated to be 29.0%. Another study, however, indicated that the amylose content to be 21% (AbrhamWondimu, 2014).While amylose content of maize and cassava starches is comparable (Bruuce-Smith, 1979).

Starch swells in hot water which shows the magnitude of starch chain interactions within the gelatinized granules. When starch was dispersed into water and heated up then the water penetrates into the starch granule until the granule is fully hydrated. In hydrated condition, the hydrogen bonding between the amylose and the amylopectin maintains the integrity of the granule and it begins to swell from the centre.

Under well-defined conditions, starches can be classified using gelatinization temperature as a means for differentiation. The properties of the starch granule are dependent upon the arrangement of the bonds which link glucose units to one-another within the starch molecule itself.

The proportions of these two types of starch molecules are established genetically and are relatively constant for each species of starch.

Both types of starch molecules amylose and amylopectin are polyhydroxy compounds and hydrate when heated in water, combining with individual water molecules.

As the molecules hydrate, they increase in size, immobilize much of the water present, thicken the aqueous system and form a paste.

Starches have different physico mechanical properties like thickening ability, ability of the starch paste to disperse and suspend other ingredients or particulate matter, gel formation and ability to produce strong adhesive films when spread on smooth surfaces and dried. These four important properties vary in degree from one starch source to another (Mateusz Stasiak 2013 ;Shujing Li, 2014,). Starches with a high percentage of amylase are difficult to gelatinize because of the extra energy needed to hydrate and disintegrate the firmly- bonded, crystalline aggregates of amylose. After gelatinization such starches form firm gels and when properly prepared, yield strong, tough films.

At the opposite end of the functional spectrum are the waxy starches, which are nearly 100% amylopectin. They gelatinize easily and yield nearly-transparent, viscous pastes that retrograde slowly to weak gels. The relative percentage of amylose and amylopectin in most common types of cereal endosperm starches ranges between 72 and 82 % amylopectin, and 18 and 28 % amylase.

When starch granules are heated in water, their molecular order is irreversibly interrupted and gelatinization occurs. As the starch slurry continues to heat past the gelatinization point, the starch granule deforms and soluble starch molecules are leached into the solution. The starch molecules and granule remnants are able to hold large amounts of water and a viscous paste is formed; indeed, this process is referred to as pasting. When starch granules are extremely swollen they are fragile and easily broken when stirred, causing a decrease in viscosity.

Heating starch in water leads to loss of hydrogen bonding in the interior of the starch granule and the starch will start to gelatinize. The starch granules will rapidly swell to many times its original volume. The gelatinization temperature range can be defined as the temperature at which granular swelling begins until the temperature at which nearly 100% of the granules are gelatinized. During the cooling phase, the starch undergoes retrogradation in which the starch chains begin to re-associate in an ordered structure, and this is accompanied by another rise in viscosity, usually referred to as setback. The recrystallization of amylose and amylopectin differs considerably.

Generally the difference in the genotype, variety, amount of amylase and amylpectin, and the presence of different molecules within a starch can affect its properties like viscosity, gelatnization temperature and film forming capability of starches which in turn can affect the performance of yarn sized with these starches.

In research done by Kusum and Rena (Kusum Lata, 2012), the following three types of starches have been compared

- Sago
- Rice and
- Corn

These three starches were used as a sizing material for the warp yarn. Different concentration of the solution was used and fabric properties like tensile strength, stiffness, Gsm, wash fastness, thickness of fabric were tested .The result indicate that highest yarn stiffness occur in case of sago starch and lowest tensile strength in case of sago, more weight gain was observed in corn. Limitation of this study is it is not clear whether the starches used are purely natural or modified.

In another study done by P.R.Patel(P.R.Patel, 2013) conventional starch (thin boiling) and modified starch (Esterified) were used to size 50s and 9s count cotton yarn Same concentration of the solution was used in this study and yarn properties like hairiness, abrasion resistance, size add on percentage and presence of starch after desizing were tested after sizing of the yarns. This study has indicated that abrasion resistance of modified starch was low. But overall performance of modified starch was good. The limitation of this study is that the source of starch used was not specified. Whether the starches used are purely natural or modified.

2.11 Development of New Sizing Agents

Developing alternative sizing agents and technologies that can reduce or eliminate the environmental problems associated with textile sizing is of vital importance for the long-term sustainability for the textile industry. Studies to make sizing more environmentally friendly are mainly based on two approaches. First, to develop new textile sizing agents which provide superior sizing properties and are at the same time also biodegradable. Second approach is to increase the biodegradability of PVA in textile effluent treatment plants.

Currently, many materials, such as modified starch, acrylate, and polyester and so on, have been developed as environmentally friendly size, with attempts to substitute PVA partly or completely, and solve the environmental problems of textiles industry.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

In order to examine the warp breakage rate and abrasion resistance of a fabric two kinds of starch was employed having with four sampling techniques. The first one is sizing Potato starch with PVA, The second one is sizing Potato starch without PVA, The third one is sizing Corn starch with PVA and finally sizing Corn starch without PVA. Fabric was also constructed on Picanol (190cm) width rapier loom using yarns sized with the two starches and the data is collected in Kombolcha Textile Share Company.

For this study, 34Nm count ring spun cotton yarn of twist 789 Tpm, potato starch, corn starch, PVA, water and weft yarn of 34Nm count ring spun yarn and the factories Weaving sizing chemical evaluation format was used.

Equipment's used

Tensile strength of yarns was tested on Autodyne 300 single strength tester following ASTMD2256 test method at clamp speed of 1000mm/min and pretension 450gram. The total number of samples tested was 10 and tests per sample were 4.

The elongation at break of yarns was tested on Autodyne 300 single strength tester following ASTMD2256 test method at clamp speed of 1000mm/min and pretension-450gram. The total number of samples tested was 10.

Abrasion resistance characteristic of fabrics which is direct effect of abrasion resistance of sized yarns was measured on Martindale fabric abrasion tester following ASTM D4966 test method. Weight of fabric samples was measured using GSM cutter and balance to compare the weight gain due to sizing. Zahn cup viscometers for viscosity testing, Stove for desizing of sized yarn, Conventional sizing machine having with 10 cylinder and picanol loom to construct fabric and test end breakage rate was used.

For sizing of the yarns the conventional cylinder sizing machine with 10 drying cylinders was used during sizing, machine speed (50-60m/min), squeezing roller pressure-3kg/cm^2,yarn tension, yarn stretch %(1-1.2) total number of ends (3986) and viscosity of solution were kept 12-15 was used according to the factories standard.

Size solution preparation and cooking is given in Table 3.1. The MLR was fixed depending on different literatures regarding functional properties of these native starches and depending on starch manufacturer data regarding the properties of these starches.

Table 3.1: Size solution preparation and cooking for the two starches

	Starch	Type
Parameters	Potato	Corn
MLR	01:11	01:11
Cooking time	25 min	25min
Cooking temp	90^0_C	90^0_C
Size box temp	90^0_C	90^0_C

i. Abrasion resistance test

An abrasion resistance characteristic of fabrics which is direct effect of abrasion resistance of sized yarns (Devsrakondn& Pope, 1970) was measured on Martindale fabric abrasion tester following ASTM D4966 test method. The total numbers of abrasive cycles were recorded till two ends break and used for comparison. The same loading of 9kpa was used for all the samples. The instrument used is shown in Figure 3.1.

Figure: 3.1 Martindale fabric abrasion tester

ii. Fabric weight test (GSM)

Weight of fabric samples was measured using GSM cutter and balance to compare the weight gain due to sizing.

iii. Tensile strength test

The tensile strength of fabric samples constructed from the sized yarns was measured on tensorapid tensile tester following ASTM D5034 test method. Sample dimension of 6×4 inches was used. Tensile strength was measured only in warp direction because the same cone yarn was used in weft direction for the four samples construction .The distance between the clamps used was 30mm at load cell of 5kN using fabric traction grab test principle.

Figure 3.2 shows the tensorapid tensile strength tester used 0.1.Tensolab fabric strength tester

iv. Size removal percentage test for sized yarn by desizing

Size removal percentage of the samples was calculated after desizing the samples using enzymatic desizing at MLR 1:20, using biolase enzyme 6%w/w, Nacl 5%, temperature 60°C, time 1hr, wetting agent-1.5g/l.

Below the table represents some of the sizing chemical parameters used in Kombolcha Textile Share Company during my work. Except the kinds of starch and PVA used all other parameters are the same the reason is that without the same parameter we can not decide weather one is better than the other. So the types of fabric produced is flat bead sheet with 34 Nm counts of a yarn for weft and warp having with 3986 ends of each fabric. 50Kg of sizing chemical is used for each yarns during sizing.

Table 3.2: Weaving sizing chemical evaluation format

s/n	Description	Potato starch without PVA	Potato starch with PVA	Corn starch with PVA	Corn starch without PVA
1	Article	Flat	Flat	Flat	Flat
2	Yarn count (Nm)	34Nm	34Nm	34Nm	34Nm
3	number of ends	3986	3986	3986	3986
4	Sizing chemical in kg	50kg	50kg	50kg	50kg
5	Sizing chemical name	Potato starch without PVA	Potato starch with PVA	Corn starch with PVA	Corn starch without PVA
6	PVA in kg	-	2.5kg	2.5kg	-
7	Anti foam	-	-	-	-
8	Wax g/l	-	-	-	-
9	Steering temperature(c^0)	27-90^{0}c	27-90^{0}c	27-90^{0}c	27-90^{0}c
10	Steering time(min)	15 min	15 min	15 min	15 min
11	Cooking temperature(c^0)	90^{0}c	90^{0}c	90^{0}c	90^{0}c
12	Cooking time(min)	25 min	25 min	25 min	25 min
13	Water used(lit)	650 lit	650 lit	650 lit	650 lit
14	Initial volume(lit)	700 lit	700 lit	700 lit	700 lit
15	Final volume(lit)	800 lit	840 lit	820 lit	800 lit
16	Return volume(lit)	720 lit	700 lit	670 lit	680 lit
17	viscosity	15	17	13	12.86
18	Refracto meter	5	4	5	3
19	Sized yarn length(mt)	700 m	700 m	700 m	700 m
20	Sizing chemical used in g/m	7.14 g/m	11.90 g/m	13.065 g/m	10.71 g/m
21	Wax used ml/m	-	-	-	-
22	PVA used g/m	-	-	-	-
23	Temperature in reserve tanker	90^{0}c	90^{0}c	90^{0}c	90^{0}c
24	Size box temperature c^0	90^{0}c	90^{0}c	90^{0}c	90^{0}c
25	Squeezing roller pressure	3 bar	3 bar	3 bar	3 bar
26	Sizing m/c speed m/min	50 m/min	50 m/min	50 m/min	50 m/min
27	Concentration in %	7.14	7.14	7.14	7.14

3.2 Methods

The methodology for this research design is asses and test the different kinds of sizing chemicals used in Kombolcha Textile Share Company and examine their effects on warp breakage rate during weaving and abrasion resistance of a fabric. Random samples were collected from the sized yarns and constructed fabrics. Then Data collected from laboratory work was analyzed using different statistical tools to analyze significance of the various yarn property differences. Comparison of the sized yarn properties with the unsized yarn properties using bar graphs was done and significance of variation in the different yarn properties was checked using paired sample T-test. Generally for data presentation and analysis the following are used:

- SPSS Software
- Bar graphs

3.2.1 Sample Preparation

Yarn of 34Nm was collected randomly from kombolcha textile Share Company® and native corn, and potato starches from Mengistu starch and starch derivative industry were used.

3.2.2 Sizing procedure

- A four beam of yarn was used for sizing
- Solution was prepared first using potato starch only
- Yarn of 700m was passed through sizing solution prepared with potato starch
- Then solution was prepared using potato starch with PVA
- Yarn of 700m from different beam was passed through the solution
- Then solution was prepared using potato starch without PVA
- Yarn of 700m from different beam was passed through the solution
- Then solution was prepared using corn starch only
- Yarn of 700m from different beam was passed through the solution
- Then solution was prepared using corn starch without PVA
- Then the yarn sized with the four starches was brought to a four loom

3.3 Tensile strength

Tensile strength of yarns was tested on Autodyne 300 single strength tester following ASTMD2256 test method at clamp speed of 1000mm/min and pretension 450gram. The total number of samples tested was 10 and tests per sample were 4.

The elongation at break of yarns was tested on Autodyne 300 single strength tester following ASTMD2256 test method at clamp speed of 1000mm/min and pretension-450gram. The total number of samples tested was 10.

3.4 End break test

Plain fabric with 24×20 EPC and PPC was constructed on rapier loom. A weft and warp yarn of count 34Nm was used. The fabric had width of 190cm with warp and weft crimp of 5%. All other machine parameters were kept constant and end break rate was attended for two hours and finally breaks/10^4 ends/10^4 picks were calculated.

The BTRA norms for end breakage rate were used which is give in Table 3.3

Table 3.3: BTRA norms for end breakage on loom from different articles

Loom type	**Articles**	**Up to 40s**		**Above 40s**	
		Warp stops/hr	Weft stops/hr	Warp stops/hr	Weft stops/hr
Projectile	Twill	1.5	0.4	1.9	0.5
	Denim	1.0	0.5	1.3	0.7
	Plain	1.1	0.5	1.4	0.7
	Poplin	1.8	0.45	2.3	0.6
Air jet	Twill	1.6	1.5	2.0	1.6
	Denim	0.8	1.3	1.0	1.4
	Plain	1.5	1.3	1.8	1.4
	Poplin	2.5	1.3	3.1	1.4
Rapier	Twill	1.2	0.7	1.5	0.9
	Denim	1.1	0.75	1.4	0.9
	Plain	0.7	0.75	0.9	0.9
	Poplin	1.4	0.75	1.8	0.9

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Yarn Test Results

4.1.1 Yarn size take up percentage

Table 4.1: Yarn size take up percentage

1	Un sized yarn strength	11.94	11.94	11.94	11.94
2	Size yarn strength in g/tex	17.75g/tex	15.03 g/tex	17.22 g/tex	16.56 g/tex
3	Size regain %	7.82	4.06	5.81	7.47
4	Strength regain %	48.66	25.87	44.22	38.69
5	Elongation un size %	4.34	4.34	4.34	4.34
6	Elongation size %	5.25	5.4	5.15	5.55
7	Beam number	10	113	48	03
8	Loom name	Picanol (190)	Picanol (190)	Picanol (190)	Picanol (190)
9	Un sized yarn (gm)	119.47 gm	119.47 gm	119.47 gm	119.47 gm
10	Size yarn(gm)	128.81 gm	124.32 gm	126.41 gm	128.4 gm
11	Loom efficiency %	90.07	85.3	84.7	87.4

Size take up percentage of the four sample starches

Size take up percentage has been calculated using the formula

$$\text{Size take up\%} = \frac{(\text{weight of sized yarn - weight of unsized yarn}) * 100}{\text{Weight of unsized yarn}} \quad \text{……….(4.1)}$$

From the formula we can calculate the amount of size take up used for potato starch sized without PVA;

Weight of sized yarn for potato starch sized without PVA=128.81

Weight of unsized yarn for potato starch sized without PVA=119.47 so

Size take up%= $\frac{128.81-119.47}{119.47}$

= 7.82%

From the formula we can calculate the amount of size take up used for potato starch sized with PVA;

Weight of sized yarn for potato starch sized with PVA=124.32

Weight of unsized yarn for potato starch sized with PVA=119.47 so

Size take up%= $\frac{124.32-119.47}{119.47}$

= 4.06%

From the formula we can calculate the amount of size take up used for corn starch sized with PVA;

Weight of sized yarn for corn starch sized with PVA=126.41

Weight of unsized yarn for corn starch sized with PVA=119.47 so

Size take up%= $\frac{126.41-119.47}{119.47}$

= 5.81%

From the formula we can calculate the amount of size take up used for corn starch sized without PVA;

Weight of sized yarn for corn starch sized with PVA=128.4

Weight of unsized yarn for corn starch sized with PVA=119.47 so

Size take up%= $\frac{128.4-119.47}{119.47}$

= 7.47%

The calculated result for potato starch sized with PVA yarn was 4.06%, potato starch sized without PVA yarn was 7.82%, corn starch sized with PVA yarn was 5.81% and corn starch sized without PVA yarn was 7.47%. The companies standard for size take up is from 7-10 so we can achieve the optimum size take up when there is no PVA on both starches.

4.1.2 Strength gain of sized yarn

Sizing solution was prepared and cooked as given on Table 3.2. Viscosity of the prepared solution was measured using the zahn cup viscometers and the result was potato starch solution without PVA 15, Potato starch solution with PVA 17, Corn starch solution with PVA 16 and Corn starch solution without PVA 12.86. The companies standard value for viscosity is from 12-15. From the viscosity values we can see that we have attained the optimum viscosity level which is near to the standard. The relatively high viscosity of corn and potato starch with PVA is due to the amount of PVA added on the solution.

Strength gain percentage has been calculated for the two starch sized yarn using the following formula

$$\text{Strength regain} = \frac{(\text{sized yarn strength} - \text{unsized yarn strength}) * 100}{\text{unsized yarn strength}} \quad \ldots\ldots\ldots\ldots..(4.2)$$

From the formula we can calculate the amount of strength regain used for potato starch sized with PVA;

Sized yarn strength for potato starch sized with PVA=15.03 gm/tex

Unsized yarn strength for potato starch sized with PVA=11.94

So Strength regain for potato starch sized with PVA= $\frac{15.03\text{gm/tex} - 11.94}{11.94} * 100$

$= 25.87\%$

From the formula we can calculate the amount of strength regain used for potato starch sized without PVA;

Sized yarn strength for potato starch sized without PVA=17.75 gm/tex

Unsized yarn strength for potato starch sized without PVA=11.94

So Strength regain for potato starch sized without PVA= $\frac{17.75\text{gm/tex} - 11.94}{11.94} * 100$

$= 48.66\%$

From the formula we can calculate the amount of strength regain used for corn starch sized with PVA;

Sized yarn strength for corn starch sized with PVA=17.22 gm/tex

Unsized yarn strength for corn starch sized with PVA=11.94

So Strength regain for corn starch sized with PVA=$\frac{17.22gm/tex-11.94}{11.94}$ * 100

= 44.22%

From the formula we can calculate the amount of strength regain used for corn starch sized without PVA;

Sized yarn strength for corn starch sized without PVA=16.56 gm/tex

Unsized yarn strength for corn starch sized without PVA=11.94

So Strength regain for corn starch sized without PVA=$\frac{16.56gm/tex-11.94}{11.94}$ * 100

= 38.69%

The calculated values for the gain in strength for the four sample starches sized yarns was potato starch sized yarn without PVA 48.66%, potato starch sized yarn with PVA 25.87%, corn starch sized yarn without PVA 38.69%, corn starch sized yarn with PVA 44.22%. Strength gain for sized yarns as per BITRA standard should be greater than 25% of unsized strength .The test results accepted in this range for the four starches sized yarns.

Sizing chemical used in gm/m is calculated through:-

(Final volume-Return volume)=700m

(800lit-720lit)=700m

So 80 lit= 700m

But 800 lit is used for 50,000gm of starch so it advisable to calculate the amount of starch used for 1 litter.

So if 800 lit= 50,000gm

1 lit= X

X= 62.5gm is used for 1 litter of solution.

So $\frac{80(62.5gm)}{700m}=\frac{700m}{700m}$

So by dividing each we get 7.14gm/m sizing chemical is used and the same calculation is also used for the others and the result shows that potato starch with PVA is 11.90gm/m, corn starch sized with PVA is 13.065gm/m, corn starch sized without PVA is 10.71gm/m.

4.1.3 Unsized Tensile Strength

Tensile and elongation tests were performed for the unsized ring spun carded yarn of 34Nm which was collected from kombolcha Textile Share Company**.** The test was done on auto dyne single yarn strength tester following the ASTM D5034 standard method and the result is given in the table 4.2

Table 4.2: Tensile and elongation tests result of unsized yarn

sample No	Tensile strength tenacity(cN/tex) of unsized yarn	Elongation In % of Unsized yarn
1	340	4.8
2	350	4.8
3	340	4.6
4	350	4.4
5	342	4.4
6	370	3.4
7	350	4.6
8	370	3.8
9	340	3.8
10	360	4.8
Total	3512	43.4
Average	351.2	4.34
Average With respect to the count of the yarn	11.94	4.34

Since the yarns are coming from warping there is no additional treatment so that the four sample tensile strength and elongation have the same result before sizing. The 11.94 is get by calculating the average sample times the count of the yarn (34Nm) and dividing by 1000.

4.1.4 Sized yarn tensile strength and elongation test

The sized yarn tensile strength and elongation was measured using the autodyne single strength tester following the ASTM D5034 and the result is given in Table 4.3.

Table 4.3: Sized yarn average Tensile Strength Elongation result

sample No	Tensile strength tenacity(cN/tex)				Elongation In %			
	Potato with PVA	Potato without PVA	Corn with PVA	Corn without PVA	Potato with PVA	Potato without PVA	Corn with PVA	Corn without PVA
1	430	510	470	530	5.4	5.6	5.3	5.6
2	420	510	480	500	5.2	5.2	5	5.4
3	450	500	480	510	4.8	5.2	4.8	5.2
4	450	570	480	480	5.0	5.2	4.6	5.8
5	450	500	500	500	5.8	5.8	5.8	5.2
6	460	500	500	510	5.2	5.2	5.2	4.8
7	430	530	480	500	5.3	5.4	5.0	5.8
8	450	570	500	505	5.6	5.6	5.6	6.4
9	440	500	490	490	4.8	~~5.4~~	4.8	5.8
10	440	530	490	540	5.4	5.4	5.4	5.5
Total	4420	5220	4870	5065	52.5	54	51.5	55.5
Average	442	522	487	506.5	5.25	5.4	5.15	5.55
	15.03	17.75	16.56	17.22	5.25	5.4	5.15	5.55

It is observed that the strength of a yarn is increased after sizing and the elongation is decreasing with the increase in the tensile strength of a yarn. This is because the size material penetrates into the yarn body and makes the yarn stiff. Adhesivity of the size material with the fiber improves the strength, makes the yarn compact and reduces the yarn elongation (BK Behera, Rajesh Mishra and Sanjay Nakum 2007). From which it may be observed the sized yarn breaking strength increases when compared with unsized yarn. Earlier attempts to assess weaveability were directed toward the assessment of the tensile strength and elongation at break of yarns before and after sizing. The increase in tensile strength was taken as a criterion to correlate with weaveability(Samah maatoug1, Néji ladhari and faouzi sakli dec 2007). As expected, this approach has not shown consistent correlation with actual weaving performance since the actual tension experienced by a yarn during weaving rarely exceeds 20% of the breaking strength of a yarn. Even unsized yarns in many instances have at least this minimum requirement of strength and elongation at break. Another approach used to assess the performance of sizing materials has been to apply sizing ingredients, such as starches, to desized cloth and then test the strength, elongation.

Bar graph showing the comparison of tensile strength between the unsized yarn and yarn sized using the three starches is given in Figure 4.1

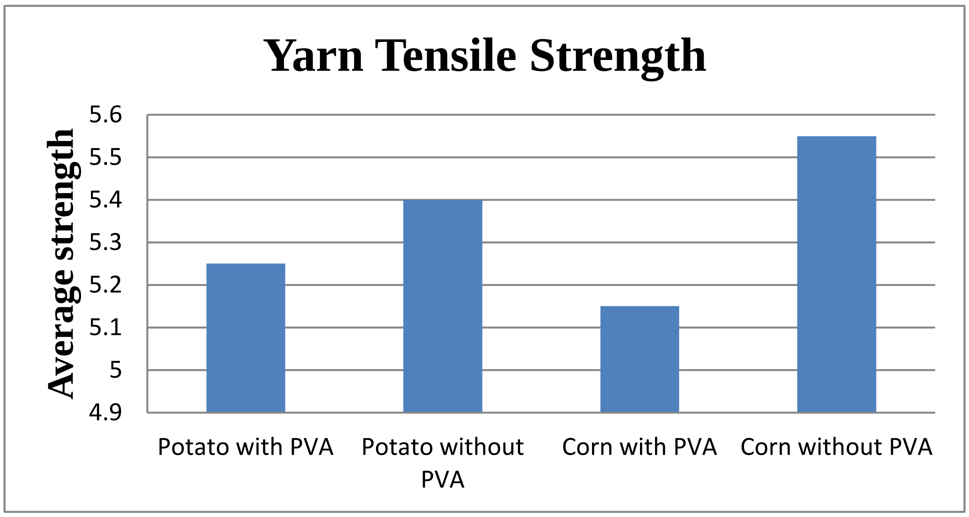

Figure 4.1: Tensile strength of unsized and sized yarns

From Figure 4.1 it is seen that there is great improvement on the tensile strength of yarn sized with the two starches. When we compare each of the starches in terms of their contribution for tensile strength of yarn, potato starch without PVA shows better improvement on the tensile strength of the sized yarn.

The significance test was done to compare the mean tensile strength test before and after sizing using two sided paired sample T-test and the result is given in Appendix A and B. So our null hypothesis was the mean tensile strength before and after sizing is the same and the alternative hypothesis is there is difference on the mean value before and after sizing. The confidence level used was 95%.Therefore to reject the null hypothesis; the absolute values of T calculate should be greater or equal to the absolute values of T tabulate. As it is seen from Appendix A and B, the two tailed significance value is 0.00 and 0.207 which is less than 14.643 and 1.358 for the two cases. Therefore we can reject our null hypothesis and this show that there is significant difference on the tensile strength of yarns before and after sizing.

The elongation at break for the unsized and sized yarns has been shown comparatively in Figure 4.2.

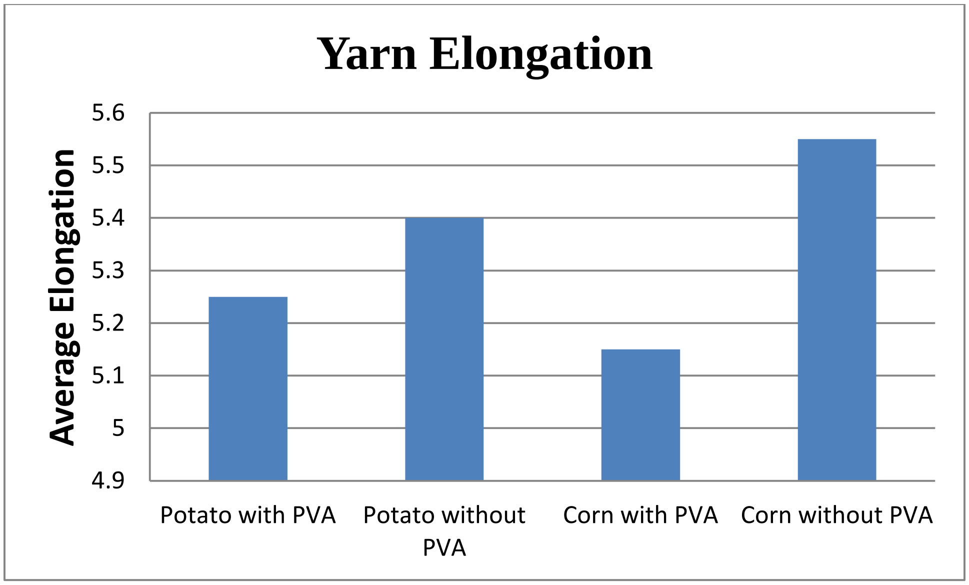

Figure 4.2: Elongation at break for unsized and sized yarns

From Figure 4.2 it can be seen that elongation at break was better on sized yarn than the unsized yarn which is expected (Mayur Sonawane, 2002). There was good elongation at break for corn starch without PVA sized yarns comparatively and very low result was obtained in the case of corn starch with PVA sized yarns.

The significance paired sample T-test result in Appendix D shows that the absolute values of T calculate which is greater than the absolute values of T tabulate. This indicates that there was significant difference on mean elongation at break of the yarns sized with the two starches and it confirms that starch type has influence on the elongation at break of yarns. As elongation at break becomes high the yarns performance on loom will be better.

4.1.5 End breakage test on loom

Plain fabric was constructed on Picanol (190cm) width rapier loom and an end breakage was observed for two hours .The total warp breaks within two hours were recorded and finally the end breakage rate was calculated. The calculated end breakage for the four samples is given in Table 4.4

Table 4.4: End breakage test result for the three samples

sample	Breaks/Loom/Hr
potato starch without PVA	1.5
potato starch with PVA	2.5
corn starch without PVA	2.0
corn starch with PVA	3.5

The end breakage rate of the four samples compared against the standard as follow:

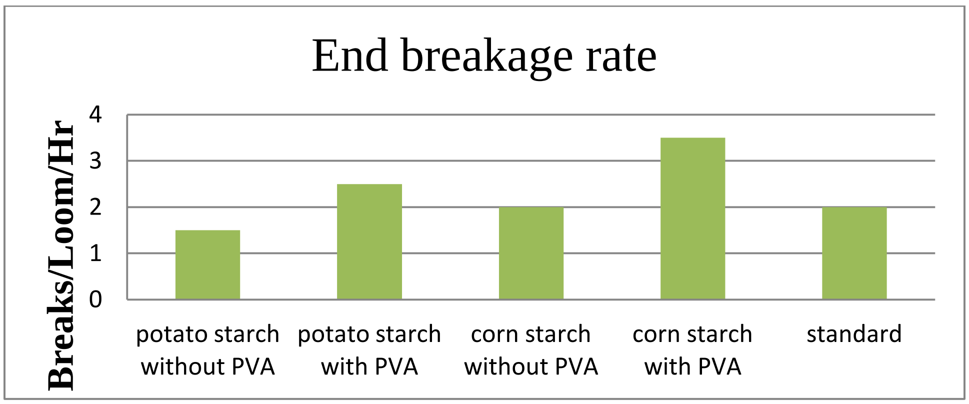

Figure 4.3: End breakage rate for the four samples

From figure 4.3 it is seen that end breakage rate for the four samples is not far from the standard in the case of potato and corn starch without PVA. But this result is acceptable as per the company specification which is 2.0 breaks per loom/hr. So when we compare the four samples corn starch with PVA sample has the highest end breakage rate which can affect the loom efficiency indicating poor performance this starch on sized yarns.

4.2 Fabric Test Result

Plain fabric of specification given on the methodology was constructed using the sized yarn which is on different beam. Samples from the constructed fabric were taken randomly and tested for different fabric characteristics.

4.2.1 Tensile Strength Test Result

Yarn breaking strength, breaking elongation and crimp are the primary factors influencing a great many fabric properties. The integral yarn strength is a major contributing factor to both tensile strength and tear strength of fabrics (Devsrakondn & Pope, 1970). Taylor (1959) stated that tensile strength is the most important property of a woven fabric (Malik, 2011). According to Ping and Greenwood, tensile strength of a fabric in either the warp or weft direction is the function of yarn strength (Malik, 2011).

The tensile strength of the fabric constructed using the two starches have been tested on the tensorapid strength tester following the ASTM D5034 method. It works based on constant rate of elongation (CRE) principle. Tensile strength of the fabric samples was measured in warp direction only because the same cone weft yarn was used for all the fabric samples construction. Here fabric of 6 by 4 inches cut and was used following fabric traction grab mechanism. A load cell of 5KN was used at machine speed of 300mm/min.

Table 4.5: Tensile strength test result for the four fabric samples

	Tensile strength tenacity(cN/tex)			
sample No	Potato with PVA	Potato without PVA	Corn with PVA	Corn without PVA
1	530	510	430	470
2	500	510	420	480
3	510	500	450	480
4	480	570	450	480
5	500	500	450	500
6	510	500	460	500
7	500	530	430	480
8	505	570	450	500
9	490	500	440	490
10	540	530	440	490
Total	5065	5220	4420	4870
Average	506.5	522	442	487

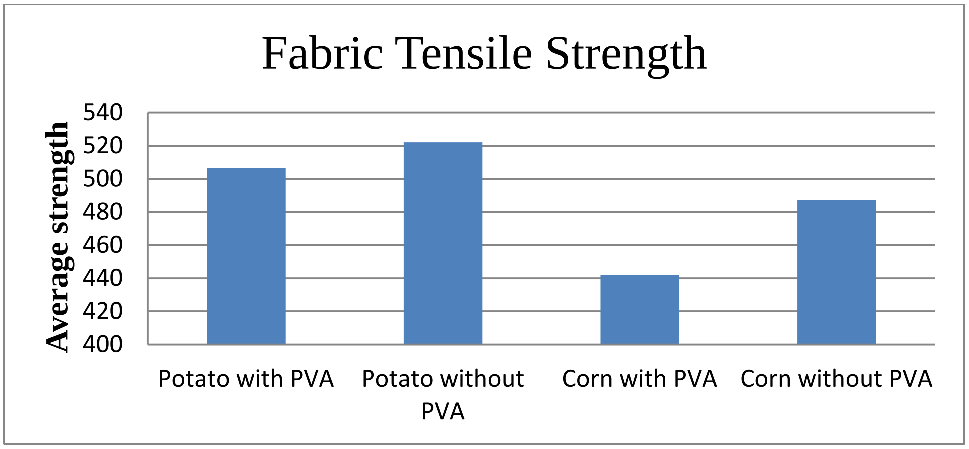

Figure 4.4: Tensile strength of the four fabric samples

From Figure 4.4, it can be seen that maximum force required to break the samples was the lowest for fabric samples constructed from corn starch with PVA sized yarns which agree with the sized yarn strength and potato starch without PVA sized yarn fabric samples were better relatively. Here the tensile strength of fabric sample constructed using corn starch sized yarns was very low. This may be due to poor adhesion and brittle nature of this starch films (EbisaTadese 2014).

4.2.2 Abrasion Resistance Test

Abrasion is wearing a way of any part of material by rubbing against another surface. Abrasion cycle is one complete movement of abradant across surface of material being abraded. Complete movement for abrasion cycle depends on action of abrasion machine and test method used. As the number of abrasive cycles increase the performance of sized yarn on loom will be high. Fabric abrasion resistance is directly related to yarn abrasion resistance (El-Dessouki, 2014; Nilgün Özdil, 2012).

Martindale fabric abrasion tester was used for measuring fabric abrasion resistance following the ASTM4966 test method. The number of abrasive cycles has been recorded until two ends of fabric sample have been broken. The test result for average abrasive cycles of fabrics constructed from yarns sized with the two starches was potato starch without PVA samples 15000 cycles, potato starch with PVA samples 13500 cycles, corn starch without PVA samples 14000 cycles and corn starch with PVA samples 13000 cycles.

The abrasion resistance characteristic of fabric constructed using the three starches has been compared and shown in Figure 4.5.

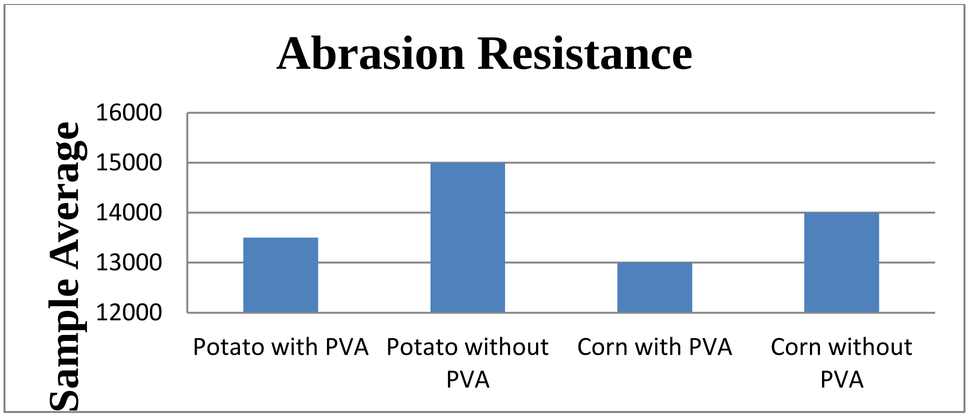

Figure 4.5: Abrasion resistance for the four fabric samples

From the test result in Figure 4.5 it is seen that abrasion resistance value of potato starch without PVA is the highest and corn starch with PVA exhibited the least abrasion resistance value. The high abrasion resistance of potato starches may be due good adhesion between yarns and the starch because of its relatively large amylose content. Low abrasion character of corn is related to low adhesion where the size will be on the surface of yarn without penetration (Ephraim Nuwamanya, 2011).

4.2.3 Fabric Weight Test

Determination of fabric weight in grams per square meter was done using GSM cutter. The sample was cut with the GSM cutter and weighed on torsion balance to determine the weight and the result is given in Table 4.6.

Table 4.6: Fabric weight test result for the four samples

Sample No	Potato with PVA	Potato without PVA	Corn with PVA	Corn without PVA
1	157.1	142.3	150.7	143.6
2	158.9	142	150.9	139.2
3	156.3	142.3	150.7	140.1
4	155.7	143.6	155.6	140.1
5	160.8	142.7	152.3	142.3
Avg	157.76	142.58	152.04	141.06

The weight of fabric samples constructed from yarns sized with the different starches has been compared and is shown in Figure 4.6.

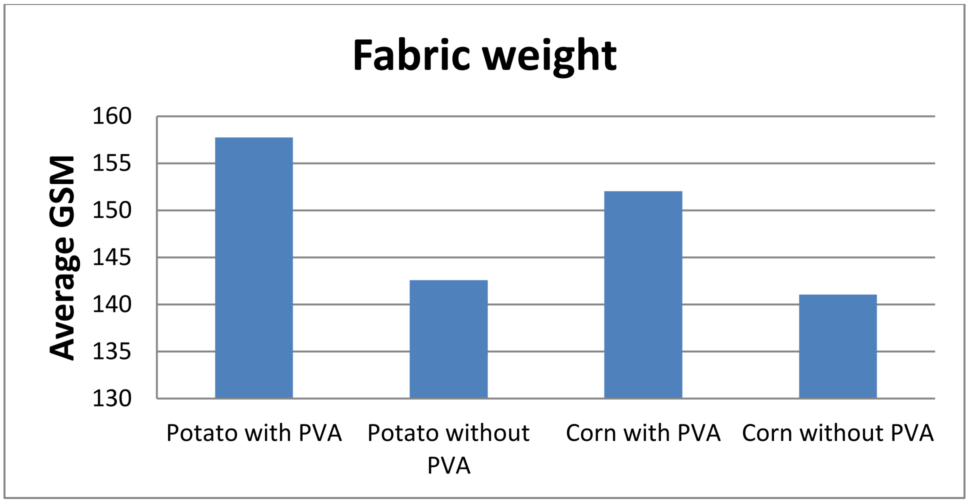

Figure 4.6 Fabric weight comparison

From Figure 4.6 it can be seen that fabric samples constructed from potato starch with PVA sized yarns had largest weight as compared to the others. Samples constructed from potato starch without PVA sized yarns had least weight.

As we see from the T –test table for significance testing Appendix E, the two tailed significance values are 0.000 and 0.001. This shows that there was significant difference of weight only in corn starch and there was no significant weight difference between the others. Generally there was no significant weight variation due to different sizing starches.

4.2.4 Desizing

Desizing is applied to remove size materials for further treatment such as coloring and printing. The importance of desizing is to prevent uneven dyeing, to enhance wettability and water absorption, and to increase better efficiency of subsequent scouring and bleaching. There are three basic ways to decompose starch to water soluble products, for example, enzyme desizing, acid desizing and oxidative desizing. The most effective method is enzyme desizing since only starch is decomposed by the action of enzyme and no fiber damage is resulted. Furthermore, the activity of enzyme is affected by several factors such as pH value, temperature and concentration.

The size removal percentage of the starches has been calculated after desizing of the fabric samples. Desizing is the process of removing the size material from the warp yarns in woven fabrics. The nature of this process depends upon the type of size applied.

Water soluble size may simply be washed out, whereas water insoluble size must first be subjected to chemical or enzymatic degradation. Easy desizability is one of the greatest requirements of sizing agent. Higher the water solubility of sizing agents, lesser will be the energy consumption. This leads to more economic process (B. K. Behera, 2008).

Desizability of sizing agents depends on factors like viscosity of size paste, moisture regain of size film, and solubility of size film in water. All these factors are directly or indirectly dependent on the chemical structure of the size material (B. K. Behera, 2008).

Size removal percentage has been calculated by enzymatic desizing of the fabric samples and weight loss calculation.

Amylase enzyme 6% owf, sodium chloride 5% owf and wetting agent1.5g/l at an MLR ratio of 1:20 was used for desizing solution preparation. All the four fabric samples of equal weight were immersed in to the solution and boiled at for one hour at 60°C.

According to Kombolcha Textile Share Company Size removal percentage was calculated using simply 5% of the weight of the fabric.

The test result for the four samples is given in Table 4.7

Table 4.7: Size removal percentage test result

Fabric sample	Size removal percentage (%)
Potato without PVA	7.129
Potato with PVA	7.88
Corn without PVA	7.053
Corn with PVA	7.602

From the test result for size removal percentage given in Table 4.7 it is seen that high size removal percentage was obtained in the case of Potato with PVA starch which in turn shows that easy solubility of this starch and its cost effectiveness. Corn starch without PVA shows the least size removal percentage which may be due to highest degree of association between molecules in its structure which lowers solubility of these starches in water.

Iodine Test:

The color produced on the fabric indicates the degree of desizing.

1. The original grey cotton fabric has a dark blue spot on the surface. It means that such fabric is sized and starch is present.
2. The treated cloth has a light brown spot. It means that most of starch is decomposed to water soluble dextrine, and hence, removed. The fabric is desized.

The iodine test aims at determining the presence of starch on fabric. Light brown spot were observed on the treated cloth, which implies most of the starch was decomposed to water soluble molecules and removed. Moreover, the treated fabric turns brighter and lighter in color and has a soft handle.

4.2.5 Cost Comparison

The cost comparison for the two starches is given in Table 4.8

Table 4.8: Cost comparison for the two starches

Starch type	unit cost/kg
potato	50 birr
corn	40 birr

Using one parameter sizing chemical used in kg/m we can calculate the cost:-

- **For Potato starch without PVA**

  Based on the data given in table 3.2 sizing chemical used for potato starch without PVA is 7.14 g/m

  This means 7.14 gram of Potato starch is used for 1 meter of fabric

  So from this how many grams of Potato starch is required for 700 meters of fabric?

  7.14 gram = 1m

  X = 700m

  So X= 4998 gram

  X= 4.998 Kg for 700m

  Currently the companies production capacity per day is 24,000m

  So from this we can calculate that 4.998kg = 700m

  X = 24,000m

  X = 171.36kg/day

  Let us assume that except Sunday and holiday machines are running 296 days per year

  X = 50,722.56kg/year

  The unit cost per kg of Potato starch based on the above table 4.16 is 50 birr

So we can calculate that 1kg = 50 birr

50,722.56kg = X

X = 2,536,128 birr/year

- **For Potato starch with PVA**

Based on the data given in table 3.2 sizing chemical used for potato starch without PVA is 11.9 g/m

This means 11.9 gram of Potato starch is used for 1 meter of fabric

So from this how many grams of Potato starch is required for 700 meters of fabric?

11.9 gram = 1m

X = 700m

So X= 8330 gram

X= 8.33 Kg for 700m

Currently the companies production capacity per day is 24,000m

So from this we can calculate that 8.33kg = 700m

X = 24,000m

X = 285.6kg/day

Let us assume that except Sunday and holiday machines are running 296 days per year

X = 84,537.6kg/year

The unit cost per kg of Potato starch based on the above table 4.16 is 50 birr

So we can calculate that 1kg = 50 birr

84,537.6kg = X

X = 4,226,880 birr/year

- **For Corn starch without PVA**

Based on the data given in table 3.2 sizing chemical used for potato starch without PVA is 10.71 g/m

This means 10.71 gram of Potato starch is used for 1 meter of fabric

So from this how many grams of Potato starch is required for 700 meters of fabric?

10.71 gram = 1m

X = 700m

So X= 7497 gram

X= 7.497 Kg for 700m

Currently the companies production capacity per day is 24,000m

So from this we can calculate that 7.497kg = 700m

X = 24,000m

X = 257.04kg/day

Let us assume that except Sunday and holiday machines are running 296 days per year

X = 76,083.84kg/year

The unit cost per kg of Corn starch based on the above table 4.16 is 40 birr

So we can calculate that 1kg = 40 birr

76,083.84kg = X

X = 3,043,353.6 birr/year

- **For Corn starch with PVA**

Based on the data given in table 3.2 sizing chemical used for potato starch without PVA is 13.065 g/m

This means 13.065 gram of Potato starch is used for 1 meter of fabric

So from this how many grams of Potato starch is required for 700 meters of fabric?

13.065 gram = 1m

X = 700m

So X= 9145.5 gram

X= 9.145 Kg for 700m

Currently the companies production capacity per day is 24,000m

So from this we can calculate that 9.145kg = 700m

X = 24,000m

X = 313.542kg/day

Let us assume that except Sunday and holiday machines are running 296 days per year

X = 92,808.432kg/year

The unit cost per kg of Potato starch based on the above table 4.16 is 40 birr

So we can calculate that 1kg = 40 birr

92,808.432kg = X

X = 3,712,337.28 birr/year

From our cost analysis for the native starches that were used in this study, we can see that 4,226,880 birr/year is required per year for Potato starch with PVA, 2,536,128 birr/year for potato starch without PVA, 3,712,337.28 birr/year for corn starch with PVA and 3,043,353.6 birr/year for corn starch without PVA. So the company well lost 507,225.6 birr/year, hence currently Kombolcha Textile Share Company uses Corn starch without PVA as a sizing ingredient.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From this result the study indicates that the tensile strength of yarns is 17.75gm/tex potato starches without PVA, 15.03gm/tex potato starches with PVA, 16.56gm/tex corn starches without PVA and 17.22gm/tex corn starches with PVA. The gain in strength for the four sample starches sized yarns was 48.66% potato starch sized yarn without PVA, 25.87% potato starch sized yarn with PVA, 38.69% corn starch sized yarn without PVA and 44.22% corn starch sized yarn with PVA. The test result for Abrasion resistance of a fabric is calculated through the average abrasive cycles of fabrics constructed from yarns sized with the four sample starches was 15000 cycles potato starch without PVA samples, 13500 cycles potato starch with PVA samples, 14000 cycles corn starch without PVA samples and 13000 cycles corn starch with PVA samples. Size removal percentage was 7.129 Potato starch sized without PVA, 7.88 Potato starch sized with PVA, 7.053 corn starch sized without PVA and 7.602 corn starch sized with PVA. Corn starch without PVA showed better result on elongation at break. Corn starch with PVA sized yarns performance was lower on overall properties and end breakage rate on loom. Yarns sized with Potato starch without PVA showed better overall performance properties and it is cost effective while corn starch showed lower performance properties and it is not cost effective.

Yarns sized with native corn starch with PVA has poor performance in terms of tensile strength, and abrasion resistance which indicate lowest yarn diameter variation due to sizing and size removal percentage which is lowest comparatively. The tensile strength and abrasion resistance characteristic of yarns sized with potato starch without PVA and Corn starch without PVA are not very far and as per paired sample T-test significance test result, there is no significant difference on the tensile strength value due to starch type which confirms that these two starches have comparable performance in terms of their tensile strength and abrasion resistance characteristics on yarn. Cost analysis result also shows that the native starches that were used in this study, we can see that the company well lost 507,225.6 birr/year, hence currently Kombolcha Textile Share Company uses Corn starch without PVA as a sizing ingredient.

Generally potato starch sized without PVA yarns have good performance in overall properties, potato starch sized with PVA also have highest size removal percentage as compared to the others which make this starch preferable and cost effective over the others. Native corn starch has poor performance in overall properties and its size removal percentage is lowest as compared to the others which make it costly and not preferable.

5.2 Recommendation

From this study it is recommended that potato starches sized without PVA should be used for better sized yarns performance on loom. By considering the cost of production of the end used fabric, potato starches sized without PVA should be better interms of cost. It is also recommended that native corn starches should not be preferred because of its poor performance on loom and its high processing cost.

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APPENDIX A

Significance T-test result for tensile strength of sized and unsized yarn

Paired Samples Test

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Unsize Yarn Tensile Strength of Potato	351.2000[a]	10	11.78323	3.72618
	Unsize Yarn Tensile Strength of Corn	351.2000[a]	10	11.78323	3.72618
Pair 2	Tensile Strength of potato with PVA	442.0000	10	12.29273	3.88730
	Tensile Strength of Potato without PVA	487.0000	10	10.59350	3.34996
Pair 3	Tensile Strength of Corn with PVA	506.5000	10	17.64621	5.58022
	Tensile Strength of Corn without PVA	522.0000	10	27.80887	8.79394

APPENDIX B

Significance T-test result for tensile strength of the two starch sized yarns

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 2	Tensile Strength of potato with PVA - Tensile Strength of Potato without PVA	-45.00000	9.71825	3.07318	-51.95202	-38.04798	-14.643	9	.000
Pair 3	Tensile Strength of Corn with PVA - Tensile Strength of Corn without PVA	-15.50000	36.09016	11.41271	-41.31735	10.31735	-1.358	9	.207

APPENDIX C

Significance T-test result for elongation of the two starch sized yarns

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	unsized potato starch yarn elongation	7.2400[a]	10	.68508	.21664
	unsized corn starch yarn elongation	7.2400[a]	10	.68508	.21664
Pair 2	sized potato starch with PVA yarn elongation	5.4000	10	.21082	.06667
	sized potato starch without PVA yarn elongation	5.2500	10	.32404	.10247
Pair 3	sized corn starch with PVA yarn elongation	5.1500	10	.38079	.12042
	sized corn starch without PVA yarn elongation	5.55000	10	.440328	.139244

APPENDIX D

Significance T-test result for elongation of the two starch sized yarns

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 2	sized potato starch with PVA yarn elongation - sized potato starch without PVA yarn elongation	.15000	.20683	.06540	.00204	.29796	2.293	9	.048
Pair 3	sized corn starch with PVA yarn elongation - sized corn starch without PVA yarn elongation	-.400000	.583095	.184391	-.817121	.017121	-2.169	9	.058

APPENDIX E

Significance T-test result for fabric weight

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	GSM of Potato without PVA - GSM of Potato with PVA	15.1800	2.3721	1.0608	12.2346	18.1254	14.309	4	.000
Pair 2	GSM of Corn without PVA - GSM of Corn with PVA	10.9800	3.0458	1.3621	7.1981	14.7619	8.061	4	.001