Efficacy Assessment of Environmental Friendly Sizing Agent from Cassia fistula Seed and its Impact on Cotton Fabric Properties

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LATIKA SANCHIHER

THESIS

MASTER OF SCIENCE (HOME SCIENCE)

IN

Department of Textile and Apparel Designing

2016

Department of Textile and Apparel Designing

MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, UDAIPUR (RAJASTHAN)

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Date: / /2016

This is to certify that this thesis entitled **"Efficacy Assessment of Environmental Friendly Sizing Agent from Cassia fistula Seed and its Impact on Cotton Fabric Properties"** submitted for the degree of **Master of Science** in the subject of **Textile and Apparel Designing** embodies bonafide research work carried out by **Miss Latika Sanchiher** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation has been fully acknowledged. The draft of the thesis was also approved by the advisory committee on - - 20 .

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Date: / /2016

This is to certify that **Miss Latika Sanchiher** (M.Sc. Scholar) has worked under me on **"Efficacy Assessment of Environmental Friendly Sizing Agent from Cassia fistula Seed and its Impact on Cotton Fabric Properties"**

1. I have monitored her research work.
2. My self and the scholar were in contact with the committee members and the research work was reviewed regularly.
3. The advisory committee members have gone through M.Sc. thesis critically and made correction as per requirement.

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COLLEGE OF HOME SCIENCE, UDAIPUR

Department of Textile and Apparel Designing

M.Sc. Thesis (2016)

Topic: Efficacy assessment of environmental friendly sizing agent from *Cassia fistula* seeds and its impact on cotton fabric properties.

ABSTRACT

With the emerging worldwide interest in adopting and studying traditional starching methods and exploiting their potential based on different plant source. Nature has provided abundant plant wealth, which possess medicinal virtues for all living creature. The essential values of some plants have long been published but a large number of them remain unexplored as yet. In this regard, one such plant is *Cassia fistula*.

With this in the mind the present research entitled "Efficacy assessment of environmental friendly sizing agent from *Cassia fistula* seeds and its impact on cotton fabric properties" was conducted. To achieve objectives of the study it was carried out in four stages. 1. Characterization of the starch obtained from *Cassia fistula* seed. 2. Application of starch. 3. Assessment of fabric parameters. 4. Assessment of the acceptability of starched fabric by consumer. Muslin cloth having different fabric weight was selected for the experiments. *Cassia fistula* pods were collected from the MPUAT University campus and then processed into fine powder. The size and shape of starch powder (particles) extracted from *Cassia fistula* seed were determined using Scanning Electron Microscope (SEM). Three concentration of starch 2.5%, 5%, and7.5% were prepared and applied on desized muslin fabrics. The starched samples were assessed to see the effect of different concentrations of starch on various physical parameters before and after. These starched samples were visually evaluated by the panel of 5 members from Textile and Apparel Design department to select one best concentration out of three. Then one selected concentration of *Cassia fistula* was compare with commercially available starch arrowroot. 30 post graduate girls were selected for assessment of the acceptability of starched dupatta in term of physical parameters.

Findings of the study revealed that *Cassia fistula* starch can be used on cotton muslin fabric with different concentrations. It gives satisfactory results in terms of texture, luster, thickness, stiffness and drapability. Five per cent concentration of *Cassia fistula* starch with medium muslin was most preferred by the judges. *Cassia fistula* starch shows better result as compare to commercial starch *Maranta Arundinacea* (arrowroot). There was increase in

physical parameters when sized with *Cassia fistula* starch. The stiffness of fabric, fabric count, thickness of the fabric and fabric weight were increased due to film formation on the surface of the fabric. Fabric colour and texture became dull and rough because of brown and larger starch particles. But there was no change in tensile strength after sizing treatment. In order to assess the acceptability of the developed starch a rating Performa was developed based on five point rating scale and was given to 30 respondents to find its relative ranking. It was found that *Cassia fistula* starched dupatta was acceptable by 86 per cent respondents.

It can be concluded that muslin can be successfully sized with natural starch of *Cassia fistula seeds.*

Major Advisor **Research Scholar**

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INTRODUCTION

Textiles have such an important bearing on our daily lives that everyone needs to know something about them. From earliest times, people have used textiles of various type for covering, warmth, personal adornment, and even to display personal wealth. Today, textiles are still used for these purposes and everyone is an ultimate consumer.

The textile industry is very complex. It begins in agriculture with fiber production. Fibers are processed into yarn and/or fabrics. The yarns are made into fabrics for industrial and consumer uses by various means, such as weaving and knitting. The fabrics are converted into finished cloths, which provide particular appearance and performances. These fabrics are made into end use products, including apparel, home furnishing, and various industrial applications.

Each person builds an image which represents him in the eyes of others it is the expression of his inner self projected through his outer appearance. A large percentage of his total image can be attributed to the clothes he wears his clothing expresses his values and his feelings about himself. Clothing has served many purposes arising from diverse need. Ever since man took to wearing clothes, the necessity of washing, finishing and restoring them to original appearance has been a problem in maintaining a satisfactory appearance of textiles.

Certain treatments are applied to improve the look and qualities of textile goods. These treatments are called finishes. A finish is a treatment given to a fabric, to change its appearance, handling /touch or performance. Its purpose is to make the fabric more suitable for its end use.Finish includes any general treatment given to clean and iron fabrics and create exclusive variations of them by using chemical treatments, dyeing, printing and sizing etc. to make fabric attractive and appealing.Basic or common finishes are applied to almost all the fabrics, with an aim to improve their appearance, feel and body. Pale white cotton fabrics may be bleached to improve their whiteness. For better look of a thin cotton fabric, starch is applied to increase its weight and shine. Temporary finishes are not durable and run off after first washing or dry-cleaning. Many of these are renewable and can be reapplied at home, e.g. starching and blueing of white fabrics. In the 19th century and early 20th century starching was commonly used to make clothing more resistant to stains and wrinkles.

Starch is generally applied to fabric of fine quality and light weight or loosely woven fibres. Starching makes the fabric heavier, stiff, and crisp. It also adds shine and smoothness to the fabric. Cottons – muslin, poplin, cambric and thin silks are generally starched.

"Size is a glutinous film forming substance in solution or dispersion form applies normally to the yarn or fabric". Textile auxiliaries that stiffen and weight fabrics have included temporary and permanent sizes and metal salts applied alone or with a binding agent. The sizes stiffen the fabric through formation of bonds between fibers, particularly at fiber crossover points. Temporary sizes include starch, naturally derived gums, carboxy-methylcellulose, and polyvinyl alcohol. Acrylic binders, polyvinyl chloride, and polyvinyl acetate emulsions act as permanent sizing agents. (kaur, 2010)

Sizing or size is any one of numerous substances that is applied to or incorporated in other material especially papers and textile, to act as protecting filers or glaze. Sizing agents are derived from both natural and synthetic polymers, starch and derivatives are the most common natural sizing agent and PVA (polyvinyl alcohol) the most common synthetic polymers used for sizing. Starch and its derivatives are mainly used for cotton and cotton blends and PVA is mainly used for synthetic fibers and their blends. (Cai, *et al*. 2003).

Sizing agents are selected on the basis of type of yarn, viscosity, environmental friendliness, ease of removal, desizing and cost consideration etc. an ideal sizing process should form a film on the surface, protect the fibers on the surface and must not penetrate into the center of the yarn to enable easy removal after weaving (Goswami, *et al.* 2004).

Starch has long history of being used as a sizing agent in the textile industry. Natural starch and its derivatives still constitute nearly 75percent of the sizing agents used in the textile industry throughout the world and could remain the predominant ingredient in most types of size (Zhu and Gao, 2008).Soy meal contains around 48percent soy proteins Therefore, more than 1.2 million tons soy meal will be consumed for sizing application each year (Moreau, *et al*. 2014).

Starch can be derived from renewable resource, abundantly available, inexpensive and forms excellent films making it a preferred sizing agent. Plant proteins are also available in large quantities at low cost and are easily biodegradable these properties make plant proteins ideal candidates as sizing chemical (Goswami, *et al.* 2004**).** Polyvinyl alcohol (PVA) has been one of the most versatile size materials available for warp sizing formulation since it was commercialized as a textile warp sizing agent sometimes around 1965. Acrylic

monomers are another class of synthetic polymers that have been widely studied for sizing applications.

In the era of industrialization and liberalization and free trade environmental protection cannot be ignored. Since market forces would compel the industries to adopt green practices, and green minded consumer demands shall have to be met. Today new development is taking place in most of the advanced countries. Ecological aspect has been manifested as a consequence. Ecofriendly dyes and chemicals are being insisted upon to be used in the garment wet processing units. Several researches are on to the study the pollution problems posed by the by-products produced during dyeing, finishing, printing, discharging the residue after use.Textile sizing is facing considerable challenges due to concerns on price and availability of sizing agents and increasing environmental restrictions(Yang and Reddy, 2013).

Textile processes such as sizing and desizing, bleaching and dyeing consume considerable amounts of water and energy and are also the primary sources of pollution. Considerable efforts are being made to find alternative approaches to the traditional textile processing and making the textile industry more environmentally friendly. (Zhang, 2013)

Nature has provided abundant plant wealth, which possess medicinal virtues for all living creature. The essential values of some plants have long been published but a large number of them remain unexplored as yet.With the emerging worldwide interest in adopting and studying traditional starching methods and exploiting their potential based on different plant source, the evaluation of the natural starch or sizing sources are essential. In this regard, one such plant is *Cassia fistula*. The products derived naturally are used more widely in comparison with the synthetic products due to the reasons like low toxicity, biodegradability, biocompatibility, easy availability and its affordable cost. Today, there are a lot of people who are opting for natural ways to starch clothes. The products which are available in the market have harsh chemicals that might tear or damage clothes after washing. The natural starch ingredients that boldsky shares with you do not contain high amount of harmful contents to tear good cotton. After every wash we need to starching cloths specially cotton and silk cloths for batter appearance, look and gives appropriate hardness so starching cloths is big and hard task. Starching clothes at home has become a regular habit for working class of people since creases do not form easily.

Cassia fistula Linn. (Cassia) family Caesalpiniaceae commonly known as Amulthus and in English popularly called “Indian Laburnum” has been extensively used in Ayurvedic system of medicine for various ailments. It is deciduous and mixed-monsoon forests throughout greater parts of India, ascending to 1300 m in outer Himalaya. It is an Indian medicinal plant. Medicinally it has been various pharmacological activities like antimicrobial, antifungal, antipyretic, analgesic, larvicidal anti-inflammatory, antioxidant ,antitumor, hepato-protective, hypoglycemic, activities. The golden shower tree is known asaragvadha, meaning "disease killer" andself-medicationor any use without medical supervision is strongly advised against in Ayurvedic texts.This plant is widely used by tribal people to treat various ailments including ringworm and other fungal skin infections (Rajan et al. 2001).

Cassia fistula is widely grown as anornamental plant in tropical and subtropical areas. *Cassia fistula* is found widely in India, Pakistan, Myanmar, Srilanka etc. This tree is the national tree of Thailand and its flower is its national flower. It is also the state flower of Kerala in India

The edible fruits also have medicinal properties, but very little is known about its total nutritive value for human consumption. *Cassia fistula* laxative actions come from a group of well documented compounds called anthraquinones that are found in all Cassia and Senna plants in varying degrees. The seeds contain approximately 2 per centanthraquinones, 24 per cent crude protein, 4.5 per cent crude fat, 6.5 per cent crude fiber, and 50 per cent carbohydrates. . In addition to the anthraquinone glycosides, other compounds documented in the plant include fistulic acid, rhein, rheinglucoside, galactomannan, sennosides A and B, tannin, phlobaphenes, oxyanthraquinone substances, emodin, chrysophanic acid, fistuacacidin, barbaloin, lupeol, beta-sitosterol, and hexacosanol.

Taxonomic Classification:Kingdom – Plantae,Subkingdom – Tracheobinota, Super Division –Spermatophyta,Division – Mangoliophyta, Class – Magnoliopsida, Sub Class – Rosidae,Order – Fabale, Family –Fabacae, Genus – Cassia, Species – *fistula*.

Geographical Source:In deciduous and mixed monsoon forests throughout greater parts of India, ascending to 1300 m in outer Himalaya. In Maharashtra, it occurs as a scattered tree throughout the Deccan and Konkan. The plant is cultivated as an ornamental throughout India.

Morphology:It is a deciduous tree with greenish grey bark, compound leaves, leaf lets are each 5-12 cm long pairs. A semi-wild tree known for its beautiful bunches of yellow

flowers and also used in traditional medicine for several indications. A fruit is cylindrical pod and seeds many in black, sweet pulp separated by transverse partitions. The long pods which are green, when unripe, turn black on ripening after flowers shed. Pulp is dark brown in colour, sticky, sweet and mucilaginous, odour characteristic, and somewhat disagreeable. Drug occurs in flat or curved thick pieces; outer surface smooth to rough with warty patches; greenish grey to red; inner surface rough, reddish with parallel striations; fracture, laminate; odour, sweet, characteristic; taste and astringent.

A tree 6-9 m high; trunk straight; bark smooth and pale grey when young, rough and dark brown when old; branches spreading, slender. Leaves 23-40 cm long; main rhachis pubescent; stipules minute, linear-oblong, obtuse, pubescent. Leaflets 4-8 pairs, ovate or ovate-oblong, acute, 5-12.5 cm by 3.8-9.5cm, bright green and glabrous above, paler and silvery-pubescent beneath when young, the midrib densely pubescent on the underside, base cuneate; main nerves numerous, close, conspicuous beneath; petiolules 6-10 mm long, pubescent or glaborous. Flowers in lax racemes 30-50 cm. long; pedicels 3.8-5.7 cm. long, slender, pubescent and glaborous. Calyx 1 cm long divided to the base, pubescent; segments oblong, obtuse. Corolla 3.8 cm across, yellow; stamens all antheriferous. The pods are pendulous, cylindric, nearly straight, smooth, shining, brown-black, indehiscent, with numerous (40-100) horizontal seeds immersed in a dark coloured sweetish pulp. Seeds broadly ovate, 8mm. long, slightly less in breadth, and 5mm thick.

The fruit pods are 40-70 cm long and 20-27mm in diameter, straight or slightly curved, smooth but finely striated transversely, the striations appearing as fine fissures. The rounded distal ends bear a small point marking the position of the style. The dorsal suture appears as a single vascular strand and the ventral suture as two closely applied strands. Internally the pod is divided by thin, buff coloured, transverse dissepiments at intervals of about 0.5cm. Each compartment contains one seed which is flat, oval, reddish brown with a well-marked raphe. The seed contains a whitish endosperm in which the yellowish embryo is embedded.

Phytochemistry:Ali *et al.* (2003) isolated three lectins, i.e. CSL-1, CSL-2 and CSL-3, purified from the *Cassia fistula* seeds and were tested for their antibacterial activities against different pathogenic bacteria. The neutral sugar contents of CSL-1, CSL-2 and CSL-3 were estimated to be 3.5 per cent, 3.1 per cent and 2.0 per cent, respectively. The sugar

composition of the lectins was found to be galactose in CSL-1, galactose and glucose in CSL-2, and galactose and mannose in CSL-3.

Sayeed*et al*. (1999) observed that *Cassia fistula* seed grown under different soil and climatic conditions of Bangladesh, contained 3 per cent golden coloured oil. The oil was fractionated into mono, di, and triglycerides by silicic acid column chromatography. The triglycerides varied from 89.16 per cent to 91.01 per cent, diglycerides from 2.51 per cent to 3.32 per cent and monoglycerides from 0.91 per cent to 0.98 per cent depending on the areas from which the seeds were collected. Fractionation of lipids into three major lipid groups neutral lipids, glycolipids and phospholipids was carried out by silicic acid column chromatography. The neutral lipids were accounted for over 89.80 per cent of the total weight of the lipid employed. Saturated and unsaturated fatty acids present in the oil were separated and varied from 23.79 per cent to 28.20 per cent and 63.28 per cent to 66.71 per cent respectively depending on the areas. The fatty acid composition of the oil was analysed by gas liquid chromatography (GLC). The major fatty acids found in the oil were linoleic acid (42.42 per cent), oleic acid (29.62 per cent), stearic acid (14.33 per cent) and palmitic acid (11.41 per cent). In addition to the above, caprylic acid (0.76 per cent) and myristic acid (1.44 per cent) were also present in minor amounts.

Kuo*et al*. (2002), revealed that four new compounds, 5-(2- hydroxyphenoxymethyl) furfural, (2′S)-7-hydroxy-5-hydroxymethyl-2-(2′-hydroxy propyl) chromone, benzyl 2-hydroxy-3,6-dimethoxybenzoate and benzyl 2β-O-D-gluco-pyranosyl-3,6-dimethoxybenzoate, together with four known compounds, 5-hydroxymethylfurfural, (2′S)-7-hydroxy-2-(2′-hydroxypropyl)-5-methylchromone, and two oxyanthraquinones, chrysophanol and chrysophanein, were isolated and identified from the seeds of *Cassia fistula*. The structures were determined on the basis of spectral data explanation, and the synthesis of a compound was carried out.

Yadav*et al*. (2003) isolated a new bioactive flavone glycoside 1 (mp 252-2540C, C28H32O16, [M]+ 624 (EIMS)) was isolated from the acetone soluble fraction of the defatted seeds of *Cassia fistula*. It was characterized as a new bioactive flavone glycoside 5,3',4'-trihydroxy-6-methoxy-7-O- alpha -L-rhamnopyranosyl-(1 -> 2)-O- beta -D-galactopyranoside by several colour reactions, spectral analysis and chemical degradations.

In this research*Cassia fistula* seeds were used which are high in carbohydrate to size muslin fabric and the effect of sizing conditions on the fabric properties (physical) and its comparison to commercially available sizing agent was studied.The researcher concentrates on this starch source as it is widely available throughout in India. The other reason for selecting the starch source is that *Cassia fistula* seed starch is totally eco-friendly and cost effective.

This research was carried out to full fill the followingobjectives:

1. To characterize the starch obtained from *Cassia fistula* seeds.
2. To optimize the starch recipe for sizing of cotton fabric with *Cassia fistula* seed starch.
3. To study the effects of sizing agents from *Cassia fistula* seeds on cotton fabric at different concentration and identify the functional and physical properties of fabrics.
4. To compare the fabric quality parameters of sample sized with *Cassia fistula* seeds against commercial starch sample.
5. To assess the acceptability of starch fabric by the consumers.

METHODOLOGY

This chapter furnishes the methodological details of the present investigation/research. To achieve the planned objectives lab experiments were conducted. The methodological details are presented below. To achieve the planned objectives, experimental research design was used.

Laboratory experiment:

A series of experiments were performed to develop starch from *Cassia fistula* seeds for stiffening cotton muslin fabric at different concentration. Starch was applied using standard techniques. Arrowroot starch was also applied on cotton to compare with *Cassia fistula*. Starched fabric was tested for varied physical parameters using standard techniques.

These experiments were replicated thrice to achieve accuracy in results. The methodological details of the study are grouped under following heads.

1. Locale of study.
2. Sample and its selection.
3. Development of tool.
4. Data collection.
5. Analysis of data.

3.1 LOCALE OF STUDY

The study was conducted in the laboratory of department of Textile and Apparel Designing, college of Home Science, Udaipur (Rajasthan).

3.2 SAMPLE AND ITS SELECTION

3.2.1 Fabric selection:

The study was conducted on cotton i.e. muslin cloth having different fabric weight (Thin, Medium and Thick) was selected for the experiments.

3.2.2 Selection of starch material:

Cassia fistula seeds were selected as natural starch for the study. Pods were collected from the MPUAT University Campus and *Gulab Bagh*(Udaipur). Seeds wereremoved from pods and dried in shade and then ground to make into fine powder.

3.2.3 Sample selection for assessment of the acceptability of starched fabric:

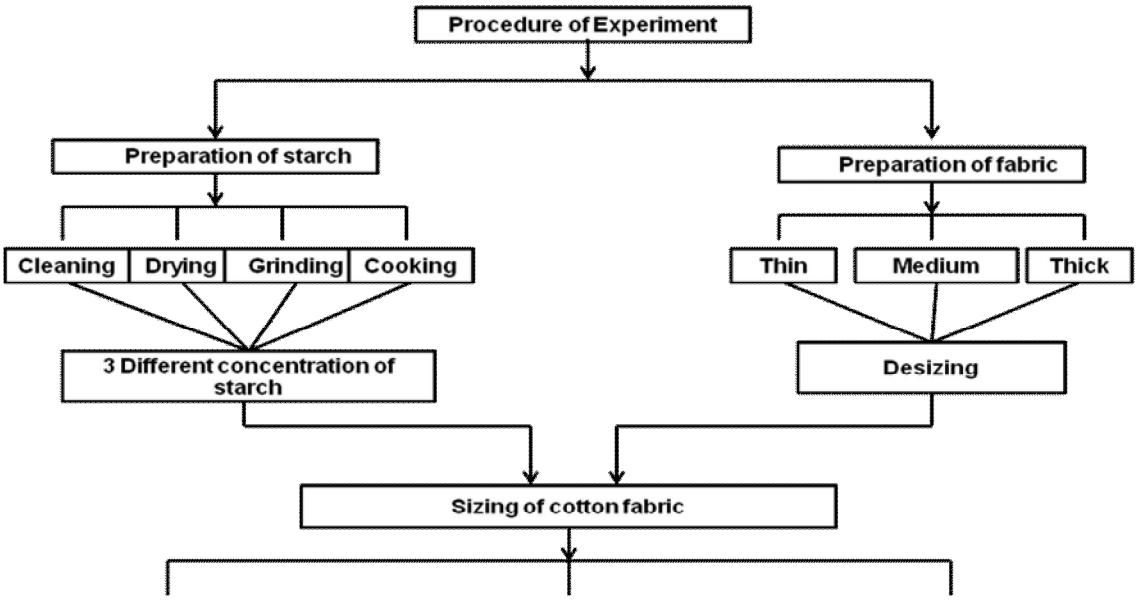
Thirty respondents who were using starched cotton dupatta were randomly selected from College of Home Science. For this purpose a list of post graduate students were collected, their willingness to participate in the study was taken and thirty respondents were selected randomly from willing candidate list.

3.3 DEVELOPMENT OF TOOL

3.3.1 Rating scale:

To assess the acceptability of starched fabric by consumer a rating scale were developed. The evaluation was in term of texture, luster, stiffness, thickness, drape, color and suitability of sized fabric to the end use.

3.4 PROCEDURE OF DATA COLLECTION



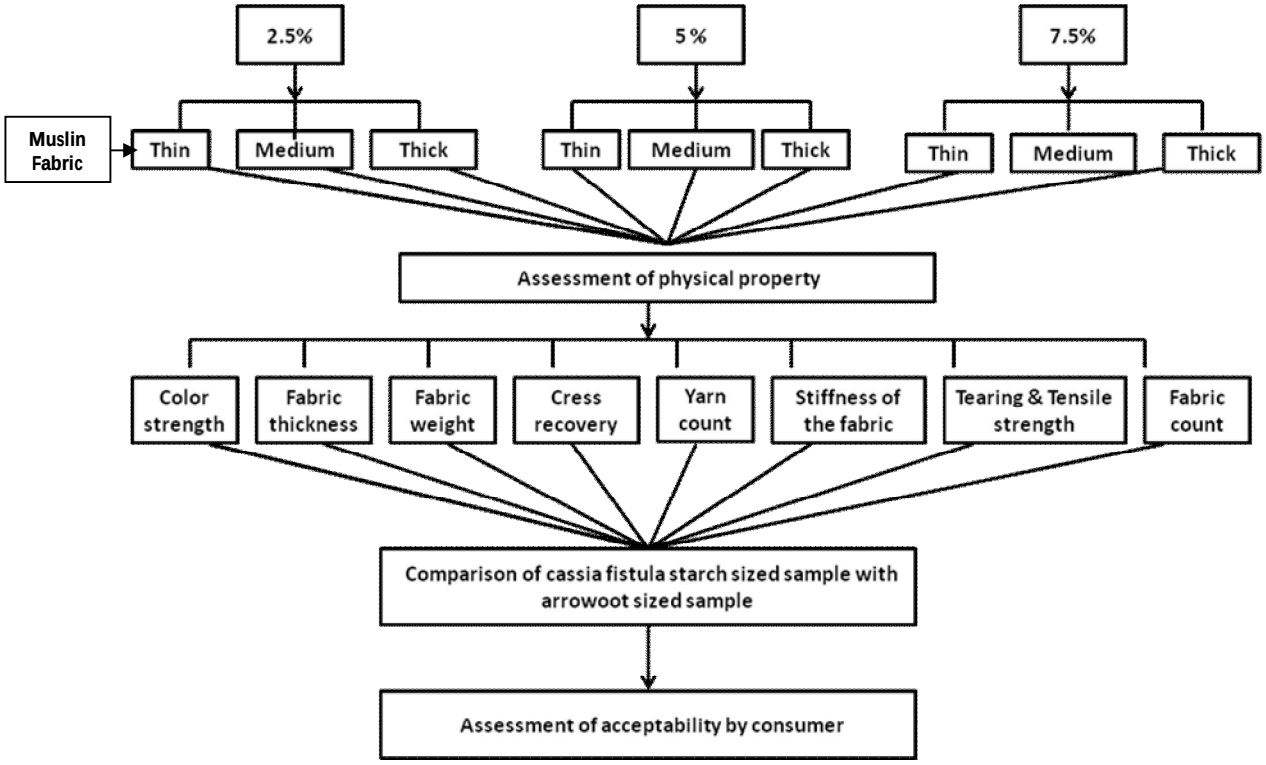


Figure 1: Flow chart showing plan of work

The study was conducted in four steps.

3.4.1 Characterization of the starch obtained from *Cassia fistula* seed.

3.4.2 Application of starch.

3.4.3 Assessment of fabric parameters.

3.4.4 Comparison of cassia *fistula* and Marmanta arundinacea starched sample.

3.4.5 Assessment of the acceptability of starched fabric by consumer.

3.4.1 Characterization of the starch obtained from *Cassia fistula* seed:

Scanning Electron Microscopy (SEM), also known as SEM analysis or SEM microscopy, is used very effectively in microanalysis and failure analysis of solid inorganic materials.

Magnification:From 5 x to 300,000 x.

Sample size:Up to 200mm (7.87in.) in diameter and 80mm (3.14 in.)in height.

Model: nova- nano SEM-450.

Materialsanalyzed: Solid inorganic materials including metals and polymers.

SEM analysis process: A pinch of the powder is sprinkled gently with a spatula on the carbon tape. The stub is tapped to remove the very loosely held powder. A blower is then used to remove the extra particles. A drier is further used to make sure of the removal of any other loose particles and also drying of the moisture content if any.

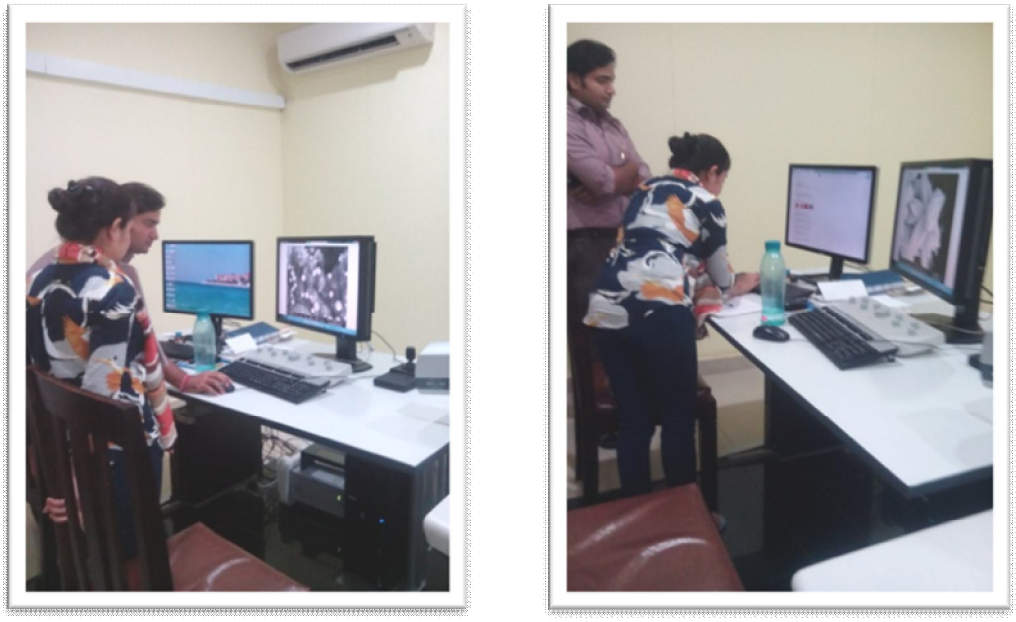


Plate 1: Testing of scanning electron microscopy (SEM)

Scanning electron microscopy uses a focused beam of high energy electrons to generate a variety of signals at the surface of solid specimens. In most SEM microscopy application/ data is collected over a selected area of the surface of the sample and a two dimensional image is generated that displays spatial variations in properties including chemical characterization, texture and orientation of materials.

3.4.2 Application of starch:

1. Preparation of raw material.
2. Preparation of fabric.
3. Optimization of the different starch concentrations.
4. Application of starch solution on the fabric.
5. Visual evaluation of starched fabric.

Preparation of raw material:*Cassia fistula* pods were collected from *Gulab Bagh* and MPUAT University Campus. 2kg 135gm seeds were removed from total 52 kg 647 gm pods. Seeds were cleaned and washed in tap water to remove sticky brown pulp from seeds. Than seeds were dried in sun light for 2-3 days then dried and processed to remove outer layer (husk) of the seed which is brown in color. Inner white portion of seed was ground into fine powder and stored in air tight container till further use.

Cassia fistula pods

↓

Removed seeds

↓

Washed in tap water

↓

Dried seeds in sunlight

↓

Removed the outer seed husk

↓

Ground in fine powder

↓

Store in air tight container

Figure2: Flow chart of preparatory process of raw material

Cassia fistula tree *Cassia fistula* fruit *Cassia fistula* seed Seeds without coat

Plate 2 : *Cassia fistula* tree and its different parts

Preparation of fabric: For conducting the experimental trials of different concentrations of *Cassia fistula* starch as starching agents on cotton fabric. It was required to have muslin fabric free from starch or any other stiffening agent. Hence a laboratory procedure for desizing prescribed at IS: B1967- 1961 was conducted and showed in flow chart -

Boiling fabric in distilled water for 45 min

↓

(MLR-1:100)

↓

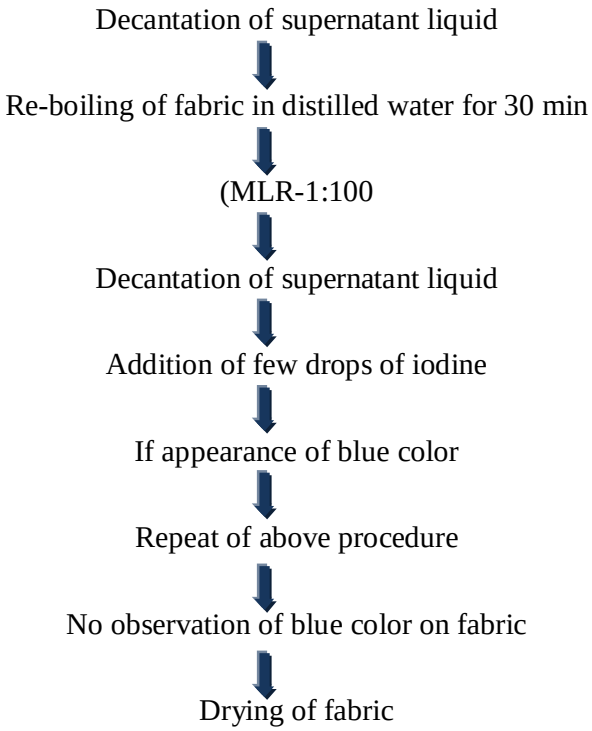
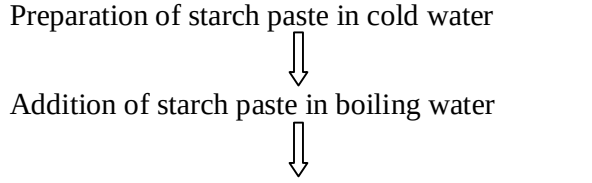


Figure 3: Line diagram of desizing process

Optimization of the different starch concentrations: The concentration of starch was optimized by taking three different concentration prepared by boiling method, 2.5, 5, 7.5, gms of *Cassia fistula* seed powder each in 3 beakers containing 1:30 MLR of distilled water. After boiling, starch solutions were filtered and starch paste applied on fabric and dried in sun light.

Application of starch solution on the fabric: For starching the cotton fabric hot starching method was adopted. The starch powder presoaked in cool water carefully removing all the lumps, this paste added in boiling water and continued boiling till the starch particles burst out and making colourless, gelatinous and translucent solution. Than cooling of starch solution and filtered it through double muslin cloth. Fabric sample (desized)soaked in prepare solution for 10 minutes. Removed the fabric sample and slightly wringing of starched sample. Dried in direct sun light and the starched fabric were packed in polythene for further physical testing.



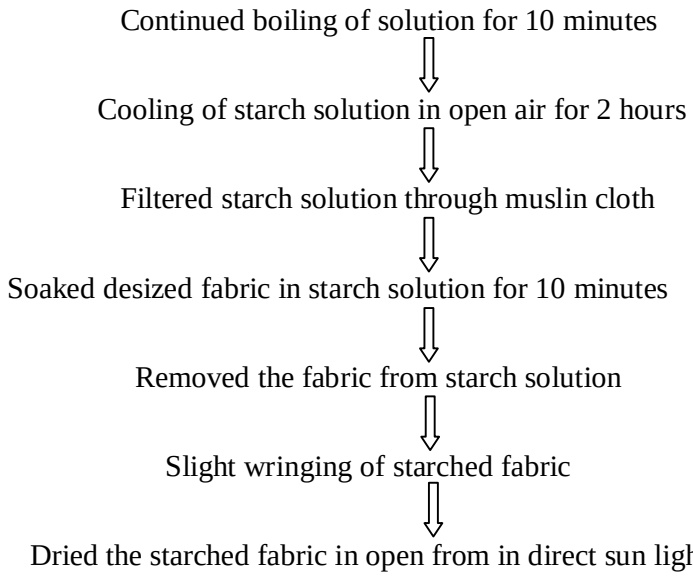


Figure 4: Flow chart of application process of starch on fabric

Visual evaluation of starched fabric:A panel of five members was selectedfrom the Department of Textile and Apparel Designing as subject matter specialists. The visual evaluationof cotton fabric samples sized with all the three concentration of *Cassia fistula* starch (2.5%, 5% and 7.5%) was done by the panel memberson the basis of texture, luster, drapability, stiffness and thickness for the selection of the best concentration.

3.4.3 Assessment of Fabric Parameters:

Properties of fabric which can be assessed with the help of mechanical devices are known as physical property for e.g. tensile strength, thickness, stiffness,weight of the fabric etc.

The starched samples were assessed to see the effect of different concentrations of starch on various physical parameters before and after treatment in terms of fabric weight, fabric count, fabric stiffness, fabric thickness, tensile strength etc. as per standard test method of ASTM (American Society for Testing Materials).

Fabric Thickness: Thickness of the samples was measuredas the distance between the reference plate on which the specimen rests and the parallel circular pressure foot under nominal pressure on the area under test. The method as per (ISI:7702-1975) was used to measure the thickness of the sample ‘fabric thickness gauze’ was used for the test the pressure foot and reference plate were cleaned and thickness gauge set on zero. All the creases and folds were removed from the sample. The fabric was kept between the two

parallel plates of thickness gauze and a known arbitrary pressure was applied between the plates and maintained for 30 second the distance between the plates was measured at 3 different places and the mean value was calculated.

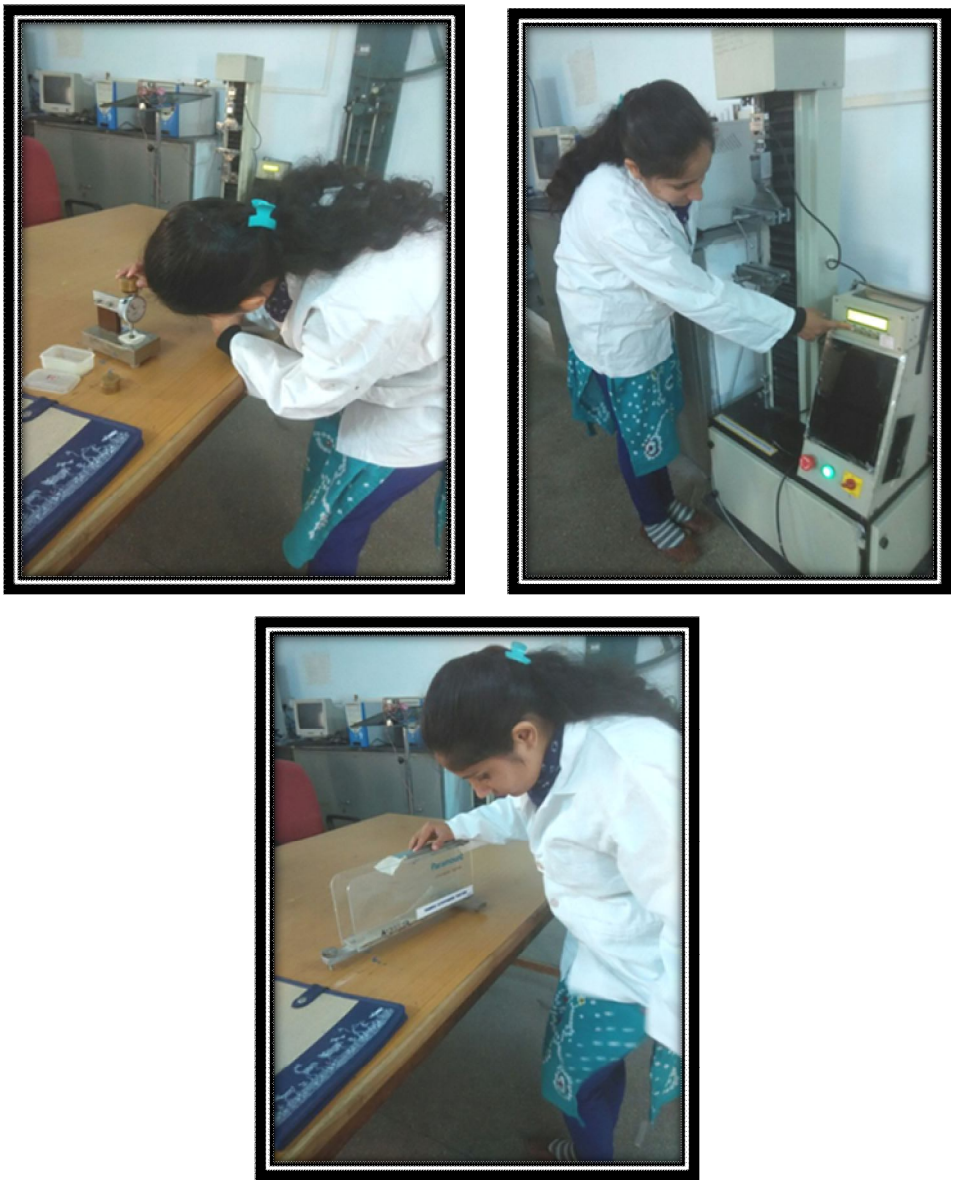


Plate 3: Testing of fabric thickness, tensile strength and fabric stiffness

Plate 4: Testing of crease recovery, fabric weight and fabric count

Tensile Strength: Tensile strength of the starched fabric before and after with different concentrations of selected starch (*Cassia fistula* and arrowroot)was measured by tensile strength testing machine raveled strip test method as described in ISI (IS: 1969- 1968) was used to measure the breaking strength of the sample the warp way and weft way test specimen of 6*4 cm were cut from the fabric the warp and weft direction for which the breaking load was required. The yarn at the edges were raveled away to obtain specified width i.e. 30*5 cm. the test specimen was mounted centrally in the clamp with the longer side parallel to the direction of application of load. Continuous load was applied longitudinally to the specimen ruptured with the speed of 75 mm/minute. Values of breaking load of the test specimen were read directly on the digital screen. Total three observations were recorded for each sample and mean breaking load was calculated separately for warp way and weft way test specimen.

Crease Recovery: Determination of wrinkle recovery or crease recovery of the fabric, which enables the fabric to resist wrinkling or mussing, was done by measuring the 'crease recovery angel' crease recovery angle was measured as per ISI (IS:4681-1968) 'On crease recovery tester'. A rectangular specimen of two inch long and 1 inch wide was cut folded precisely in half and placed on the anvil under 2 kg weight of loading device for 1 minute for creating the crease in the fabric After the load was removed and specimen was directly transferred to the instrument by holding 1 limb in the clamp of the instrument. The specimen was allowed to recover from the crease. The dial of the instrument was rotated to keep the free edge of the instrument in line with the knife edge. After 1 minute, the period allowed for recovery, the recovery angel in degrees was read on the engraved scale. Three observations were taken and mean value for the recovery angles were calculated for the warp and weft direction of each test fabric.

Fabric Stiffness: To determine the stiffness of the fabric i.e. resistance of fabric to bending, until ever test as described in ISI (IS: 6490-1971) was used. The instrument used was 'cloth stiffness tester'. A rectangular specimen was cut from the fabric to be tested according to the size of bending length scale i.e.6*1 inch. The specimen was placed length wise on the platform with one end coinciding with the upper front edge of the platform the bending scale was placed over the test specimen in such a way that the zero of the scale were pushed forward gently and slowly until the leading edge of the specimen projects beyond edge of the platform and overhangs like cantilever and bends down wards. The length of the overhanging portion of the sample was read from the scale, when the edge of the sample coincides with

the inclined lines of the tester. Same test were repeated for three samples both in warp and weft direction and bending length was calculated by following formula given by booth (1947)

Bending length = l/2 cm

Where,

L= the mean length of overhanging portion in cm.

Fabric Weight: Measurement of GSM: the GSM was determined using ASTM D3776 test method. Principle: fabric weight refers to the relative weight of fabric, not the absolute weight. Fabric weight is an important factor for international selling and buying. GSM is a device to cut circular specimens of 100 square cm of a fabric very accurately. The result is obtained directly from the reading on the balance. It may be expressed as the weight of a particular size piece, such as grams per square meter or ounces per square yard. Apparatus: the "specified GSM quadrant size" was used to determine the weight of the fabric i.e. before and after starched fabric sample. Preparation of test specimens: fabric sample was cut to the standard area by sample cutter for GSM and weighed by a precision digital scale. Procedure: the sample to be cut was placed between the sample cutter and a special cutting board.

Yarn Count: Fabric count is determined by counting the number of warp and filling yarn per inch in woven fabric. In the research work fabric dissection method was used to study the effect of sizing on thread count of fabric. The thread count was determining using ASTM-1910-64 test method. Fabric dissection literally means unraveling the cloths and the threads unraveled are counted. The fabric sample cut of 2" * 2" dimension with the help of die. Then 1" * 1" square was measured in center of the sample and marked with a marker. The test specimen was unraveled about ½" on both warp and weft side. Unrivalled threads were counted with an all pin. Test were replicated to take the reading five times. The mean value was obtained to evaluate the results.

Fabric Count: Fabric count is determined bytravelling microscope counting the number of warp and filling yarn per inch in woven fabric. The fabric count was determined using ASTM test method. Place the fabric sample for thread counting first in warp direction under the travelling microscope and adjust the light intensity. With the aid of moving device, count the number of yarns in 1 inch repeat in the same in weft direction also. Test were replicated to take the reading five times. The mean value was obtained to evaluate the results.

Fabric Colour: colour value of the sample was analyzed on the basis of L* a* b* values using reflectance spectra through (colour eye 3100) Macbeth UV spectrophotometer. The L* value is measure of lightness and darkness of the colour while a* and b* define the colour on a two dimensional chromatic space of green-red axis and blue- yellow axis, a* and b* values were evaluated.

3.4.4 Assessment of the acceptability of starched fabric by consumer:

To assess the acceptability of developed starched powder both *Cassia fistula* and arrowrootstarch wasapplied on cotton dupatta having same fabric weight and colour than starched dupatta was evaluated by 30 post graduatestudents for various attributes (Texture, Luster, Drapability, Stiffness, Thickness).

3.5 ANALYSIS OF DATA

To achieve the objectives of the present study the data was transferred on to tables and tally sheets it was coded tabulated and analyzed statistically in the light of objectives of the study.

Coding: To facilitate the procedure a coding key was developed and the data were recorded in the coding sheet (in ms excel).

Tabulation: The data were composed into tables and then percentage values were calculated using statistical method.

Statistical measures used:

Following statistical measures were used to analyze the data.

Frequency: Data obtained from consumer acceptability rating scale was expressed in frequency.

Percentage: The rating obtained by the starched dupatta of each category was tabulated according to the scores obtained and converted into percentage.

Ranking: The opinion on starched dupatta or fabric of respondents (panel of judges from TADdesign) was recorded on a separate rating Performa. The total score obtained by each attribute of judgment was ranked in order of acceptance.

Mean Percent Score (MPS): To measure the acceptability of developed starch by respondents, mean percent score was calculated with the help of following formula:

$$MPS = \frac{\text{SUM of scores obtained by starched dupatta}}{\text{Maximum obtainable scores}} \times 100$$

Acceptability Index: To assess the percentage of consumer preference of the starched duptta an index was setup:

$$\text{Acceptability Index} = \frac{\text{Total score of each attribute of evaluation}}{\text{Maximum score obtained}} \times 100$$

ANOVA: In order to analyze the significant difference in fabric weight, thickness, stiffness, and crease recovery, count, tensile strength, and yarn count, analysis of variance was calculated.

Table 1 : ANOVA for one way classified data

Source of Variance	Degree of Freedom (d.f.)	Sum of squares (s.s.)	Mean Sum of Squares (MSS)	F Ratio
Treatment	t-1	SST	$F = \frac{SST}{t-1}$	$F_1 = \frac{MST}{MSE}$ F (t -1), t (r-1) d.f.
Error	t (r -1)	SSE	$MST = \frac{SSE}{t(r-1)}$	
Total	Tr -1	TSS		

Sum of square due to treatment (SST)

$$SST = \frac{\sum_{i=1}^{t}\left(\sum_{j=1}^{r} X_{ij}\right)^2}{r} - C.F.$$

Total sum of square (TSS):

$$TSS = \frac{\sum_{i=1}^{t}\left(\sum_{j=1}^{r} X_{ij}\right)^2}{r} - C.F.$$

Sum of square due to error (SSE):

$$SSE = TSS - SST$$

Critical difference (CD): The critical difference was calculated for finding out the significant difference between the corresponding two mean values:

Standard error for means:

$$SEm = \sqrt{\frac{EMS}{r}}$$

Where,

EMS = Error mean square

r = Number of replications

JUSTIFICATION OF THE STUDY:

Cassia fistula is an indigenous plant widely grown throughout India. It is derived from renewable resources, abundantly available at large quantity, low cost and is easily biodegradable. These properties of *Cassia fistula* make it as an ideal sizing agent. *Cassia fistula* seeds contain 50% carbohydrate, 24% crude protein, 4.5% crude fat and 6.5 % fiber it also have antimicrobial and antifungal properties. A number of study have been done to obtain size substance from natural sources (plant) i.e. corn starch, soy protein, potato starch, arrowroot, etc. but no study have been reported about the use of *Cassia fistula* seed starch hence Cassia seed gum is selected for the present research study. In this research we will use *Cassia fistula* seeds which are high in carbohydrate and eco-friendly, to sized cotton fabric and the effect of sizing condition on the fabric properties (physical and its comparison to commercially available sizing agent.

IMPLICATION OF THE STUDY:

1. This study will be useful in initiating cottage and small scale industries of natural sizing material which will prove very beneficial for income generation in rural and tribal areas.
2. Result of this research work will be beneficial in fighting back the environmental pollution to a certain level.
3. The study shall contribute to the present knowledge on naturally available sizing agent
4. The study will give direction towards exploring new and wider possibilities in the use of natural sizing agent.
5. The work shall be used as a guideline towards exploring more plant source for extraction as sizing agent.
6. The study will suggest *cassia fistula* seed as a suitable sizing agents source for cotton thus providing totally eco-friendly cost effective sizing.

OPERATIONAL DEFINATION:

1. **Environment - friendly –** It means earth-friendly or not harmful to the environment. This term most commonly refers to products that contribute to green living or practices that help conserve resources like water and energy.
2. **Sizing agent** – A fabric finish that adds weight, stiffness, and firmness.Treatment of a fabric surface with glutinous material.
3. **Physical-property -** Property which can be measured with the help of mechanical device.
4. **Muslin Cloth –** Course type of cotton fabric made of carded yarns. Grey print cloths are known as unbleached muslins.

DELIMITATION: The study will be delimited to-

1. Use of only *Cassia fistula* seeds from plant with three different concentrations i.e. 2.5%, 5%, 7.5%.
2. Under physical property only fabric count, yarn count, fabric thickness, fabric weight, fabric crimp, cress recovery, stiffness of the fabric, tearing and tensile strength will be assessed.
3. Grey cotton fabric will be used.
4. Only one commercial starch that is Arrowroot (*Maranta Arundinacea)* will be used for comparison with natural sizing agent.

REVIEW OF LETERATURE

"One of the simplest ways of economizing effect in an inquiry is to review and build upon the work already done by others".

A review of literature can give us an overview or act as stepping stone in the field of enquiry what has already been said on the topic, which the key writers are, how prevailing ideas fit into our study and how our findings are differs from them. It keeps on up to date with what is current in the field.

In the present study the investigator made a survey of literature by reviewing pertinent text and researches related to the content and modalities of

- *Cassia fistula* and its properties
- Natural and synthetic sizing agents
- Eco-friendly textile finishes

Cassia fistula and its properties

Sayeed*et al*. (1999) the presence of glycerides with linoleic, oleic, strearic and palmitic acids as major fatty acids together with traces of caprylic and myristic acids in the seeds of *Cassia fistula* were reported.

Bhakta*et al.* (2001) reported that the seeds show hypo-cholesterolemic potential in hypercholesterolemic rats and the hepatoprotective activity of leaf extract of *cassiafistula*.

Rajan*et al.* (2001) this plant is widely used by tribal people to treat various ailments including ringworm and other fungal skin infections.

Siddhuraju*et al*. (2002) the microbial activity of hydroalcohol extracts of leaves of *Cassia fistula* Linn. (anethnomedicinal plant) was evaluated for potential antimicrobial activity against medically important bacterial and fungal strains. The antibacterial and antifungal activities of extracts (5, 25, 50, 100, 250 µg/ml) of *Cassia fistula* were tested against two Gram-positive— Staphylococcus aureus, Streptococcus pyogenes; two Gram-negative— Escherichia coli, Pseudomonas aerugi-nosa human pathogenic bacteria; and three fungal strains—Aspergillusniger, Aspergillusclavatus, Candida albicans. The results revealed that in the extracts for bacterial activity, S. pyogenes and S. aureus were more sensitive as

compared with E. coli and P. aeruginosa, and for fungal activity, C. albicans shows good result as compare with A. niger and A. clavatus. The results show that the extracts of *Cassia fistula* were found to be more effective against all the microbes.

According to Ali *et al.* (2003) a fast growing, medium-sized, deciduous tree which grows to about 9 meters in height. Leaves are compound, with 4-8 pairs of opposite leaflets. It produces flowers which are golden yellow and hang in showering bunches of up to 40 cm long earning its common name of golden shower tree. The ensuing pods are one inch thick, and can reach length of 24 inches. *Cassia fistula*is semi deciduous after flowering.

Ali *et al.* (2003) reported in study on antibacterial activity and cytotoxicity of three lectins purified from the seeds of *Cassia fistula* three lectins CSL-1, CSL-2, and CSL-3 purified from the seeds were tested for their antibacterial l activity against 14 pathogenic bacteria using 30 microgram disc. The lectin CSL-3was found to be active against all of the bacterial strains. The lectinCSL-2 showed poor activity against most of the bacterial strains. But the lectin CSL-1was found to be inactive against all the bacterial strains.

Ali *et al.* (2004) reported that the antibacterial and antifungal activities of*C. fistula* and M. ferrea extract were tested on 14 bacteria and 6 fungi. *C. fistula* extracts showed stronger antibacterial activity than M. ferrea.

Kumar *et al.* (2006) *Cassia fistula* exhibited significant antimicrobial activity and showed properties that support folkloric use in the treatment of some diseases as broad-spectrum antimicrobial agents.

Patel *et al.* (2007) stated in the article variety of flora and fauna was gifted by nature to us. Natural and herbal products are used by human from the earliest century in the pharmaceutical field. Natural or herbal products are preferred over the synthetic product because of their good biocompatibility with the other materials, ease of availability, lesser toxic effect in comparison with the synthetic, low cost.

Khare (2007) reported that *Cassia fistula* seeds give galactomannan free sugars and free amino acids; flowers gave ceryl alcohol, kaempferol, rhein and a bianthraquinone glycoside, fistulin. Leaves gave free rhein, its glycosides- sennosides A & B.

Moshahid(2009) bio efficacies of *Cassia fistula*, a review on the plant covers the hepato protective, wound healing and antioxidant properties and the review also conclude by

saying that these properties of the plant are due to the presence of total phenolic content, proanthocyanidin and flavonoid content.

Gupta (2010) stated in the book “medicinal and aromatic plants” (Cassia) family Caesalpiniaceae commonly known as Amulthus and in english popularly called “Indian Laburnum” has been extensively used in Ayurvedic system of medicine for various ailments. It is deciduous and mixed-monsoon forests throughout greater parts of India, ascending to 1300 m in outer Himalaya, is widely used in traditional medicinal system of India has been reported to possess hepatoprotective, anti-inflammatory, antitussive, antifungal and used also check wounds healing and antibacterial.

Jaffary*et al.* (2010) evaluated the potential of *Cassia fistula* boiled extract in the treatment of cutaneous leishmaniasis, to evaluate the efficacy of intralesionalmeglumineantimonate-*C. fistula* fruit gel combination for the treatment of cutaneous leishmaniasis. A total of 140 patients with cutaneous, one group received intralesionalmeglumineantimonate injection and *C. fistula* fruit gel, and the second group (control) was treated with intralesionalmeglumineantimonate plus placebo gel. Improvement was defined as complete cure, partial cure and treatment failure. At week 12, forty-seven (67.1%) patients in the experimental group achieved complete cure, compared to 29 (41.4%) patients in the control group. Results indicate that the *C. fistula* fruit gel increases the efficacy of intralesionalmeglumineantimonate for the treatment of cutaneous leishmaniasis. Combination therapy with intralesionalmeglumineantimonate and *C. fistula* fruit gel should be considered for the treatment of acute cutaneous leishmaniasis.

Bhalodia (2011) reported that the evaluation of in vitro Antioxidant activity of hydro-alcoholic seed extract was done. The study revealed that the hydro-alcoholic extracts of the seeds have significant radical scavenging activity. In this study *Cassia fistula* was identified as potentially novel source of free radical scavenging compound. The results clearly indicate that *Cassia fistula* is effective against free radical mediated diseases and also helpful to draw special attention for further studies.

Panda *et al.* (2011) conducted research on “Antibacterial activities and phytochemical analysis of *Cassia fistula* (Linn.) Leaf”reported thatSequential extraction was carried out using solvents viz. petroleum ether, chloroform, ethanol, methanol and water from leaf of the plant were investigated for preliminary phytochemical and antibacterial property. Results of the study showed that all the extracts had good inhibitory activity against Gram-positive test

organism. Although all five extracts showed promising antibacterial activity against test bacterial species, yet maximum activity was observed in ethanol extract. The minimum inhibitory concentration ranged in between 94 to 1 500 μg/ml.

Bhalodia (2011) stated that antimicrobial screening of the seed extract of *Cassia fistula* was evaluated. The aim of the study was to assess the antimicrobial activity and to determine the zone of inhibition of extracts on some bacterial and fungal strains. The results showed that the remarkable inhibition of the bacterial growth against the tested organisms.

Manzoor (2011) antibacterial activity of the fruit pulp and seeds of *Cassia fistula* and its effect on ergosterol biosynthesis was studied. The activity was determined by minimum inhibitory concentration (MIC), Growth Curve Studies, Cytotoxicity, and Ergosterol estimation assay. The study was concluded that the crude extract of fruit pulp t is a promising source of anticanadial compounds.

Bhalodia*et al.* (2011) antimicrobial properties of medicinal plants are being increasingly reported from different parts of the world. The world health organization estimates that plant extracts or their active constituents are used as folk medicine in traditional therapies of 80% of the world's population.

Danish *et al.* (2011) the fruit pods are 40-70 cm long and 20-27mm in diameter, straight or slightly curved, smooth but finely striated transversely, the striations appearing as fine fissures. The rounded distal ends bear a small point marking the position of the style. The dorsal suture appears as a single vascular strand and the ventral suture as two closely applied strands. Internally the pod is divided by thin, buff coloured, transverse dissepiments at intervals of about 0.5cm. Each compartment contains one seed which is flat, oval and reddish brown. The seed contains a whitish endosperm in which the yellowish embryo is embedded.

Daisy (2012) C. fistula, a member of the Leguminosae family, has been extensively used in traditional Indian medicine. Different parts of *C. fistula* are reported to have hepatoprotective, anti-inflammatory, antitussive, antifungal, antitumor, antioxidant, and antibacterial activity.

Thirumal*et al*. (2012) tested the leaf extract of *Cassia fistula* for antifungal activity against Candida albicans. Extracts of the leaves of *Cassia fistula* were prepared in acetone, diethyl ether and methanol. The antifungal activity was performed by paper disc diffusion assay. The methanol extract showed highest activity

Dave and Ledwani (2012) reported that *Cassia* Linn. (Family - Caesalpiniaceae) is a large tropical genus with about 600 species of herbs, shrubs and trees. Most of the plants of the genus are wellknown in Indian system of medicine for their cathartic, purgative and antibiotic properties. Many compounds of structural significance and medicinal importance have been reported from different species of this genus. Species of*Cassia* are rich source of anthraquinones which are wellknown as natural dyes, and are gaining importance in recent years due to environmental pollution caused by synthetic dyes.

Rajagopal*et al.* (2013) reported in the review article -nature has provided abundant plant wealth, which possesses medicinal virtues for all living creatures. The essential values of some plants have long been published but a large number of them remain unexplored as yet.

Rajagopal*et al*. (2013) reported that *Cassia fistula* (Aragvadhah) is an important drug used in the Indian system of medicine. It is a medium sized deciduous tree with long and cylindrical fruits containing pulp and also with a bright yellow coloured flower. The tree is found throughout India in all deciduous forests and hilly tracts.

Yadav*et al.* (2015) reported in study on comparative study of mucilage extracted from seeds of *Cassia fistula* and gum karaya the products derived naturally are used more widely in comparison with the synthetic products due to the reasons like low toxicity, biodegradability, biocompatibility, easy availability and its affordable cost.

Natural and synthetic sizing agents:

Rutenberg and Solanek (1984) stated in the book “Starch Chemistry and Technology” Chemical, physical and biological means have been used to modify starch. The purposes of starch modification are to change the properties of natural starch paste, such as gelatinization point, viscosity stability, freeze-thaw stability, transparency, adhesion force, and film properties, like flexibility.

Malia*et al.* (2002) stated that the use of a biopolymer such as starch can be an interesting solution because this polymer is quite cheap, abundant, biodegradable and edible. Yam tubers (Dioscorea sp.) are a good source of starch for film production, because native yam starch contains about 30% of amylose and amylose is responsible for the film forming capacity of starches.

Cai*et al*. (2003) reported in the article In addition to the primary ingredient, sizing chemicals contain many other additives such as waxes and lubricants, softeners, emulsifiers, and finishing and wetting agents. Starch and starch derivatives are mainly used for cotton and cotton blends and PVA is mainly used for synthetic fibers and their blends. A size is evaluated based on its performance during weaving, ability to be removed (desized) after weaving, cost of the chemical, and biodegradability. A good size should decrease the yarn breakage during weaving, prevent or decrease hairiness, reduce electrostatic problems, and be easily removed during desizing.

Tharanathan (2003) stated that starch consists primarily of branched and linear chains of glucose molecules, name as amylopectin and amylase, respectively. Amylase is essentially a linear molecule with a few branches, whereas amylopectin is a highly branched molecule. Preponderance of amylase in starches give stronger films branched structure of amylopectin generally leads to films with different mechanical properties.

Mostafa and El-Sanabary (2004) reported that Sizing properties of starch could be evidently improved through the grafting of a quantity of acrylic acid onto starch.

Goswami*et al*. (2004) 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.

According to Qin (2006) performance and quality of liquid or solid state acrylic size made in China is identical compared to foreign products. It is possible that combination of acrylic size and modified starch was applied in the sizing process of thin cotton fabric completely instead of PVA. Acrylic size has good film forming ability and adhesion, and excellent size film strength, flexibility and wearability, which is the cardinal basic condition of less or no consumption of PVA in China.

Yang (2008) in study on “Green environment protection textile size” revealed that Main variety guar gum is a kind of natural macromolecular plant gum with excellent water solubility, and extracted from the endosperm of guar beans planted in India and Pakistan. It has excellent adhesion to both total cotton and polyester-cotton. In combination with starch and CMC, its size film had weaker fracture strength, but breaking tensile rate attained 18.59% with great wear ability and 1043 times buckling resistance.

Zhu and Gao (2008) reported in his book “Weaving” Starch has a long history of being used as a sizing agent in the textile industry. Natural starch and its derivatives still constitute nearly 75% of the sizing agents used in the textile industry throughout the world and could remain the predominant ingredient in most types of sizes.

Zhu and Gao (2008) acrylic monomers are another class of synthetic polymers that have been widely studied for sizing applications. In some cases the acrylic size is used alone as the primary film former or as binder component of the size to improve the adhesion between a primary base sizing agent (film former) and the yarn.

Kumar *et al.* (2009) revealed in his article the extracts were subjected to preliminary phytochemical testing to detect for the presence of different chemical groups of compounds. Air-dried and powdered plant materials were screened for the presence of saponins, tannins, alkaloids, flavonoids, triterpenoids, steroids, glycosides, anthraxquinones, cumarin, saponins, gum, mucilage, carbohydrates, reducing sugars, starch, protein and amino acids as described in literatures.

Kurakake*et al.* (2009) reported that starch is semi-crystalline composite of biopolymers of glucose composed of liner α-(1,4)-linked residues with α-(1,6)-linked branch chains. Generally, most starches, such as maize starch, tapioca starch and potato starch contain amylase and amylopectin at proportions of 70 per cent to 80 per cent and 20 per cent to 30 per cent respectively. How waver, waxy corn starch essentially consists of amylopectin alone and is often studied as a model of amylopectin.

According to Rongrong*et al.* (2011) one of the major criteria in evaluating a sizing chemical is the ability to form film and have good adhesion to the substrate. Plant proteins such as soy proteins, wheat gluten, and zein have been extensively studied as films for food packing and other applications. Plant proteins have been made into fibers and nano- and microparticles and have also been used as matrix for composites.

According to kittiphoom (2012) mango kernel starch is eco-friendly and does not create any sort of health hazard to the wearer. Mango kernel starch can be low cost non-conventional starch. Starch is white, odorless and has good pasting and film forming property.

Khalaf (2012) conducted study on “compatibility study in natural rubber and maize starch blends”. Natural rubber (NR) and maize starch (MS) were used and effect of starch

contents on physic - mechanical properties and curing characteristics of the prepared blend vulcanizates was investigated. Results showed an improvement in the physic – mechanical properties.

Chen *et al.* (2013) reported that soy proteins can be used as environmentally friendly sizing agents to replace poly vinyl alcohol. Plant proteins are also available in large quantities at low cost and are easily biodegradable. These properties make plant proteins ideal candidates as sizing chemicals.

Kale (2014) conducted a study on subjective evaluation of cotton fabric stiffened with mango kernel starch reported that mango kernel are rich in starch content which can be used as substitute for cereal starches in the preparation of stiffening agents. Mango kernel contains 69- 79 per cent carbohydrates. Out of which starch alone accounts 92 per cent, which could be extracted by a simple laboratory method. It was observed that as the concentration of mango kernel starch applied to the cotton fabric increased the fabric was preferred more stiffness and texture while the cotton fabric stiffened with less concentration of mango kernel starch then it was more preferred for whiteness and overall appearance.

Lewicka, *et al.* (2015) cationic starches are important commercial modified starches, and widely used as additives in the paper, textile, oilfield drilling, wastewater treatment or cosmetic industry because of their relatively low price, excellent properties and biodegradability.

Liu *et al*. (2015) reported that Cationic starches are important commercial modified starches, and widely used as additives in the paper, textile, oilfield drilling, wastewater treatment or cosmetic industry because of their relatively low price, excellent properties and biodegradability.

Babel *et al.* (2015) revealed that tamarind seed gum or tamarind kernel powder (TKP) is derived from the seed of tamarind indica. Tamarind seed gum, a crude extract of tamarind seeds, is rich in polysaccharide, which contain glucose, xylose and galactose units, in a molecular ratio of 3:2:1. It is insoluble in organic solvents and dispersible in hot water to form a highly viscous gel such as mucilaginous solution with a broad ph tolerance and adhesively.

Eco-friendly textile finishes:

According to Bisschops and Spanjers (2003) textile production consumes considerable amounts of water and chemicals and the textile industry is a major contributor to water pollution and toxic discharges across the world. Producing a kilogram of fabric is estimated to consume about 600–1,000 kilogram of water during the preparation, dyeing, and finishing stages depending on the type of fabric made and processes used. A significant proportion of the dyes and chemicals used for textiles which are released into effluents are reportedly hazardous to the environment.

According to Zhang *et al. (*2005) 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.

Sivaramkrishna (2008) discussed in aarticle “effluent treatment a review” that, due to the nature of various chemical processing of textile, large volumes of waste water with numerous pollutants are discharged. Since these streams of water affect the aquatic ecosystem in number of ways such as depleting the dissolved oxygen content or settlement of suspended substance in anaerobic condition, a special attention needs to be paid.

Kale (2010) carried out a survey study entitled “Aspects related to household practices of stiffening clothes” stated that stiffening is the last finishing done by the housewives to their family clothes after washing them at home. Stiffening helps to restore body to the limp clothes. A survey was conducted among five hundred housewives of Parbhani town for studying different aspects of clothes stiffening practices who used to stiffen their family clothes at home. The findings revealed that cent per cent housewives stiffened cotton clothes followed by synthetic clothes and then silk clothes at home. Housewives mostly stiffened white and light coloured Sari, *Punjabi suits, Duppatta, gent’s Kurta- Pajama* and shirts using sago, commercial starches and aerosol stiffeners by adopting boiling and instant methods. Clothes were stiffened in summer, spring or whenever required and were worn for three to six times prior to next stiffening.

According to Bhavani (2011) starching of cottons is an age old aristocratic and well known process for giving a fabric stiff and smooth finish, elegant look and good drape. Stiffening agents are applied on cloth in order to build up the apparent weight, impart thickness to improve luster and also to prevent the fabric from soiling quickly.

Swami *et al.* (2012) reported in the recent past, the pollution resulting from the production and use of synthetic colorants, has received increased worldwide awareness. This has led to a significant revival of interest in natural colorants in the last few years. There is a realization amongst consumers and in textile industry for a need to re-invent natural dyes to impart color to textiles.

Babel *et al.* (2013) stated that natural dyes and printing can exhibit better biodegradability and generally have a higher compatibility with environment. In the recent years concern for environment has created an increasing interest in eco-friendly, biodegradable and non-toxic rational products.

Chattopadhyay*et al.* (2013) reported that various wet processing operations of textile from initial preparatory process to final finished cloths are now focused for green technology. Several conventional non eco-friendly chemicals are being replaced by natural based products that are safe to environment and health during manufacturing and usage. Application of enzymes in preparatory and in bio polishing, natural dyes for coloration, biopolymers and their derivatives in fiber production and finishing processes, etc. are some of the.

Chattopadhyay and Inamdar (2009) reported that nano-chitosan treatement on cotton fabric showed improvement in tensile strength and wrinkle recovery properties. The appearance and handale of nano-chitosan treated cotton fabric was quite satisfactory.

Kurlageri (2009) carried out research on “Impact of Special Finishes on Mechanical and Functional Properties of Organic Cotton Fabric” Organic handloom cotton fabric with Rib and Basket weaves were subjected for enzyme and softener finishes and assessed their impact on mechanical and functional properties. Results showed that on enzyme finishing yarns became finer with slight increase in cloth count; considerable improvement in bending length, crease recovery angle and drapability was observed.

Bhavani (2011) carried out study on “Effect of sizing agents on handle properties of bleached cotton material” reported that sizing agents are applied on cloth in order to build up

the apparent weight, impart thickness to improve luster and also to prevent the fabric from soiling quickly. Unless proper care is exercised in the selection of sizing ingredients and subsequent preparation of size paste, the performance of sizing process will not be to the desired level. Results of the study showed mat, the trend of increase in the fabric weight % was not similar among the sizing agents and within the sizing concentrations. Among the natural sizing agents, higher weight gain was observed among the samples sized with sago at four per cent concentration and among all starched fabric samples, samples starched with sago were thicker.

Devi (2012) carried out study entitled "Efficiency of sizing materials on cottons" reported that the study consisted of survey and experimental procedure. On the basis of the survey results, two sizing materials one each from arrowroot and revive were selected for the present study. Cotton muslin suitable for sari having 70 ends x 60 picks per inch with 34.80 GSM was selected and starched separately with 10% concentration of each arrowroot and revive with 1:1 and 1:2 dilution levels and were assessed for various physical parameters. Further samples were hand washed to assess its impact on these physical parameters, visual appearance and tactile properties. There was increase in physical parameters when sized with both arrowroot and revive. The stiffness was greater at 1:1 dilution than 1:2 because of higher concentration of sizing solution that deposited mechanically on the fabric surface. The chromatic and geometric attributes improved when sized at 1:1 than 1:2 dilution. But there was no change in luster, cloudy appearance and visibility yarn directionality at 1:2 dilution because of low viscosity and starch strength. The fabric texture became rough, hard and crisp on sizing at 1:1 dilution level than 1:2. Greater patchy effect was observed with arrowroot than revive because of larger starch particles and viscosity.

Kaur and Bains (2012) reported that the garments worn by the pesticide applicators may not provide adequate protection to the skin, when contaminated with a sprayed liquid, unless the surface of the fabric has been treated in some way to reduce the penetration to an acceptable level. A study was conducted in which the cotton/ polyester blended samples were given barrier treatment with 10 per cent, 20 per cent and 30 per cent starch solution and pesticide was sprayed on all these samples. These pesticide contaminated cotton/ polyester blended samples were given different laundering treatments i.e. 5 per cent salt at 50ºC, 5 per cent salt at 80ºC, 2 per cent heavy duty detergent at 50ºC, 2 per cent heavy duty detergent at 80ºC. While comparing the transmittance, it was observed that the starched samples given barrier treatment with 20 per cent starch solution had more per cent transmittance value than

the samples treated with 10 per cent and 30 per cent starch solution thus reducing penetration of pesticide to some level. Further, it was observed that washing cotton/ polyester blended fabric with 2 per cent heavy duty detergent solution at 80ºC was the best condition from all the starched samples. Overall, cotton/ polyester blended fabric given barrier treatment with 20 per cent starch solution and laundered with 2 per cent heavy duty detergent solution at 80ºC can be recommended for the pesticide applicators as it reduced the contamination.

Kulkarni (2015) reported that a list of fabric characteristics which are generally taken into consideration while selecting cloth for suitings and shirtings. These characteristics included stiffness, crease resistance, fabric thickness, softness, fabric design, colour of fabric, fabric brightness, fabric fineness, strength of fabric and overall attractiveness. He further reported the assessment of fabric quality and its performance in actual end use is of commercial and technical importance. Fabric handle is the assessment of textile material obtained from sense of touch.

A number of studies have been done to obtain size substance from natural sources (plant) i.e. corn starch, soy protein, potato starch, arrowroot, etc. but no studies have been reported about the use of *Cassia fistula* seed starch hence Cassia seed gum is selected for the present research study. In this research*Cassia fistula* seeds will be used which are high in carbohydrate, to size cotton fabric and the effect of sizing condition on the fabric properties physical will be studied and its comparison to commercially available sizing agent will be made.

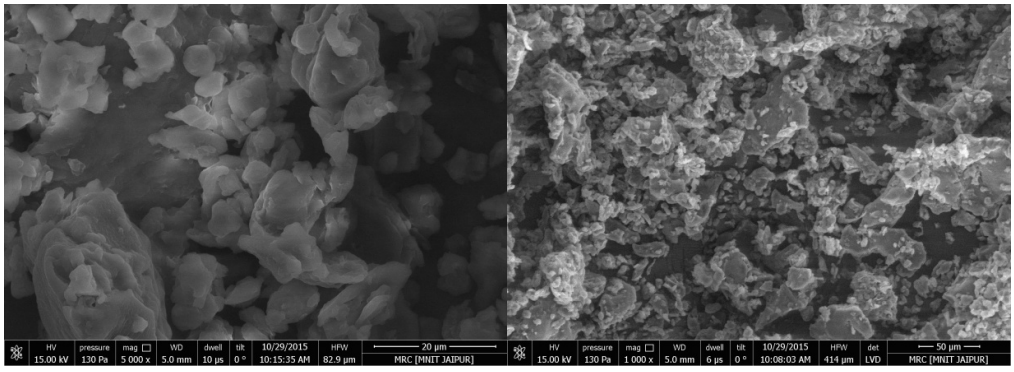
RESULTS AND DISCUSSION

Empirical and verifiable interpretation of data collected during the course of investigation plays a pivotal role in determining the success of any study. Results obtained during the course of investigation were subjected to suitable statistical analysis, tabulated and systematically presented through classified and supportive material enabling investigator to interpret the comprehensive outcomes. The findings of the present investigation have been discussed under the following sections:

1. **Characterization of the starch obtained from *Cassia fistula* seeds.**
2. **Optimization of different concentrations of *Cassia fistula* seed starch through visual evaluation.**
3. **Effect of sizing material on quality parameters of cotton fabric.**
4. **Comparison of the fabric quality parameters of sample sized with *Cassia fistula* seed starch against commercial starch sample *(Arrowroot)*.**
5. **Assessment of the acceptability of starched fabric by the consumer.**

1. Characterization of the starch obtained from *Cassia fistula* seeds:

The morphology (size and shape) of starch powder from *Cassia fistula* seed was captured by means of scanning electron microscope (SEM). All micrographs were taken at different magnification and an accelerating voltage (kv). *Cassia fistula* starch particles have a morphology that is asymmetric and irregular in shape.



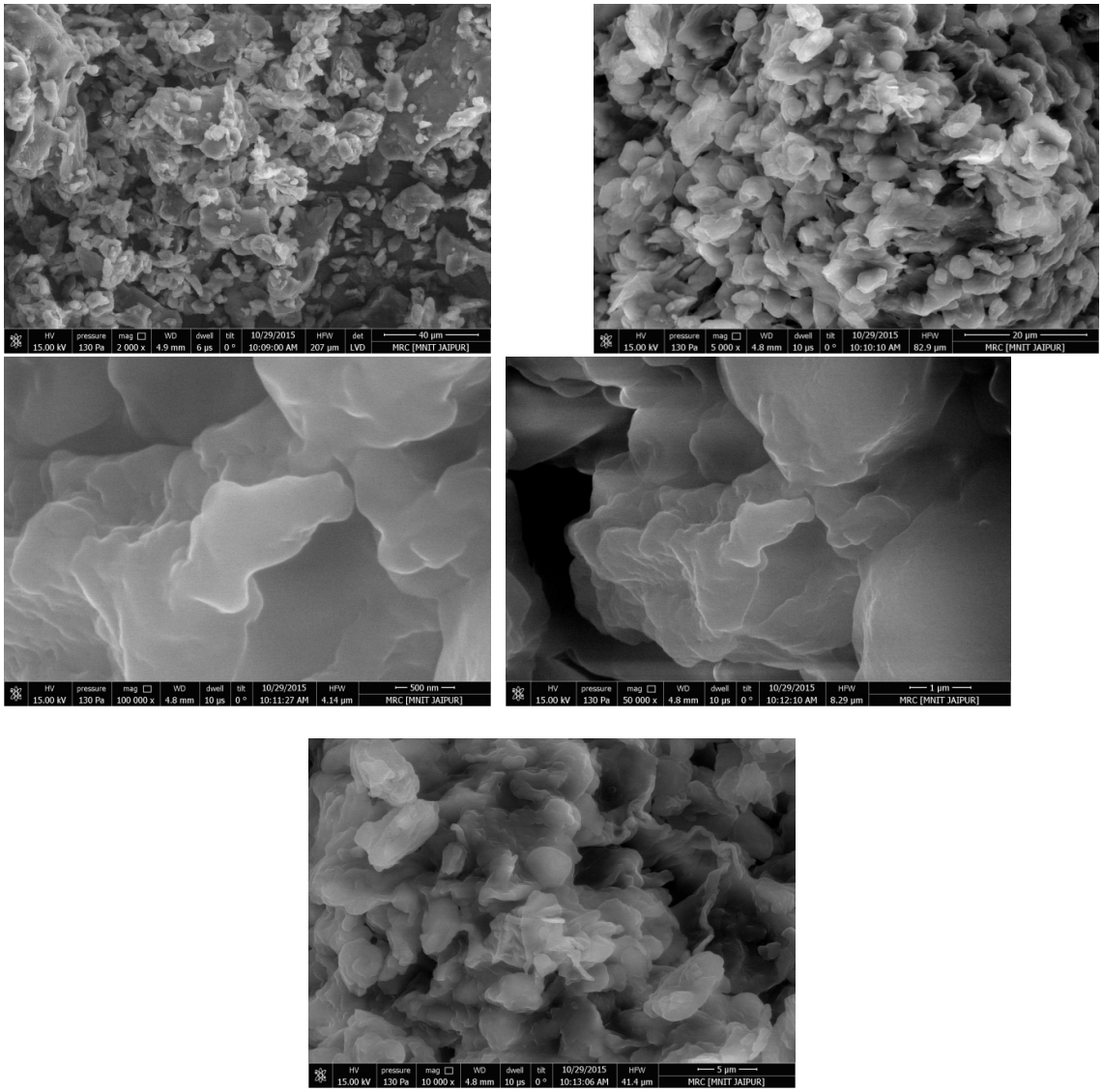


Plate 5:*Cassia fistula* starch powder photograph at higher magnification (SEM)

2. Optimization of the different concentration of *Cassia fistula* seed starch through visual evaluation:

Fabric sample starched using different concentrations of *Cassia fistula* seed starch (2.5, 5 and 7.5 gm) were visually evaluated by a panel of experts for various attributes viz. texture, luster, stiffness, thickness and drapability of the starched fabric sample. Result of visual assessment is presented in table no-2

Table-2: Score obtained for cotton fabric starched with different concentration of *Cassia fistula*.

N = 5

S. No.	Sample	Texture	Luster	Stiffness	Thickness	Drape
1.	**Thin Muslin**					
	2.5%	10	12	6	6	14
	5%	12	15	12	8	15
	7.5%	14	11	14	12	14
2.	**Medium Muslin**					
	2.5%	23	23	18	18	20
	5%	24	21	21	22	24
	7.5%	20	18	21	16	18
3.	**Thick Muslin**					
	2.5%	18	17	17	18	16
	5%	15	13	11	16	11
	7.5%	12	10	10	12	6

Table no – 2 showed that on the basis of texture medium weight sample with 5 per cent starch concentration was given the highest preference with a total mark of 24 out of 25. The next preferred concentrations on the basis of texture were 2.5 per cent medium weight fabric with total marks of 23. It is clearly visible from the table that the starched sample were not smooth in texture in thin and thick fabric at 2.5 per cent, 5 per cent and 7.5 per cent concentration hence least preferred by the judges.

In terms of luster of the starched fabric 2.5 per cent in medium weight fabric was highly preferred by the judges with a total score of 23 out of 25, whereas medium weight sample with 5 per cent wasnext preferred with 21 marks out of 25. Sample starched with 7.5 per cent at thin, thick and medium fabric showed poor result due to dullness of the fabric.

In term of stiffness, medium weight fabric with 5 per cent and 7.5 per cent concentration were equally preferred with a maximum score of 21 out of 25. The second most preferred concentration is 2.5 per cent at medium weight fabric with a total score of 18 out of 25. Thin muslin at 2.5 per cent concentration were least preferred by the judges.

In term of thickness of the fabric 5 per cent concentration at medium weight muslin was highly preferred by the judges with total score of 22 out of 25, whereas medium and thick muslin at 2.5 per cent concentration were next preferred with 18 marks out of 25. In term of thickness of the fabric thin muslin fabric showed poor results with all three concentrations.

In term of drapability of the fabric again medium weight muslin at 5 per centwas given the highest preference with a total score of 24 out of 25. The next preferred concentration on the basis of drapability of the fabric was 2.5 per cent at medium muslin with total marks of 20 out of 25. Thin and thick muslin at different concentration did not show satisfactory results.

Table-3: Mean score, per cent and rank assigned by the college students through visual evaluation.

N = 5

S.No.	Sample	Total score	Percentage (%)	Rank	Mean Percent Score
1.	**Thin Muslin**				
	2.5 %	48	38.4	3	9.6
	5 %	62	49.6	2	12.4
	7.5 %	65	52	1	13
2.	**Medium Muslin**				
	2.5 %	84	67.2	3	16.8
	5 %	112	89.6	1	22.4
	7.5 %	93	76.8	2	18.6
3.	**Thick Muslin**				
	2.5 %	86	68.8	1	17.2
	5 %	66	52.8	2	13.2
	7.5 %	50	40	3	10

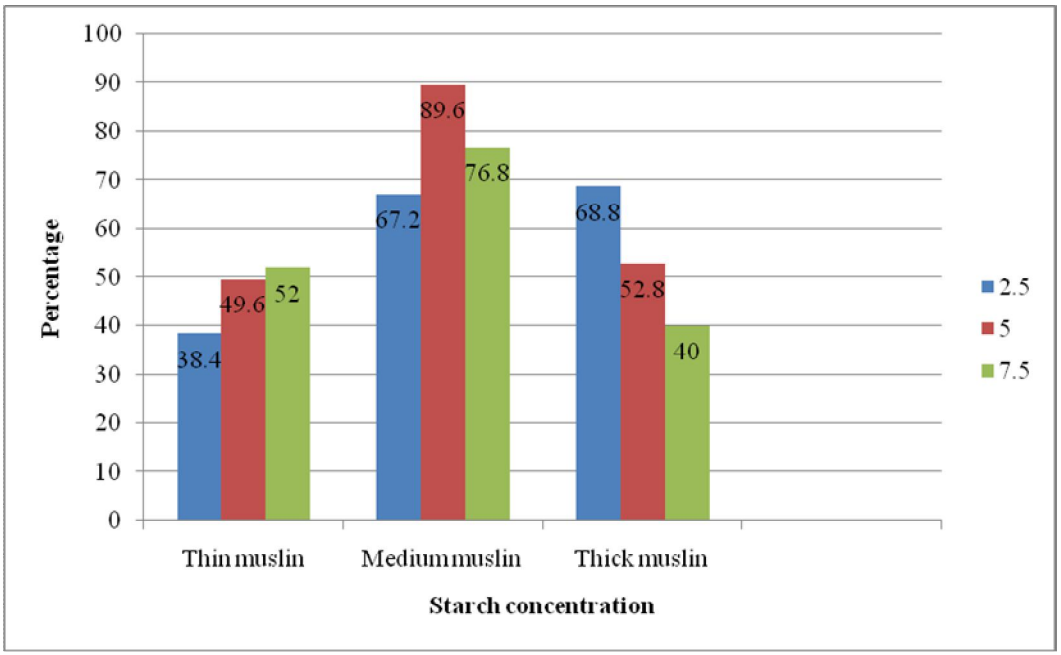


Fig. 5: Percentage obtained by different starch concentration through visual evaluation

Considering the result of all the attributes of visual evaluation the one most preferred concentration of developed starch was selected. The selected highest scored concentration was further to assess the acceptability of starch fabric by consumer.

3. Effect of sizing material on quality parameters of cotton fabric:

Fabric Crease Recovery(Angle): The creasing of textile material is a complex involving tensile, flexing, compressive and tensional stresses. Creasing of a fabric results in the bending of constituent (Booth, 1983). The data regarding the wrinkle recovery of the tested samples is furnished in table 4.

Table- 4:Effect of sizing treatment on crease recovery in warp direction.

Type of Fabric →	Thin Muslin		Medium Muslin		Thick Muslin	
Starch cons. ↓	Mean	SD	Mean	SD	Mean	SD
Control	118.67	2.31	100.00	2.00	91.33	2.31
2.5 %	125.00	1.00	131.00	3.61	151.67	0.58
5%	127.67	1.53	143.33	4.16	155.33	2.52
7.5%	129.33	1.15	150.33	1.53	158.33	2.89

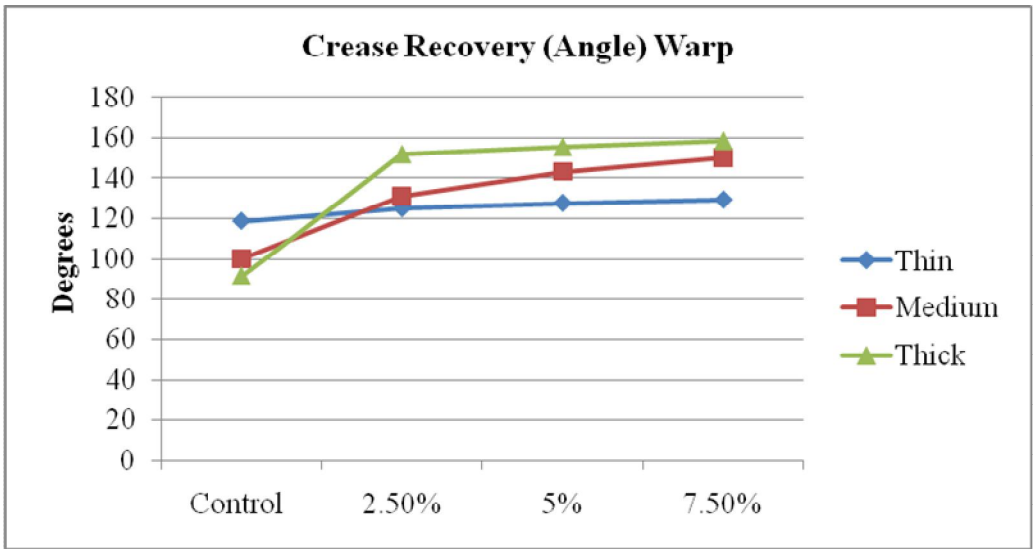


Fig. 6:Effect of sizing treatment on Crease recovery (Angle) Warp

Table-5: CRD ANOVA for fabric crease recovery (Angle) in warp direction

S.No.	SOURCE	df	SS	MS	F
1.	A	2	1184	592	106.30**
2.	B	3	10215.2	3405.07	609.864**
3.	AXB	6	3661.78	610.296	109.307**

**A= Type of the fabric*

**B= Type of concentration*

It is clear from the Table 4that thick starched sample at 7.5 per cent concentration warp direction had maximum degree of crease recovery i.e. 158.33; the least crease recovery was observed in case of thick starched control sample i.e. 91.33.

It was evident from ANOVA table that there is significant difference in crease recovery angel at different starch concentrations, and there is also significant difference in different type of fabric sample. It is clearly visible from ANOVA table that thin fabric has good crease recovery.

Table-6:Effect of sizing treatment on crease recovery in weft direction

Type of Fabric →	Thin Muslin		Medium Muslin		Thick Muslin	
Starch cons. ↓	Mean	SD	Mean	SD	Mean	SD
Control	109.33	1.15	110.33	2.08	109.33	1.15
2.5%	111.33	1.15	130.00	2.00	145.67	4.04
5%	113.67	1.53	135.67	2.08	149.33	0.58
7.5%	114.67	1.15	146.00	1.73	154.00	3.46

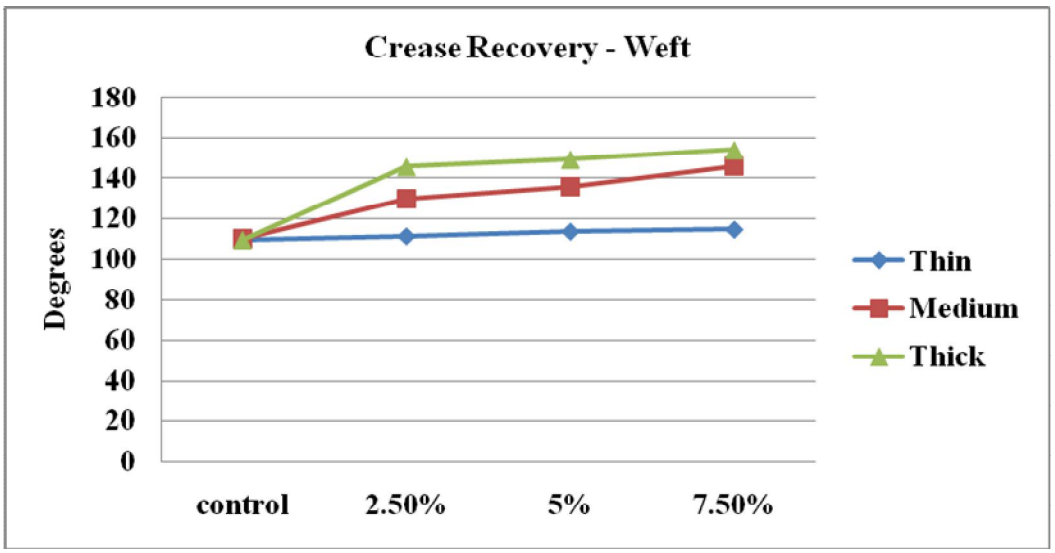


Fig. 7:Effect of sizing treatment on Crease recovery (Angle) Weft

Table-7: CRD ANOVA for fabric crease recovery (Angle) in weft direction

S.No.	SOURCE	df	SS	MS	F
1.	A	2	4650.72	2325.36	536.622**
2.	B	3	4178.44	1392.81	321.419**
3.	AXB	6	1659.72	276.62	63.835**

**A= Type of the fabric*

**B= Type of concentration*

The result showed that maximum crease recovery angel in weft direction (lengthwise) was observed in thick fabric i.e. 145.33. Minimum crease recovery was observed in weft direction in thin and thick control fabric sample i.e. 109.33.

It is apparent from ANOVA table that there is significant difference between all the starched concentrations in weft direction. Lower starch concentration showed good crease recovery than compare to higher starch concentration.

Fabric Stiffness (Bending Length cm)

Stiffness is an important characteristic of a fabric. Stiffness is measured by bending length of the fabric. Bending length is the length of fabric that will bend under its own weight to a definite extent. Bending length determines the draping quality of a fabric.

Table-8:Effect of sizing treatment on fabric Stiffness in warp direction.

Type of Fabric →	Thin Muslin		Medium Muslin		Thick Muslin	
Starch cons. ↓	Mean	SD	Mean	SD	Mean	SD
Control	3.33	0.32	2.97	0.15	3.03	0.21
2.5%	5.07	0.06	4.40	0.53	3.43	0.12
5%	5.30	0.20	5.97	0.15	4.03	0.32
7.5%	5.67	0.21	6.20	0.26	4.30	0.17

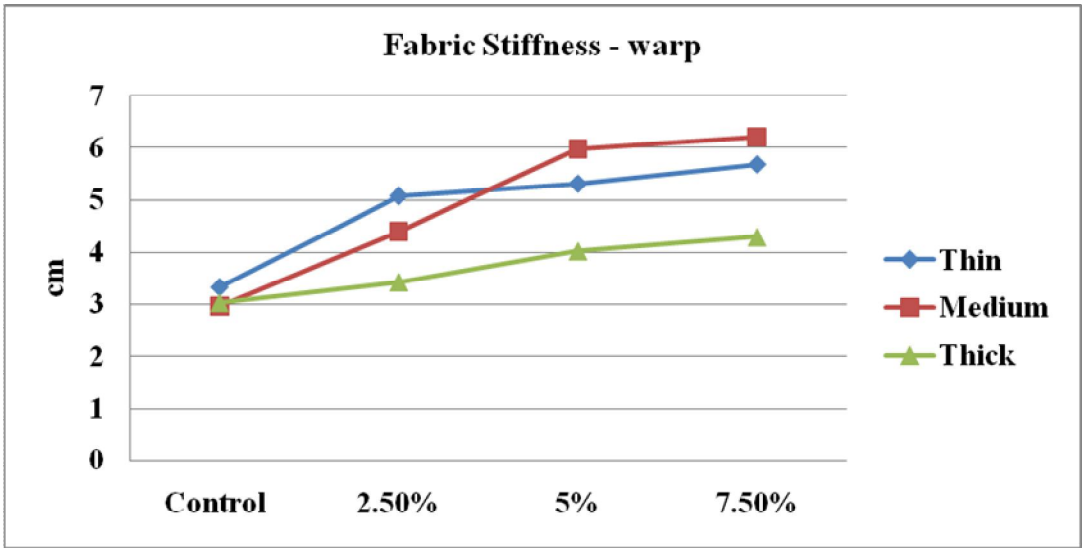


Fig. 8:Effect of sizing treatment on Fabric Stiffness (cm) warp

It is clearly depicted from Table 8 thatthin fabric obtained highest mean value at different concentrations in warp direction it showed poor bending length of the fabric. In other hand medium and thick fabric shows batter results as compare to thin fabric at different concentrations. Highest bending length shows poor results to stiffness of the fabric. The lowest mean values were found in thick muslin starched fabric with all the three concentrations means these samples are good stiffened.

Table-9: CRD ANOVA for fabric stiffness (cm) in warp direction

S.No.	SOURCE	df	SS	MS	F
1.	A	2	10.8217	5.41083	83.601**
2.	B	3	28.0497	9.34991	144.462**
3.	AXB	6	5.00278	0.833796	12.883**

**A= Type of the fabric*

**B= Type of concentration*

The Table – 9 explicit that there is significance difference between the calculated F values of the different fabric (A), with different concentrations (B) in warp direction with the tabulated value of the same so it was interpreted that all the concentrations cannot be applicable on all the fabric.

Table-10:Effect of sizing treatment on fabric Stiffness in warp direction

Type of → Fabric	**Thin Muslin**		**Medium Muslin**		**Thick Muslin**	
Starch ↓ cons.	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Control	2.47	0.38	2.93	1.47	3.07	0.31
2.5%	3.20	0.26	3.47	0.25	3.43	0.21
5%	3.87	0.42	3.77	0.23	3.67	0.21
7.5%	4.10	0.17	4.40	0.35	4.77	0.55

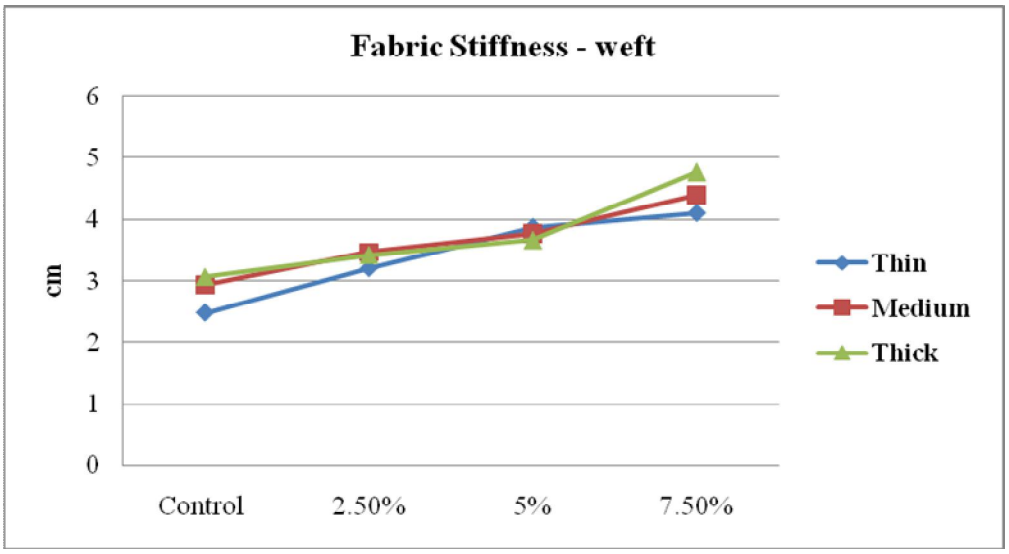


Fig. 9:Effect of sizing treatment on Fabric Stiffness (cm) weft

Table – 10indicate the mean value of different starched sample in weft direction with different concentration table revealed that thick muslin fabric obtained best result in weft direction with 7.5 per cent starch concentration with respect to stiffness of the fabric. The lowest mean value was found in thin muslin control fabric with all the three concentrations.

Table-11: CRD ANOVA for fabric stiffness (cm) in weft direction

S.No.	SOURCE	df	SS	MS	F
1.	A	2	0.673889	0.336944	1.222
2.	B	3	12.2678	4.08926	14.825**
3.	AXB	6	0.777222	0.129537	0.470

**A= Type of the fabric*

**B= Type of concentration*

The Table – 11 revealed that there is significance difference between the calculated F values with different concentrations (B) in weft direction with the tabulated value of the same.

Stiffness means resistance of fabric to bending length, is one of the factor that determine the manner in which fabric drapes. It is related to the quality of stiffness and the fabric having high bending length has more stiffness.

Fabric Tensile Strength (kg):

Tensile strength is the ability of the material to resist strain or rupture induced by external force.

Table-12:Effect of sizing treatment on Fabric Tensile Strength in warp direction

Type of Fabric → / Starch cons. ↓	Thin Muslin		Medium Muslin		Thick Muslin	
	Mean	SD	Mean	SD	Mean	SD
Control	16.93	1.10	28.70	4.85	36.89	4.96
2.5%	11.53	1.15	25.57	3.43	27.43	8.83
5%	14.67	1.07	28.93	3.96	35.73	3.79
7.5%	15.73	1.39	27.80	3.38	25.80	5.52

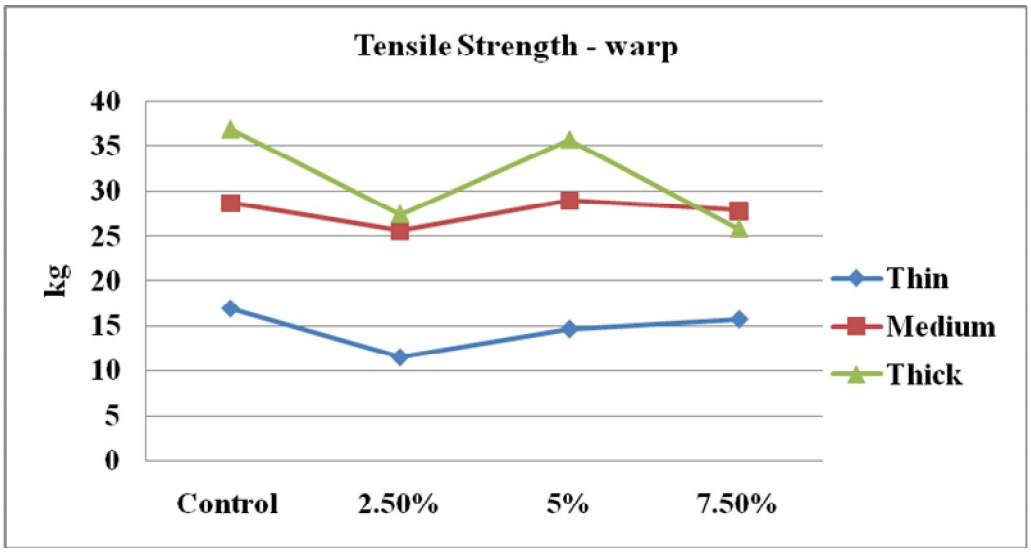


Fig. 10:Effect of sizing treatment on Fabric Tensile Strength (kg): warp

Table - 12shows the mean values of starched samples in warp direction with different starch concentrations with respect to tensile strength of the fabric. Mean values showed that tensile strength was found to be good in control sample with all type of starch concentration.

Starched sample slightly decreases in strength only medium weight muslin fabric with 5 per cent concentration showed good result (28.93 kg).

Table-13:CRD ANOVA for fabric tensile strength (kg) in warp direction

S.No.	SOURCE	df	SS	MS	F
1.	A	2	1856.63	928.314	51.717**
2.	B	3	212.354	70.7845	3.943
3.	AXB	6	144.948	24.158	1.346

**A= Type of the fabric*

**B= Type of concentration*

It was clearly evident from Table 13 that there is significance difference between the calculated F values of the different fabric sample (A) in warp direction with the tabulated value of the same. After statistical analysis it was observed that mean values was found significantly different in different fabric. Tensile strength of different fabrics was found different.

Table-14 :Effect of sizing treatment on Fabric Tensile Strength in weft direction.

Type of Fabric →	**Thin Muslin**		**Medium Muslin**		**Thick Muslin**	
Starch cons. ↓	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Control	12.93	2.45	14.33	1.46	24.37	6.38
2.5%	12.30	1.15	13.23	1.25	24.93	1.85
5%	13.27	1.18	14.03	1.12	25.10	5.38
7.5%	9.47	1.19	15.47	1.16	21.87	3.19

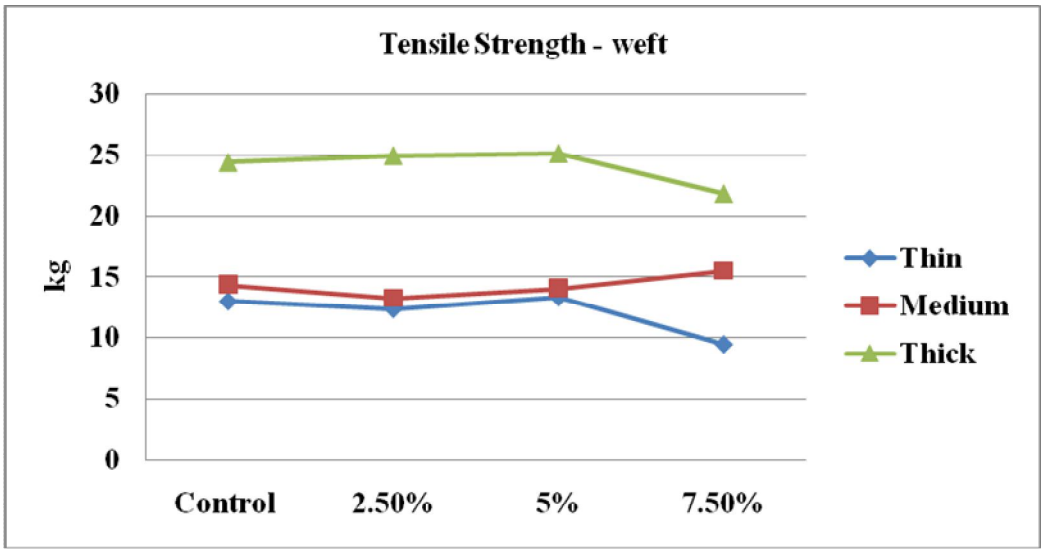


Fig. 11:Effect of sizing treatment on Fabric Tensile Strength (kg) weft

Table – 14 depictsthe mean values of starched sample in weft direction with different concentration with respect to tensile strength of the fabric. The Mean table revealed that thinmuslin fabric obtained similar mean values with all the three concentrations. Similar results showed in both medium and thick fabric the mean values laying between 13.23 to 15.47 kg and 21.87 to 25.10 kg medium and thick fabric respectively. There was not much difference in these values.

Table-15: CRD ANOVA for fabric tensile strength (kg) in weft direction

S.No.	SOURCE	df	SS	MS	F
1.	A	2	988.085	494.042	59.479**
2.	B	3	18.4631	6.15435	0.741
3.	AXB	6	36.4328	6.07213	0.731

**A= Type of the fabric*

**B= Type of concentration*

Table – 15reveal that there is significance difference between the calculated F values of the different fabric sample (A) in weft direction with the tabulated value of the same. After statistical analysis it was observed that mean values was found significantly different in different fabric. Tensile strength of different fabrics was found different. Sample having different fabric weight and thickness showed significant difference. Higher the weight showed good tensile strength.

Fabric Count:

Fabric count is the number of ends and picks per unit area and is affected by the yarn count and compactness of the weave.

Table-16:Effect of sizing treatment on Fabric Count in warp direction.

Type of Fabric → / Starch cons. ↓	Thin Muslin		Medium Muslin		Thick Muslin	
	Mean	SD	Mean	SD	Mean	SD
Control	49.00	1.00	56.67	1.15	63.00	1.00
2.5%	50.67	1.15	54.00	1.00	59.67	0.58
5%	51.67	0.58	55.33	0.58	60.67	0.58
7.5%	53.67	0.58	57.67	0.58	61.67	0.58

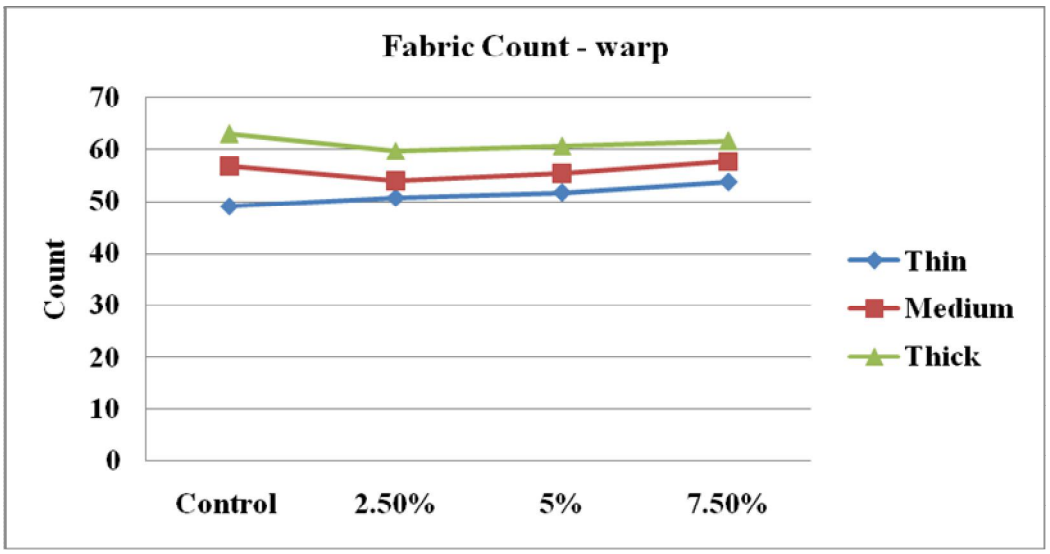


Fig. 12:Effect of sizing treatment on Fabric Count warp

Table - 16indicate the mean value of starched fabric sample in warp direction with different concentrations. Table reveals that the mean of the unstarched (before sizing) sample were lying between 49.00 to 63.00 in all the three fabric.

The mean values of starched (after sizing) thin sample ranged between 51.67 to 53.67. The mean values of starched (after sizing) medium sample ranged between 54.00 to 57.67,

and thick sample ranged between 59.67 to 63.00. Thick sample showed higher mean values followed by all the three concentration. But on thin and medium sample mean values were found similar in warp direction.

Table-17: CRD ANOVA for fabric count in warp direction

S.No	SOURCE	df	SS	MS	F
1.	A	2	600.889	3000.444	450.667**
2.	B	3	38.3056	12.7685	19.153**
3.	AXB	6	37.1111	6.18519	9.278**

**A= Type of the fabric*

**B= Type of concentration*

The table – 17 Explicit that there is significance difference between the calculated F value of the different fabric (A), with different concentrations (B) in warp direction with the tabulated value of the same so it was interpreted that all the concentrations cannot be applicable on all the fabric.

Table-18:Effect of sizing treatment on Fabric Count in weft direction

Type of → Fabric	**Thin Muslin**		**Medium Muslin**		**Thick Muslin**	
Starch ↓ cons.	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Control	48.00	1.00	47.67	0.58	47.33	1.15
2.5%	48.00	0.58	35.67	0.58	47.33	1.15
5%	49.33	0.58	37.67	0.58	47.67	0.58
7.5%	51.33	1.15	39.33	0.58	47.67	0.58

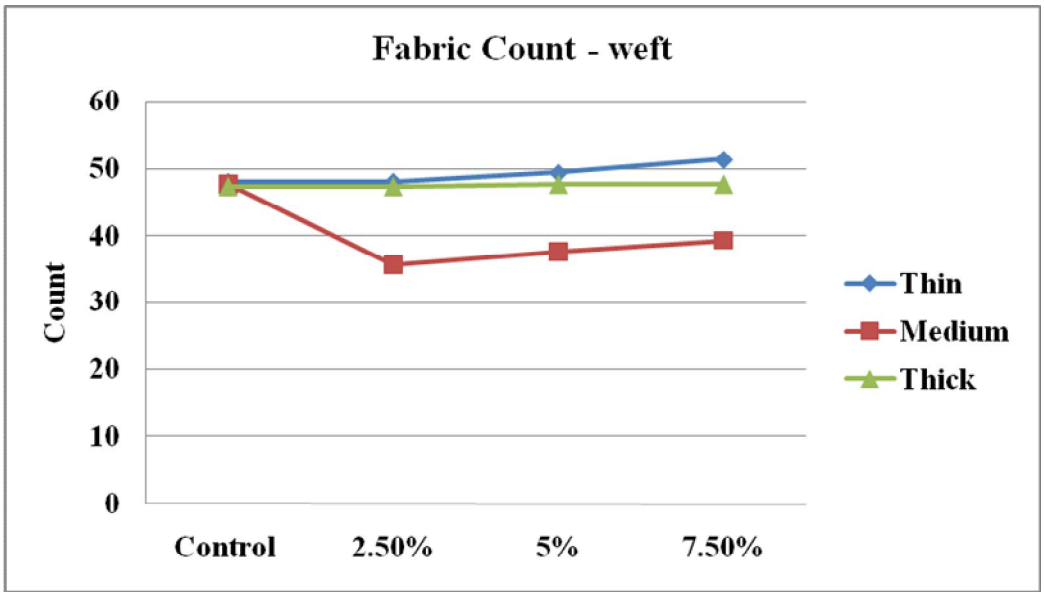


Fig. 13:Effect of sizing treatment on Fabric Count weft

Table - 18 Shows the mean value of starched fabric sample in weft direction with different concentrations. Highest mean value of the unstarched (before sizing) was observed in thin fabric sample (48.00). the highest mean value of starched (after sizing) sample was found at 7.5 per cent with thin fabric. Mean value of thin and thick starched sample were mostly found similar in weft direction.

Table-19: CRD ANOVA for fabric count in weft direction

S.No.	SOURCE	df	SS	MS	F
1.	A	2	568.389	284.194	444.826**
2.	B	3	75.2222	25.0741	39.246**
3.	AXB	6	195.611	32.6019	51.029**

**A= Type of the fabric*

**B= Type of concentration*

Table-19 Depicted that there was significant difference between F calculated value and F tabulated value. Means all the fabrics cannot be sized with all the concentrations with respect to fabric count.

Fabric Count: Traverse microscopy method

Table-20 : Effect of sizing treatment on Yarn Count in warp direction.

Type of Fabric →	Thin Muslin		Medium Muslin		Thick Muslin	
Starch cons. ↓	Mean	SD	Mean	SD	Mean	SD
Control	47.67	0.58	54.67	4.16	61.33	1.15
2.5%	51.33	1.15	56.00	2.00	59.00	1.00
5%	52.33	1.53	56.33	1.53	61.33	1.15
7.5%	53.00	1.00	55.33	4.73	62.33	1.53

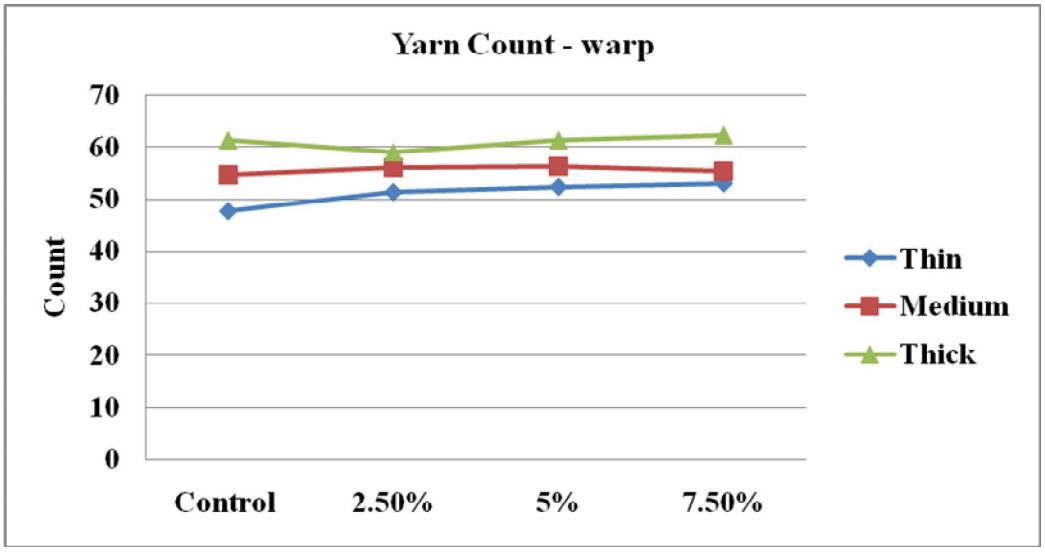


Fig. 14:Effect of sizing treatment on Yarn Count warp

Table-20 revealed the mean values of starched (before / after) sample in warp direction with different concentration. Table revealed that the mean values unstarched (before sizing) samples were lying between 47.67 to 61.33.

The mean values of starched (after sizing) thin sample ranged between 51.33 to 53.00. The mean values of starched (after sizing) medium sample ranged between 55.33 to 56.33, and thick sample ranged between 59.00 to 62.33. Thick sample showed highest mean values followed by all the three concentration. But on thin and medium sample mean values were found mostly similar in warp direction.

Table-21: CRD ANOVA for yarn count in warp direction

S.No.	SOURCE	df	SS	MS	F
1.	A	2	591.722	295.861	62.287**
2.	B	3	32.2222	10.7407	2.261
3.	AXB	6	41.6111	6.93519	1.460

**A= Type of the fabric*
**B= Type of concentration*

The Table – 21 concluded that there is significance difference between the calculated F values of the different fabric (A), in warp direction with the tabulated value of the same so it was interpreted that all the concentrations cannot be applicable on all the fabric.

Table-22:Effect of sizing treatment on Yarn Count in weft direction

Type of Fabric →	**Thin Muslin**		**Medium Muslin**		**Thick Muslin**	
Starch cons. ↓	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Control	47.67	1.15	47.67	0.58	46.67	0.58
2.5%	48.00	1.00	36.00	0.00	47.67	0.58
5%	49.00	1.00	37.67	0.58	47.33	0.58
7.5%	48.00	2.00	37.67	1.53	47.33	0.58

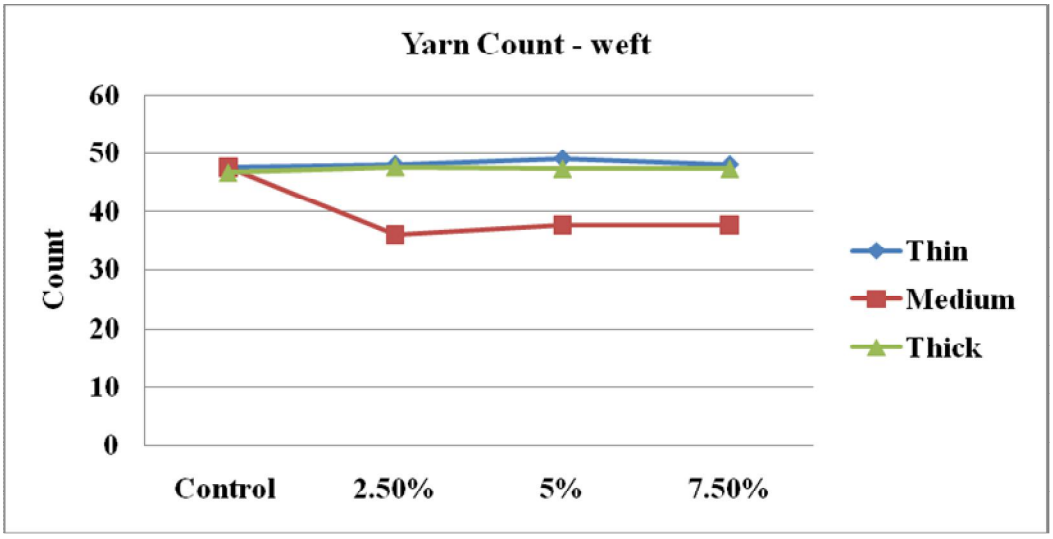


Fig.-15:Effect of sizing treatment on Yarn Count weft

Table – 22 shows the mean values of starched (before / after) sample in weft direction with different concentration. Results revealed that the mean values unstarched (before sizing) sample was 47.67 in all the three fabric.

Medium sample showed least mean values followed by all the three concentration. Mean values of thin and medium sample were found mostly similar in weft direction.

Table-23:CRD ANOVA for yarn count in weft direction

S.No.	SOURCE	df	SS	MS	F
1.	A	2	511.722	255.861	263.171**
2.	B	3	65	21.6667	22.286**
3.	AXB	6	195.833	32.6389	33.571**

**A= Type of the fabric*

**B= Type of concentration*

In the Table – 23 found that there is significance difference between the calculated F value of the different fabric (A), with different concentrations (B) in warp direction with the tabulated value of the same so it was interpreted that all the concentrations cannot be applicable on all the fabric.

According to corbman, (1983) starch fills in the opening in the constructed cloth creating an appearance of greater compactness. Thus low thread count is not immediately discernible at the time of purchase. The starching give the weight of the fabric.

Fabric Weight (g/m^2):

Fabric mass per unit area is expressed either as grams per square meter or grams per linear meter.

Table-24:Effect of sizing treatment on Fabric Weight

Type of Fabric → / Starch cons. ↓	Thin Muslin		Medium Muslin		Thick Muslin	
	Mean	SD	Mean	SD	Mean	SD
Control	0.48	0.00	0.97	0.01	1.38	0.02
2.5%	0.51	0.01	1.00	0.01	1.35	0.02
5%	0.56	0.01	1.06	0.01	1.49	0.02
7.5%	0.58	0.01	1.07	0.01	1.57	0.01

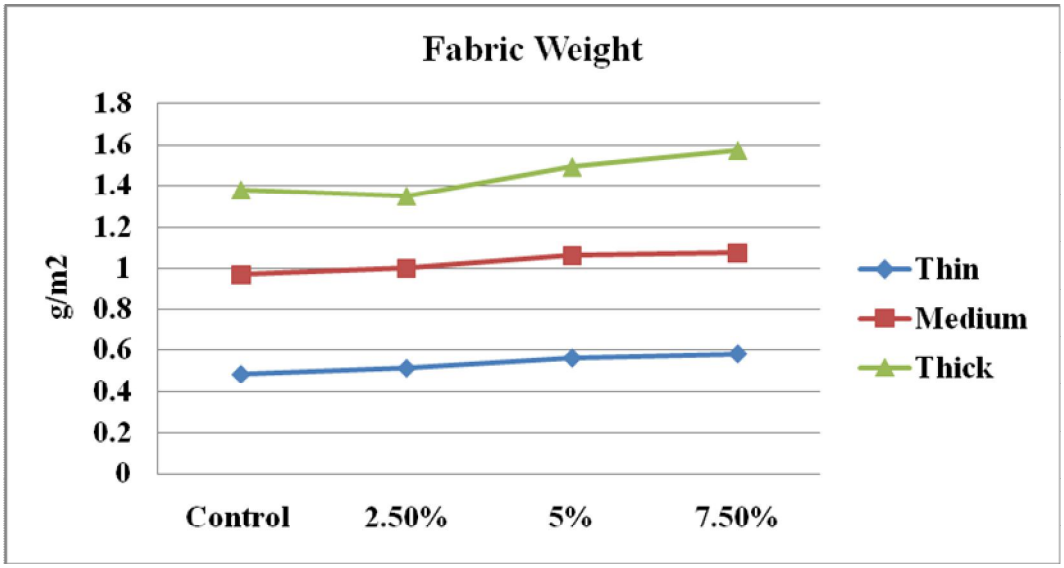


Fig.-16Effect of sizing treatment Fabric Weight (g/m^2)

Table-24 revealed the mean values of starched sample with different starch concentration. On visual inspection, it was observed that out of three concentration used, thick fabric shows highest mean value as compare to thin and medium fabric. Based on the

mean values obtained it can be inferred that weight of the fabric was slightly increases after application of size.

The result conformed to the findings of Bhawani (2011) where it was found that the fabric weight was increased on the starch concentration and different type of fabric.

Table-25: CRD ANOVA for fabric weight (g/m^2)

S.No.	SOURCE	df	SS	MS	F
1.	A	2	5.01632	2.50816	18811.188**
2.	B	3	0.109431	0.0364769	273.576**
3.	AXB	6	0.0213278	0.00355463	26.660**

**A= Type of the fabric*

**B= Type of concentration*

It is clearly evident from Table-25 that there was significant difference between F calculated value and F tabulated value.

Fabric Thickness (mm):

The compression property of a fabric is one of the most important properties and it is directly related to the handle measurement of the fabric.

Table-26: Effect of sizing treatment on Fabric Thickness at 50gm weight.

Type of Fabric →	Thin Muslin		Medium Muslin		Thick Muslin	
Starch cons. ↓	Mean	SD	Mean	SD	Mean	SD
Control	13.33	0.58	25.00	1.00	34.00	1.00
2.5%	21.00	1.00	33.67	1.15	33.67	0.58
5%	23.67	1.53	36.67	1.15	35.67	0.58
7.5%	19.67	0.58	36.00	1.00	37.67	1.53

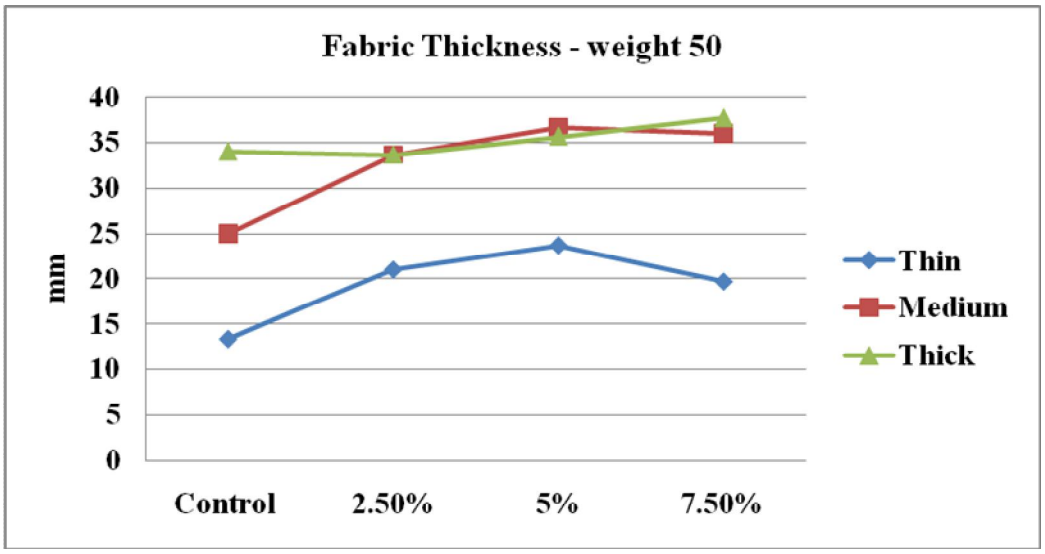


Fig.-17: Effect of sizing treatment on Fabric Thickness (mm) weight 50 (gm)

Table- 26 indicate the mean value of starched (before and after) sample at 50W with different concentration with respect of stiffness of the fabric.

Unstarched fabric sample with different concentration showed mean values followed by all the three fabric between 13.33 to 34.00 mm.

Results showed that after application of size (starch) thickness of the fabric were increases in all the three fabric with different concentrations. Thick sample with 7.5 per cent starch concentration obtained highest mean value.

Table-27: CRD ANOVA for fabric thickness (mm) weight50 (gm)

S.No.	SOURCE	df	SS	MS	F
1.	A	2	1746.17	873.083	827.132**
2.	B	3	337	112.333	106.421**
3.	AXB	6	126.5	21.0833	19.974**

**A= Type of the fabric*

**B= Type of concentration*

The Table – 27 explicit that there is significance difference between the calculated F values of the different fabric (A), with different concentrations (B) in warp direction with the tabulated value of the same so it was interpreted that all the concentrations cannot be applicable on all the fabric.

Table-28: Effect of sizing treatment on Fabric Thickness at 100gm weight.

Type of Fabric →	Thin Muslin		Medium Muslin		Thick Muslin	
Starch cons. ↓	Mean	SD	Mean	SD	Mean	SD
Control	15.00	1.00	17.67	1.53	33.00	0.00
2.5%	17.33	1.53	31.67	0.58	32.67	0.58
5%	22.33	1.53	33.33	1.53	33.67	0.58
7.5%	18.00	1.00	32.00	2.65	31.67	4.04

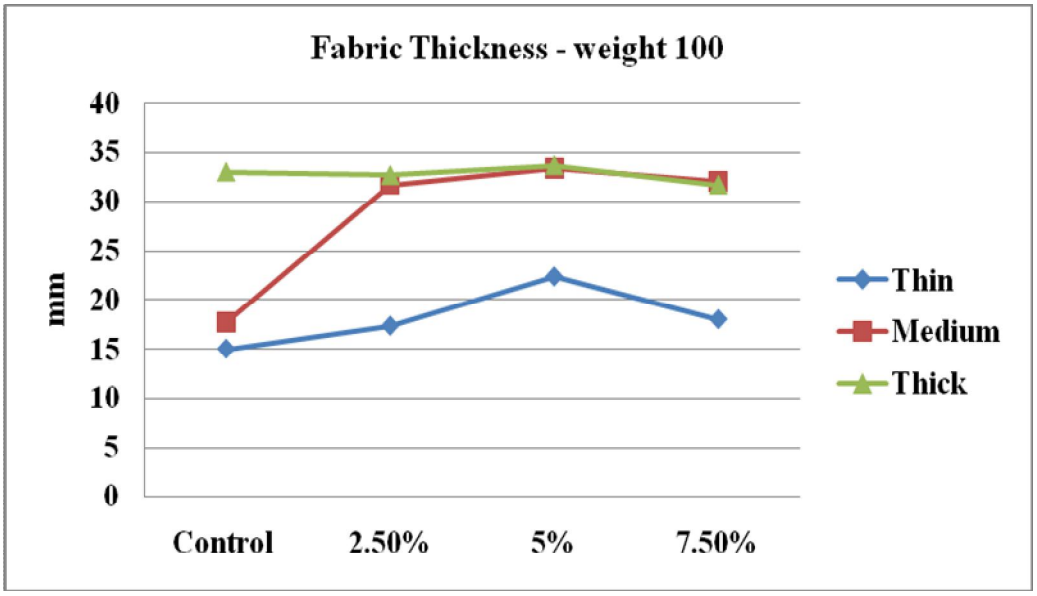


Fig. 18:Effect of sizing treatment on Fabric Thickness (mm) weight 100 (gm)

Table – 28 Shows the mean value of starched (before and after) sample at 50W with different concentration with respect of stiffness of the fabric.

Unstarched fabric sample with different concentration showed mean values followed by all the three fabric between 15.00 to 33.00 mm.

Table reveals that after application of size (starch) thickness of the fabric were increases in all the three fabric with different concentrations. Thick sample with 5 per cent starch concentration obtained highest mean value.

Table-29: CRD ANOVA for fabric thickness (mm) weight100 (gm)

S.No.	SOURCE	Df	SS	MS	F
1.	A	2	1358.39	679.194	228.514**
2.	B	3	297.417	99.1389	33.355**
3.	AXB	6	281.833	46.9722	15.804**

**A= Type of the fabric*

**B= Type of concentration*

The Table – 29 indicates that there is significance difference between the calculated F value of the different fabric (A), with different concentrations (B) in warp direction with the tabulated value of the same so it was interpreted that all the concentrations cannot be applicable on all the fabric.

Table-30: Effect of sizing treatment on Fabric Thickness at 200gm weight

Type of Fabric →	**Thin Muslin**		**Medium Muslin**		**Thick Muslin**	
Starch cons. ↓	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Control	12.67	1.15	16.00	1.00	23.67	0.58
2.5%	15.67	0.58	30.00	1.00	30.33	0.58
5%	19.00	1.00	28.00	1.73	32.33	0.58
7.5%	15.67	0.58	29.67	2.52	29.33	2.52

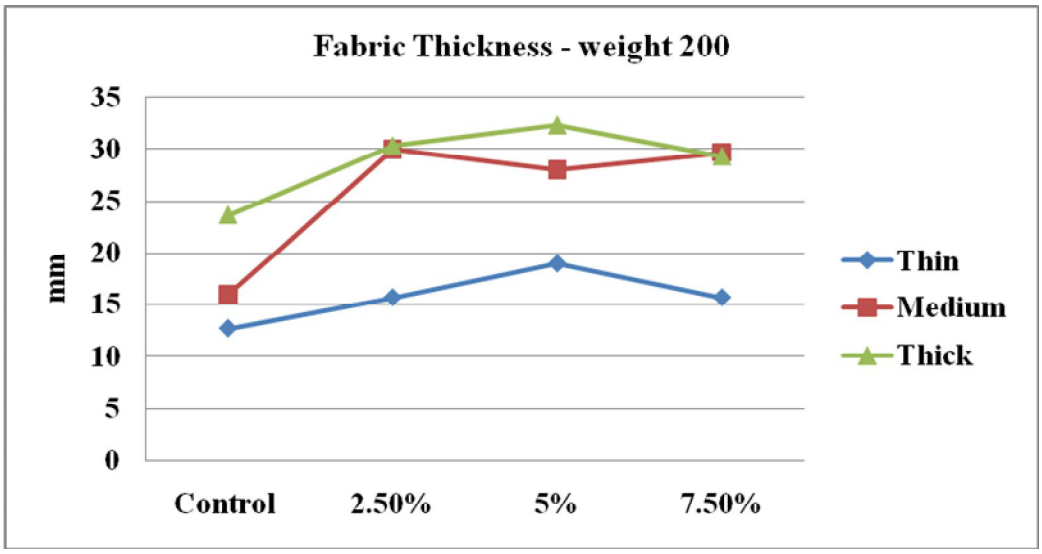


Fig. 19:Effect of sizing treatment on Fabric Thickness (mm) w200

Table – 30 reveal the mean value of starched (before and after) sample at 200W with different concentration with respect of stiffness of the fabric.

Unstarched fabric sample with different concentration showed mean values followed by all the three fabric between 12.67 to 16.00 mm.

Table - 30 clearly evident that after application of size (starch) thickness of the fabric were increases in all the three fabric with different concentrations. Thick sample with 5 per cent starch concentration obtained highest mean value.

Table-31:CRD ANOVA for fabric thickness (mm) weight200 (gm)

S.No.	SOURCE	df	SS	MS	F
1.	A	2	1142.89	571.444	316.492**
2.	B	3	455.639	151.88	84.118**
3.	AXB	6	129.111	21.5185	11.918**

**A= Type of the fabric*

**B= Type of concentration*

The Table-31 explicit that there is significance difference between the calculated F values of the different fabric (A), with different concentrations (B) in warp direction with the tabulated value of the same so it was interpreted that all the concentrations cannot be applicable on all the fabric.

Study conducted by Kale (2010) explained that varing concentration of starch influenced the thickness of the fabric.

Fabric colour:

Table-32:Effect of Sizing Treatment on fabric colour

S.No.	Sample	k/s	L*	a*	b*	C*
1	**Thin Muslin**					
	Control	0.592	90.187	0.148	8.987	8.988
	2.5%	1.140	85.135	2.285	15.093	15.265
	5%	1.037	85.377	2.388	14.088	14.289
	7.5%	0.896	87.422	0.970	12.099	12.130
2	**Medium Muslin**					
	Control	0.876	85.715	1.347	13.088	13.149
	2.5%	1.251	82.573	2.531	16.133	16.33
	5%	1.121	82.951	2.653	14.838	15.073
	7.5%	1.351	84.414	1.572	15.303	15.384
3	**Thick Muslin**					
	Control	1.275	83.707	2.945	17.079	17.331
	2.5%	1.208	79.739	3.612	15.344	15.763
	5%	1.292	79.498	3.765	15.969	16.407
	7.5%	1.187	80.833	2.805	15.636	15.886

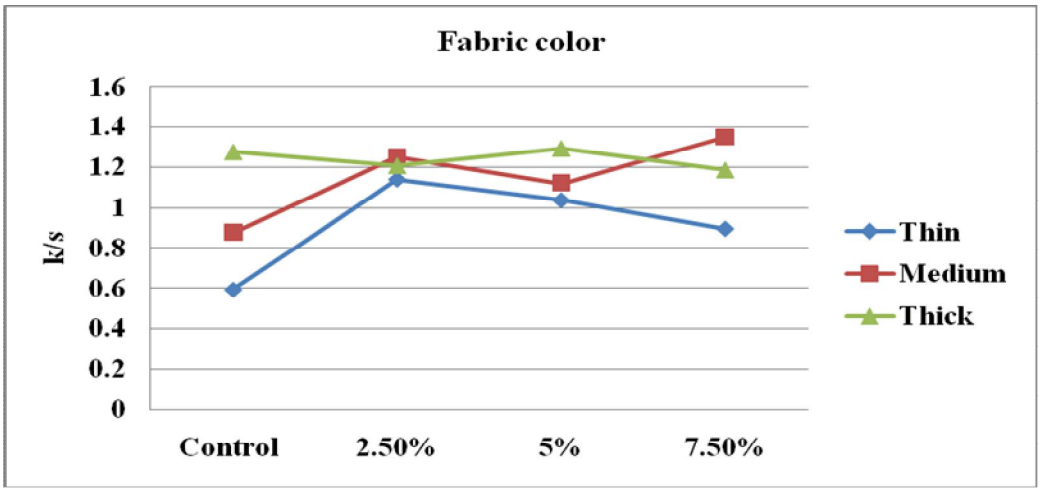


Fig.-20: Effect of sizing treatment on fabric color (k/s)

The Table 32 shows that colour strength of different starched sample at all the starch concentration was increased as compare to control or unstarched fabric sample. L* of the starched samples was slightly decrease. The l* value of different starched sample at 2.5 per cent and 5 per cent concentrations shows similar results. The L* value of 7.5 concentration is less which shows more darkness of starched sample. The a* value indicates redness or greenness and b* value indicates yellowness and blueness.

The findings are supported by Kale (2010) and Devi (2012) concluded that after application of starch physical properties of the gray cotton fabric was slightly increase in terms of fabric weight, fabric thickness, fabric stiffness, fabric count etc.

4. Comparison of the fabric quality parameters of sample sized with *Cassia fistula* seed starch against commercial starch sample *Maranta Arundinacea (Arrowroot)*:

Table-33: Comparison between *Maranta Arundinacea (Arrowroot)* and *Cassia fistula* starched fabric of crease recovery.

S.No.	Crease Recovery (Angle)									
	MARANTA ARUNDINACEA				*CASSIA FISTULA*				T Value	
	Warp		Weft		Warp		Weft		Warp	Weft
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd		
1.	133.000	2.646	131.333	1.155	143.333	4.163	135.667	2.082	3.628	3.153

It was clear from the Table - 33 that mean values of sample sized with *Cassia fistula* starch showed high as compare to *Maranta Arundinacea (Arrowroot)*in both warp and weft direction. The table 1 explicit that there is no significance difference between the calculated t values with the tabulated value. So it can be interpreted that both the starch concentration can be used for sizing with respect to crease recovery of the fabric.

Table-34: Comparison between *Maranta Arundinacea (Arrowroot)* and *Cassia fistula* starched fabric of tensile strength

S.No	Tensile Strength (kgf)

.	*MARANTA ARUNDINACEA*				*CASSIA FISTULA*				T Value	
	Warp		**Weft**		**Warp**		**Weft**			
	Mean	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**	**Warp**	**Weft**
1.	30.300	3.816	12.500	0.819	28.933	3.955	14.033	1.115	0.431	1.920

After statistical analysis it was found that highest mean values indicates the best results with *Maranta Arundinacea (Arrowroot)* starched sample in both warp and weft direction.

The results of statistical analysis depicts that there was no significance difference between t calculated values and t tabulated values. Means both the starch can be used to size medium weight muslin fabric with respect to tensile strength of the fabric.

Table-35: Comparison between *Maranta Arundinacea (Arrowroot)* and *Cassia fistula* starched fabric of fabric count

S. No.	Fabric Count									
	MARANTA ARUNDINACEA				*CASSIA FISTULA*				T Value	
	Warp		**Weft**		**Warp**		**Weft**			
	Mean	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**	**Warp**	**Weft**
1.	57.667	0.577	47.333	1.155	55.333	0.577	37.667	0.577	4.950*	12.969**

Table 35 explicit that there is significant difference between the calculated t values with the tabulated value so it was interpreted that *Cassia fistula* starch is best as compare to *Maranta Arundinacea (Arrowroot)* with respect to fabric count.

Table-36: Comparison between *Maranta Arundinacea (Arrowroot)* and *Cassia fistula* starched fabric of fabric stiffness.

S.	Fabric Stiffness (cm)

No.	*MARANTA ARUNDINACEA*				*CASSIA FISTULA*				t Value	
	Warp		Weft		Warp		Weft		Warp	Weft
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd		
1.	5.767	0.321	3.133	0.321	5.967	0.153	3.767	0.231	0.973	2.771

Table–36 indicates the results of statistical analysis of data with the observation it can be concluded that there was not much difference between mean values in both warp and weft direction and calculated value and t tabulated value.

With this analysis it can be concluded that there is no significance difference so both the starch *Cassia fistula* and *Maranta Arundinacea (Arrowroot)*t is applicable on medium weight muslin fabric.

Table-37: Comparison between *Maranta Arundinacea (Arrowroot)* and *Cassia fistula* starched fabric of fabric weight

S.No.	Fabric Weight (g/m^2)				
	MARANTA ARUNDINACEA		*CASSIA FISTULA*		t Value
	Weight (gm)		Weight (gm)		
	Mean	Sd	Mean	Sd	
1.	1.247	0.032	1.060	0.010	9.604*

On visual inspection, it was observed that *Maranta Arundinacea (Arrowroot)* starch gave high mean value as compare to *Cassia fistula* starch.

The Table – 37shows that there is significant difference between the t calculated values and t tabulated values.

Table-38.1: Comparison between *Maranta Arundinacea (Arrowroot)* and *Cassia fistula* starched fabric of fabric thickness weight50 (gm)

S.No.	Fabric Thickness (mm)

	MARANTA ARUNDINACEA		*CASSIA FISTULA*		t Value
	Thickness of fabric (mm)		**Thickness of fabric (mm)**		
	Mean	**Sd**	**Mean**	**Sd**	
1.	25.667	0.577	36.667	1.155	14.758**

Cassia fistula starched sample had higher fabric thickness which might be due to the reason that the paste which are used in sizing attached on fabric surface not penetrate within the fabric so, it increases the thickness of the fabric.

It is clear from the Table 38.1 that *Cassia fistula* starched fabric had higher mean value as compare to *Maranta Arundinacea (Arrowroot)* starched fabric. Both the starched sample was significantly different.

Table-38.2: Comparison between *Maranta Arundinacea (Arrowroot)* and *Cassia fistula* starched fabric of fabric thickness weight100 (gm)

S.No.	**Fabric Thickness (mm)**				
	MARANTA ARUNDINACEA		*CASSIA FISTULA*		t Value
	Thickness of fabric (mm)		**Thickness of fabric (mm)**		
	Mean	**Sd**	**Mean**	**Sd**	
1.	17.000	1.000	33.333	1.528	15.495**

Cassia fistula starched sample had higher fabric thickness which might be due to the reason that the paste which are used in sizing attached on fabric surface not penetrate within the fabric so, it increases the thickness of the fabric.

It is clear from the Table 38.2 that *Cassia fistula* starched fabric had higher mean value as compare to *Maranta Arundinacea (Arrowroot)* starched fabric. There is significance difference between t calculated and t tabulated values so it can say that both the starched sample was significantly different.

Table- 38.3: Comparison between *Maranta Arundinacea (Arrowroot)* and *Cassia fistula* starched fabric of fabric thickness weight200 (gm)

S.No.	**Fabric Thickness (mm)**

	MARANTA ARUNDINACEA		*CASSIA FISTULA*		t Value
	Thickness of fabric (mm)		**Thickness of fabric (mm)**		
	Mean	**Sd**	**Mean**	**Sd**	
1.	15.000	1.000	28.000	1.732	**11.258****

Cassia fistula starched sample had higher fabric thickness which might be due to the reason that the paste which are used in sizing attached on fabric surface not penetrate within the fabric so, it increases the thickness of the fabric.

It is clear from the Table 38.3 that *Cassia fistula* starched fabric had higher mean value as compare to *Maranta Arundinacea (Arrowroot)* starched fabric. Both the starched sample was significantly different.

Table-39:Comparison between *Maranta Arundinacea (Arrowroot)* and *Cassia fistula* starched fabric of yarn count

S. No.	Yarn Count									
	MARANTA ARUNDINACEA				*CASSIA FISTULA*				T Value	
	Warp		**Weft**		**Warp**		**Weft**		**Warp**	**Weft**
	Mean	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**		
1.	**58.000**	**0.000**	**47.000**	**1.000**	**56.333**	**1.528**	**37.667**	**0.577**	1.890	** 14.00

It is clear from Table – 39 that there is significant difference between the calculated t values with the tabulated values in weft direction there was no significant difference in warp direction. Both *Cassia fistula* and *Maranta Arundinacea (Arrowroot)* shows similar mean values in warp direction but slightly difference was found in weft direction.

The result confirmed to the findings of Bhavani (2011) where it was found that the fabric weight was increased on the starch concentration and different type of fabric.

Comparison of the starched duapptas by subjective evaluation.

Subjective evaluation of the fabric was carried out to comparison between *Cassia fistula* and *Maranta Arundinacea (Arrowroot)* by the consumer. The evaluation was carried in terms of texture, luster, stiffness, thickness, drape and color of the fabric.

Table-40: Texture of the starched fabric **n=30**

S.No.	Type of Starch	Highly Acceptable		More Acceptable		Acceptable		Fairly Acceptable		Least Acceptable	
		F	%	F	%	F	%	F	%	F	%
1.	***MarantaArundinacea***	27	90	1	3.33	2	6.66	0	0	0	0
2.	***Cassia fistula***	23	76.66	4	13.33	3	10	0	0	0	0

Table 40 revealed that very slight difference was found between both the *Cassia fistula* and *Maranta Arundinacea (Arrowroot)* starched fabric. *Maranta Arundinacea (Arrowroot)* starched treated fabric showed more smoothness as compare to *Cassia fistula* starched sample. *Maranta Arundinacea (Arrowroot)* starched sample was highly acceptable by 90 per cent respondents. And *Cassia fistula* was rated between highly acceptable to acceptable. This might be due to large particles of the cassia starch.

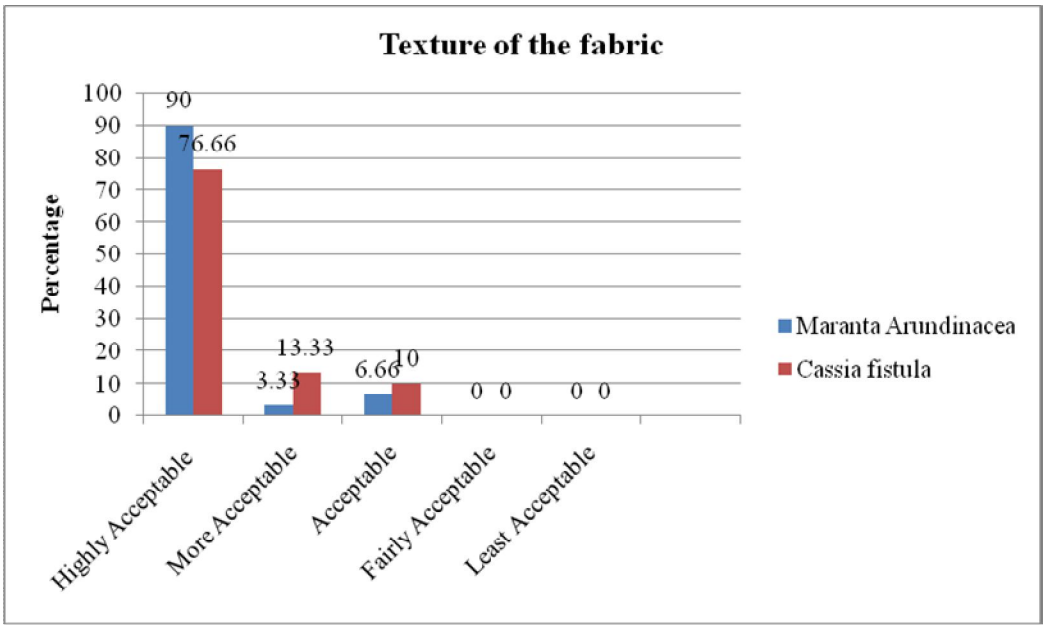


Fig.-21: Acceptability of the starched dupattas on the basis on the texture of the fabric.

Table-41: Luster of the starched fabric

n=30

S. No.	Type of starch	Highly Acceptable		More Acceptable		Acceptable		Fairly Acceptable		Least Acceptable	
		F	%	F	%	F	%	F	%	F	%
1.	*Maranta Arundinacea*	24	80	6	20	0	0	0	0	0	0
2.	*Cassia fistula*	12	40	4	13.33	12	40	0	6.33	2	6.66

It was apparent from the table-41 that the luster of the fabric slightly reduces or become dull after application of *Cassia fistula* starch as compare to *Maranta Arundinacea (Arrowroot)* starch. The brightness is rated high by 80 per cent respondents for *Maranta Arundinacea (Arrowroot)* starched dupatta. The brightness is rated low for cassia starched dupatta. Hence it was concluded that in term of luster of the fabric *Maranta Arundinacea (Arrowroot)* starch showed batter result as compare to *Cassia fistula.*

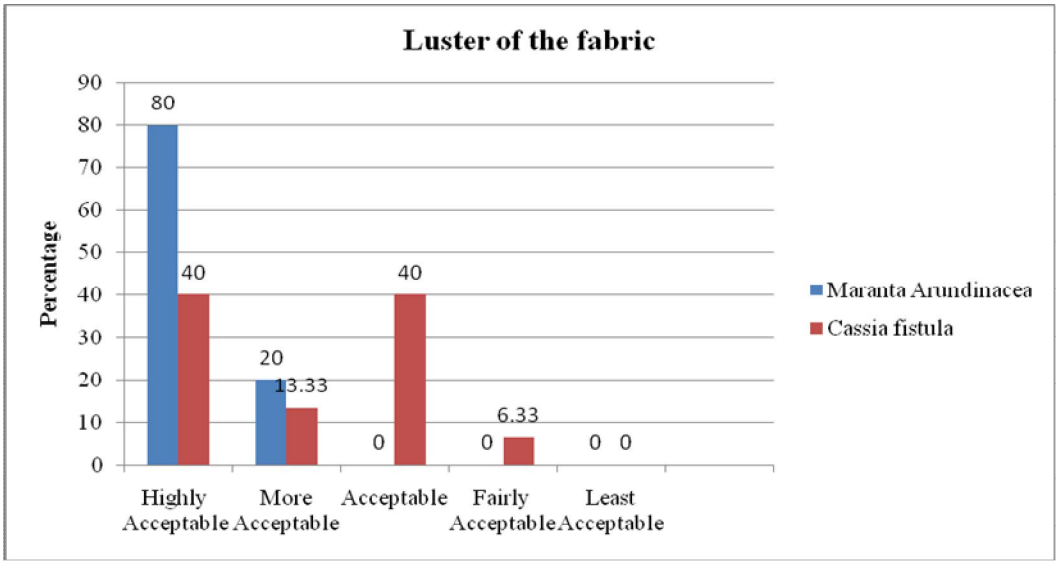


Fig.-22: Acceptability of the starched dupatta on the basis on the luster of the fabric

Table-42: Stiffness of the starched fabric

n=30

S.No.	Type of Starch	Highly Acceptable	More Acceptable	Acceptable	Fairly Acceptable	Least Acceptable

		F	%	F	%	F	%	F	%	F	%
1.	***Maranta Arundinacea***	0	0	0	0	7	23.33	21	70	2	6.66
2.	***Cassia fistula***	24	80	6	20	0	0	0	0	0	0

Majority of the respondents (70%) rated *Maranta Arundinacea (Arrowroot)* starched dupatta as fairly acceptable. It was concluded from the table – 42 that in term of stiffness *Cassia fistula* starch treated dupatta was highly acceptable by the greater number of the respondents. 24 respondents out of 30 felt that *Cassia fistula* starched dupatta was highly acceptable. *Cassia fistula* starched dupatta showed best result as compare to *Maranta Arundinacea (Arrowroot)*.

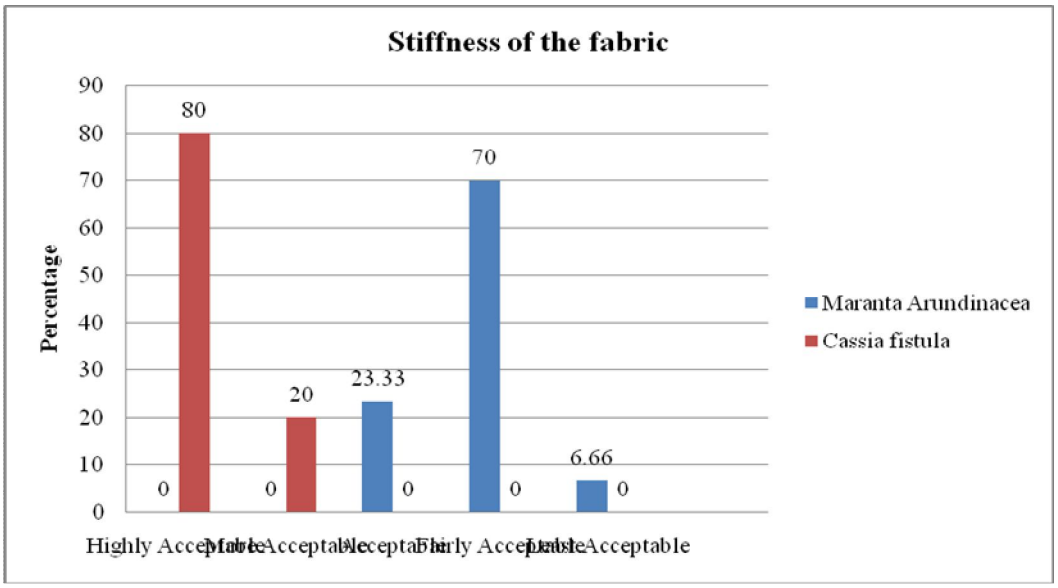


Fig.-23: Acceptability of the starched dupatta on the basis on the stiffness of the fabric

Table-43: Thickness of the starched fabric n=30

S.No.	Type of Starch	Highly Acceptable		More Acceptable		Acceptable		Fairly Acceptable		Least Acceptable	
		F	%	F	%	F	%	F	%	F	%
1.	***Maranta Arundinacea***	0	0	2	6.66	18	60	10	33.33	0	0

2.	***Cassia fistula***	17	56.66	9	30	4	13.33	0	0	0	0

It was apparent from the above table that there was difference in thickness between both the starched dupatta. Majority of the respondents felt that *Cassia fistula* starched dupatta was thicker than the dupatta starched with *Maranta Arundinacea (Arrowroot)*. Overall, the *Cassia fistula* starched dupatta showed best result (56.66) as compare to *Maranta Arundinacea (Arrowroot)* starched dupatta.

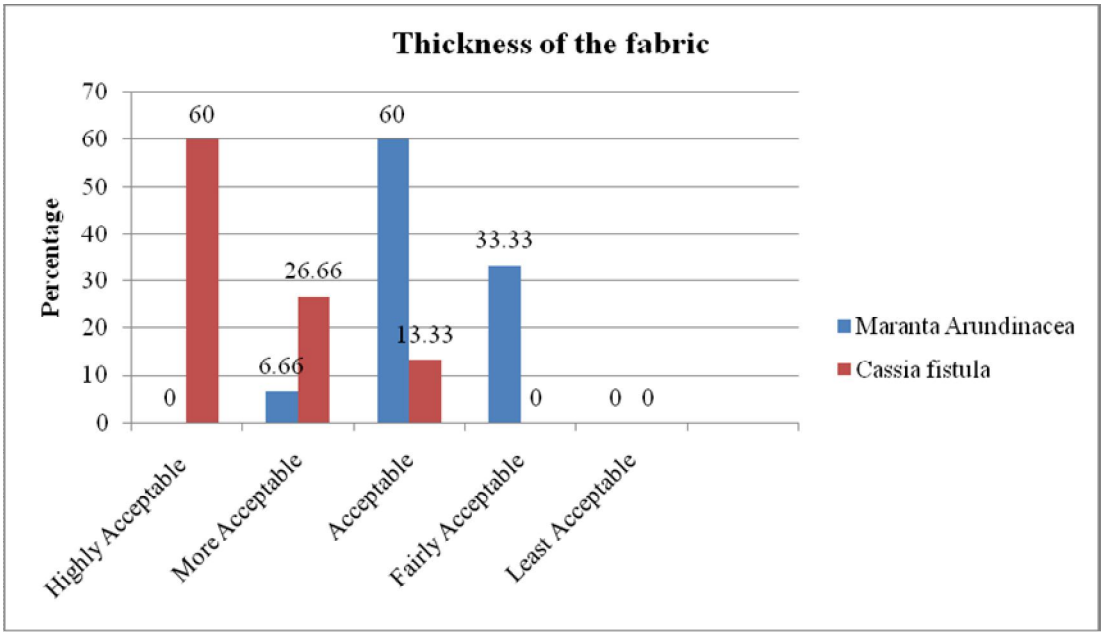


Fig.-24: Acceptability of the starched dupatta on the basis on the thickness of the fabric

Table-44: Drape of the starched fabric

n=30

S. No.	**Type of Starch**	**Highly Acceptable**		**More Acceptable**		**Acceptable**		**Fairly Acceptable**		**Least Acceptable**	
		F	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
1.	***MarantaArundinacea***	0	0	6	20	14	46.66	9	30	1	3.33
2.	***Cassia fistula***	13	43.33	12	40	4	13.33	1	3.33	0	0

The data on the drape of both treated *Maranta Arundinacea (Arrowroot)* and *Cassia fistula* starched samples is furnished in table- 44. *Cassia fistula* starched dupatta was graded as highly acceptable (43.33%) for drapability of the fabric. Majority of the respondents felt that the drape of the fabric ranged between highly acceptable to acceptable. *Maranta Arundinacea (Arrowroot)* starched dupatta was felt as acceptable by greater number of respondents so it can be concluded that drapability of the fabric was high in *Cassia fistula* starched dupatta.

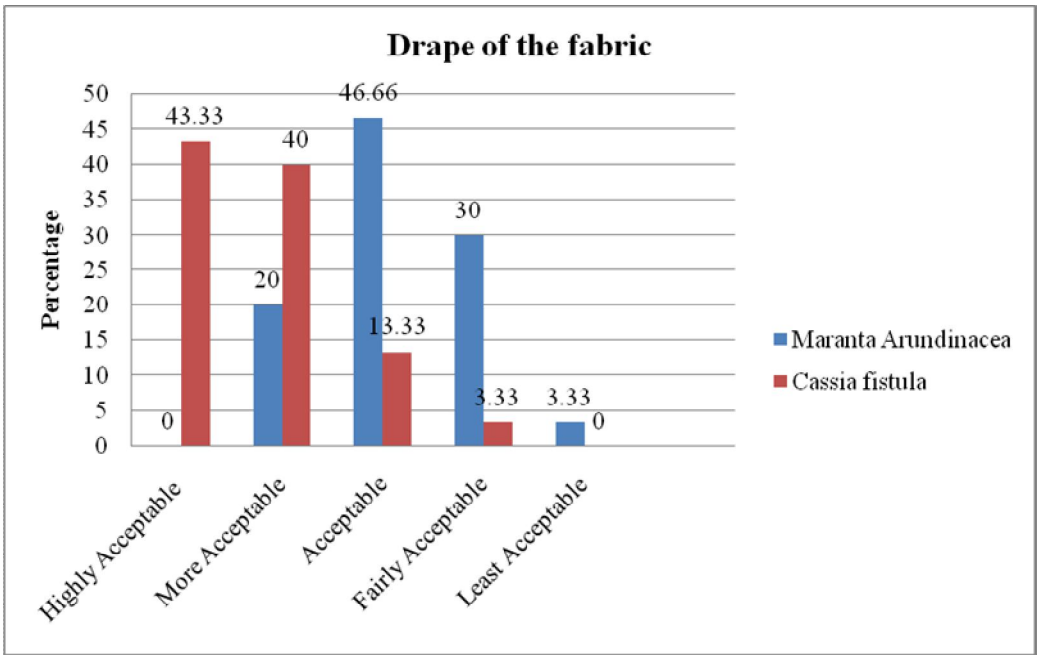


Fig.-25: Acceptability of the starched dupatta on the basis on the drape of the fabric

Table-45:Colour of the starched fabric

n=30

S. No.	Type of Starch	Highly Acceptable		More Acceptable		Acceptable		Fairly Acceptable		Least Acceptable	
		F	%	F	%	F	%	F	%	F	%
1.	***MarantaArundinacea***	2	6.66	2	6.66	26	86.66	0	0	0	0
2.	***Cassia fistula***	9	30	11	36.66	7	23.33	3	10	0	0

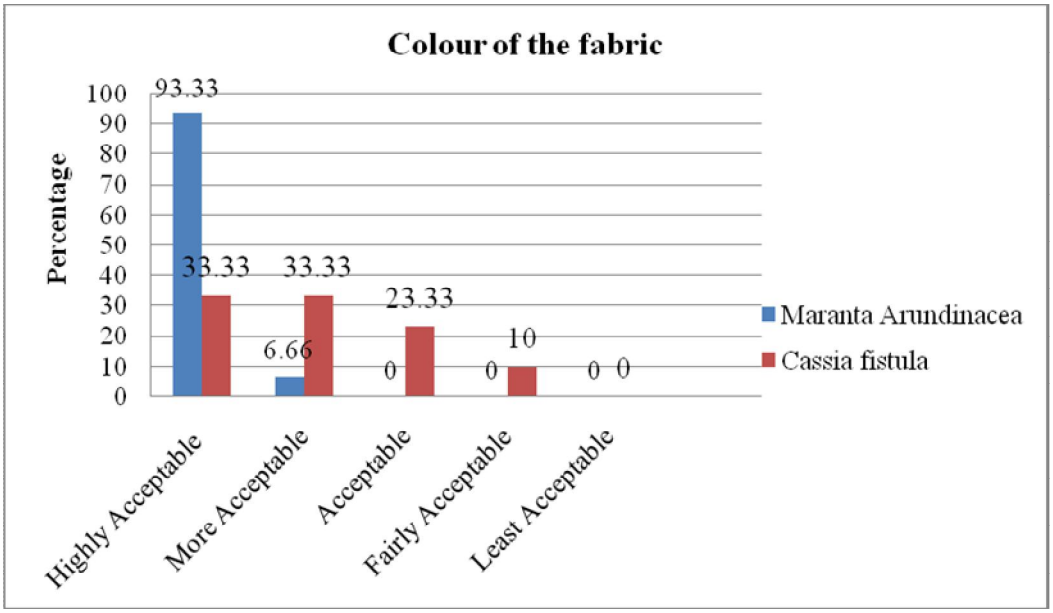


Fig. 26: Acceptability of the starched dupatta on the basis on the colour of the fabric

Table-45 shows the opinion of the respondents with regard to the colour of the fabric. Majority of the respondents felt that the colour of the *MarantaArundinacea (Arrowroot)* starched dupatta ranged between highly acceptable to acceptable. The *MarantaArundinacea (Arrowroot)* starched dupatta was felt as having good color as compare to *Cassia fistula* starched dupatta. 86.66 percent respondents felt that *MarantaArundinacea (Arrowroot)* starched dupatta as acceptable and only 36.66 per cent respondents felt that *Cassia fistula* as more acceptable.

Table-46:Comparison of the starched dupatta by subjective evaluation

S. No.	Criteria of evaluation	Type of Starch			
		MarantaArundinacea		***Cassia fistula***	
		Score	**%**	**Score**	**%**
1.	Texture of the fabric	145	96.66	140	93.33
2.	Luster of the fabric	144	96	114	76
3.	Stiffness of the fabric	66	44	144	96
4.	Thickness of the fabric	82	54.66	133	88.66
5.	Drape of the fabric	85	56.66	127	84.66
6.	Color of the fabric	96	64	116	77.33
	Total score	618/900	68.66	774/900	86

It was apparent from the table – 46 that the acceptability of the *Cassia fistula* starched duppata was higher than *Maranta Arundinacea (Arrowroot)*. Total 86% respondents felt that *Cassia fistula* was good. So it can be concluded that *Cassia fistula* starch showed best results as compare to *Maranta Arundinacea (Arrowroot).*

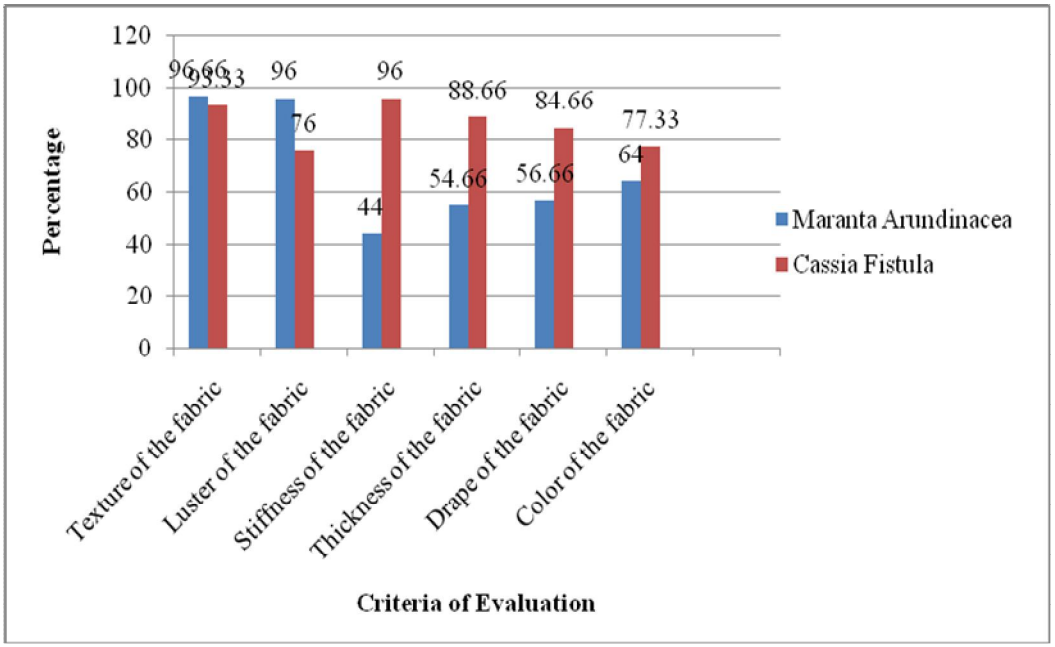


Fig.-27: Percentage obtained by *Cassia fistula* and *Maranta Arundinacea (Arrowroot)* by subjective evaluation

5. Assessment of the acceptability of starched fabric by the consumer:

The developed starch solution applied on cotton dupatta and than this dupatta was evaluated by 30 respondents to find frequency and percentage of consumer acceptability. In order to assess the acceptability of the developed starch a rating Performa was developed bases on five point rating scale and was given to the respondents. The responses derived by respondents for each attribute were coded and presented in table.

Table-47: Acceptability score obtained by starched dupatta with *Cassia fistula* seed on the basis on relative ranking

n=30

S.No..	Criteria of the evaluation	Score	Percentage (%)
1.	Texture of the fabric	140	93.33
2.	Thickness of the fabric	133	88.66
3.	Stiffness of the fabric	144	96
4.	Drapability of the fabric	127	84.66
5.	Luster of the fabric	114	76
6.	Color of the fabric	116	77.33
	Total score obtained	**774**	**86%**
	Acceptability index		

It was found that in term of stiffness of the fabric was highly acceptable (86%) with a total score of 143 out of 150. Texture of the fabric was next favored with total marks of 140 out of 150. Following the same trend, thickness of the fabric and drapability of the fabric were next favored with a total score of 133 and 127 respectively. Among the all attributes luster of the fabric and color of the fabric were least favored by the respondents with a total score of 114 and 116 out of 150 respectively.

The finding in Table 48 shows that the respondents gave score 773 out of 900. Dupatta starched with *Cassia fistula* seed starch was found acceptable by 86 per cent respondents.

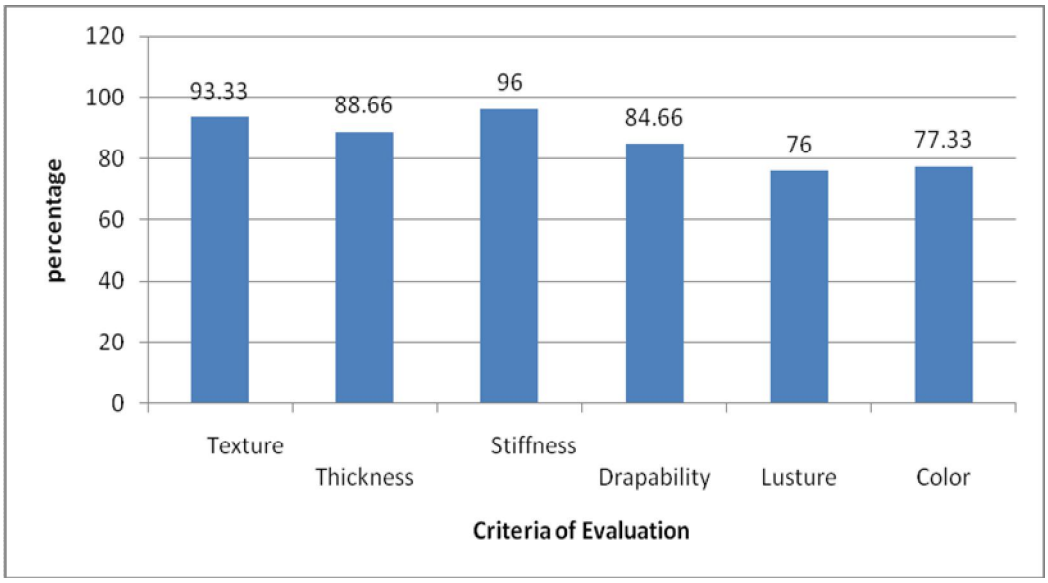


Fig.-28: Percentage obtained by starched dupatta on the basis of each criteria of evaluation

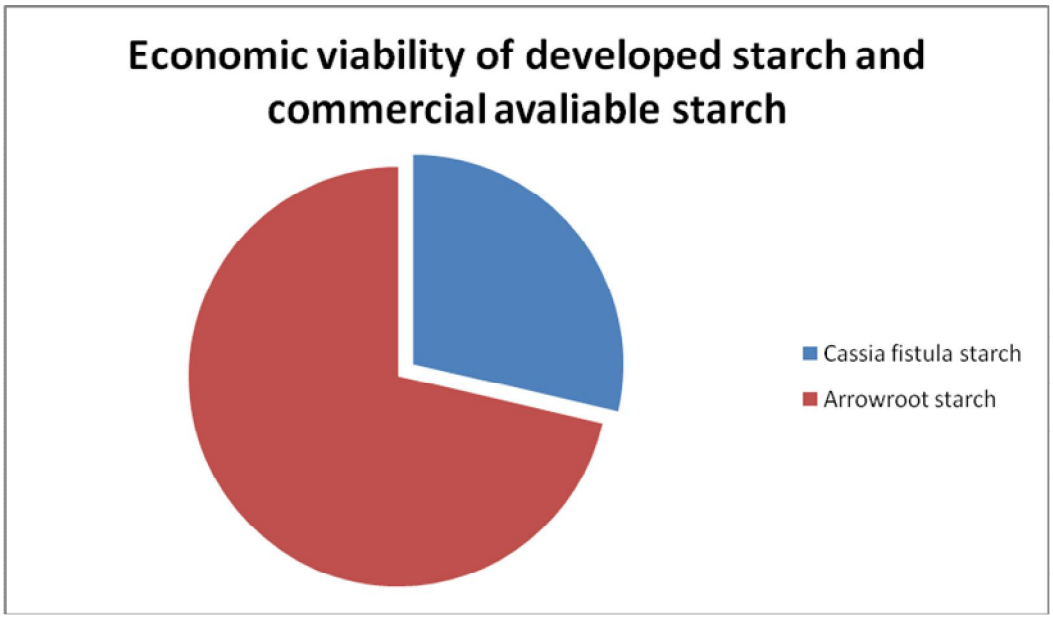
Thus, it can be concluded that developed starch showed batter results as compare to commercially available starch *(Arrowroot)*. There was improvement in the physical properties like yarn count, fabric count, GSM, fabric bending length and crease recovery when treated with *Cassia fistula* seed starch. Developed starch was highly appreciated and liked by the consumers. *Cassia fistula* starch can be recommended as on eco-friendly and user friendly sizing agent.

Economic viability of the developed starch and its comparison

Table-48: Cost comparison of commercial starch (arrowroot) and developed starch (cassia fistula) per kg.

Particles	**Arrowroot** **Cost (Rs)**	**Cassia fistula** **Cost (Rs)**
Actual raw material	50/kg	Collected
Processing / Grinding	_	20/kg
Total	50	20

Cassia fistula starch found very economical as compared to the commercially available starch arrowroot.



So it can be concluded that developed cassia fistula starch was economical and eco friendly.

By processing and preparing starch powder by cassia fistula seeds. One can earn handsome art of money. As there no initial investment is need. A person can collect pod take seed and get it pulverized in market and saved and sell it to other person.

SUMMARY AND CONCLUSION

Textiles have such an important bearing on our daily lives that everyone needs to know something about them. Each person builds an image which represents him in the eyes of others it is the expression of his inner self projected through his outer appearance. A large percentage of his total image can be attributed by the clothes he wears his clothing expresses his values and his feelings about himself. Clothing has served many purposes arising from diverse need. Ever since man took to wearing clothes, the necessity of washing, finishing and restoring them to original appearance has been a problem in maintaining a satisfactory appearance of textiles.

Sizing or size is any one of numererous substances that is applied to fabric of fine quality and light weight or loosely woven fibres. Starching makes the fabric heavier, stiff, and crisp. It also adds shine and smoothness to the fabric. Cottons – muslin, poplin, cambric and thin silks are generally starched.

Sizing agents are derived from both natural and synthetic polymers. Starch has long history of being used as a sizing agent in the textile industry. Natural starch and its derivatives still constitute nearly 75 per cent of the sizing agents used in the textile industry throughout the world.

Nature has provided abundant plant wealth, which possess medicinal virtues for all living creature. The essential values of some plants have long been published but a large number of them remain unexplored as yet. In this regard, one such plant is *Cassia fistula*.

Cassia fistula Linn. (Cassia) family Caesalpiniaceous commonly known as Amulthus and in English popularly called “Indian Laburnum” has been extensively used in Ayurvedic system of medicine for various ailments. *Cassia fistula* is widely grown as an ornamental plant in tropical and subtropical areas. It is deciduous and mixed-monsoon forests throughout greater parts of India, ascending to 1300 m in outer Himalaya. It is an Indian medicinal plant.

With the emerging worldwide interest in adopting and studying traditional starching methods and exploiting their potential based on different plant source, the evaluation of the natural starch or sizing sources are essential. The other reason for selecting the starch source is that *Cassia fistula* seed starch is totally eco-friendly and cost effective.

The main aim of the study was to develop eco-friendly and cost effective sizing for cotton.

The present study was under taken keeping in view the following objective-

6. To characterize the starch obtained from *Cassia fistula* seeds.
7. To optimize the starch recipe for sizing of cotton fabric with *Cassia fistula* seed starch.
8. To study the effects of sizing agents from *Cassia fistula* seeds on cotton fabric at different concentration and identify the functional and physical properties of fabrics.
9. To compare the fabric quality parameters of sample sized with *Cassia fistula* seeds against commercial starch sample.
10. To assess the acceptability of starch fabric by the consumers.

METHODOLOGY

1. Locale of the study

The present study was conducted in the Udaipur district. Laboratory experiments were conducted in the laboratory of Department of Textile and Apparel Designing, College of Home Science, Udaipur (Rajasthan).

Three type of sample had been selected for the study

- Muslin cloth having different fabric weight (Thin, Medium and Thick) was selected for the experiments. *Cassia fistula* seeds were selected as natural source of starch for the study.
- A panel of 5 judges for selection of one best concentrations of starch.
- Thirty respondents who were using starched cotton dupatta were randomly selected from College of Home Science for assessment of the acceptability of starched fabric.

2. Development of tool

Rating scale (five points) was developed to assess the acceptability of starched fabric by consumer in term of texture, luster, drape, thickness, stiffness of the starched fabric.

3. Data collection process

The data was collected in these following headings and sub headings-

Characterization of the starch obtained from *Cassia fistula* seed-

The size and shape of starch particles extracted from *Cassia fistula* seed were determined using Scanning Electron Microscope (SEM).

Application of starch

- *Cassia fistula* pods were collected from *Gulab Bagh* and MPUAT University campus. Seeds were separated from pods, than cleaned and washed in tap water to remove sticky brown pulp from seeds. Dried in sun light for 2-3 days outer brown cote was removed than Inner white portion of seed was ground into fine powder.
- For conducting the experimental trials of different concentrations of *Cassia fistula* starch as starching agents on muslin fabric. It was required to have muslin fabric free from starch or from any other stiffening agent. Hence a laboratory procedure for desizing prescribed at IS: B1967- 1961 was used to desize the fabric.
- The concentration of starch was optimized by taking three solution prepared by boiling method, 2.5, 5, 7.5, gms of *Cassia fistula* seed powder each in 3 beakers containing 1:30 MLR of distilled water after boiling, starch solutions were filtered and keep in side.
- For starching the muslin fabric hot starching method was adopted. The starch powder presoaked in cool water carefully removing all the lambs, this solution added in boiling water and continued boiling till the starch particles burst out and making colorless, gelatinous and translucent solution. Then cooling of starch solution and filtered it through double muslin cloth. Fabric sample (desized) soaked in prepared solution for 10 minutes. Removed the fabric sample and slightly wringing of starched sample. Dried in direct sun light.
- A panel of five members was selected from the Department of Textile and Apparel Designing as subject matter specialists. The visual evaluation of cotton fabric samples sized with all the three concentration of *Cassia fistula* starch (2.5%, 5% and 7.5%) was done by these panel members on the basis of texture, luster, drapability, stiffness, thickness for the selection of the one best concentration.

Assessment of fabric parameters

The starched samples were assessed to see the effect of different concentrations of starch on various physical parameters before and after in terms of fabric weight, fabric count, fabric stiffness, fabric thickness, tensile strength etc.

- **Fabric thickness:** The method described in (ISI: 7702-1975) was used to measure the thickness of the sample.
- **Tensile Strength:** Tensile strength of the starched fabric before and after with different concentrations of selected starch (*Cassia fistula* and arrowroot) was measured by tensile strength testing machine raveled strip test method as described in ISI (IS: 1969- 1968).
- **Crease Recovery:** Determination of wrinkle recovery or crease recovery of the fabric, which enables the fabric to resist wrinkling or mussing, was done by measuring the 'crease recovery angel' crease recovery angle was measured as per ISI (IS:4681-1968) 'On crease recovery tester'.
- **Fabric Stiffness:**To determine the stiffness of the fabric i.e. resistance of fabric to bending, until ever test as described in ISI (IS: 6490-1971) was used. The instrument used was 'cloth stiffness tester'.
- **Fabric Weight:** Measurement of GSM: the GSM was determined using ASTM D3776 test method. Principle: fabric weight refers to the relative weight of fabric, not the absolute weight. Fabric weight is an important factor for international selling and buying.
- **Yarn Count:** Fabric count is determined by counting the number of warp and filling yarn per inch in woven fabric. In the research work fabric dissection method was used to study the effect of sizing on thread count of fabric. The thread count was determining using ASTM- 1910-64 test method. Fabric dissection literally means unraveling the cloths and the threads unraveled are counted.
- **Fabric Count :** Fabric count is determined by travelling microscope counting the number of warp and filling yarn per inch in woven fabric. The fabric count was determined using ASTM- test method.
- **Fabric Colour:** colour value of the sample was analyzed on the basis of L* a* b* values using reflectance spectra through (colour eye 3100) Macbeth UV

spectrophotometer. The L* value is measure of lightness and darkness of the colour while a* and b* define the colour on a two dimensional chromatic space of green-red axis and blue- yellow axis, a* and b* values were evaluated.

Assessment of the acceptability of starched fabric by consumer

To assess the acceptability of developed starched powder both *Cassia fistula* and *Maranta Arundinacea(Arrowroot)* starch was applied on cotton dupatta having same fabric weight and colour than starched dupatta was evaluated by 30 post graduate students for various attributes (Texture, Luster, Drapability, Stiffness, Thickness Color).

4. Analysis of data

Frequency: Data obtained from consumer acceptability rating scale was expressed in frequency.

Percentage: The rating obtained by the starched dupatta of each category was tabulated according to the scores obtained and converted in percentage.

Ranking : The rating obtained by the different concentration of starch was tabulated according to the score obtained and converted into the percentage. The total scores obtained by each attribute were ranked in the order to acceptance.

Acceptability index: To assess the acceptability of starched dupatta, an acceptability index was used.

ANOVA: In order to analyze the significant difference in fabric weight, thickness, stiffness, and crease recovery, count, tensile strength, and yarn count, analysis of variance was calculated.

T – Test: To compare the physical parameters of *Cassia fistula* starch with commercially available starch *(Arrowroot)* t – test was used.

RESULTS AND DISCUSSION

The major findings of the study have been summarized as follows.

Characterization of the starch obtained from *Cassia fistula* seed:

The morphology of (size and shape) starch powder from *Cassia fistula* seed was captured by means of scanning electron microscope (SEM). All micrographs were taken at

different magnification and an accelerating voltage (kv). *Cassia fistula* starch particles have a morphology that is asymmetric, irregular in shape.

Optimize of the different concentration of *Cassia fistula* seed starch through visual evaluation:

Fabric starched using different concentration of *Cassia fistula* seed starch (2.5 gm, 5 gm and 7.5 gm) were visually evaluated by a panel of experts for various attribute viz. texture, luster, stiffness, thickness and drapability of the starched fabric sample.

- On the basis of texture of the starched sample medium weight with 5 per cent was given highest preference with total marks of 24 out of 25. Results showed that the starched samples were not smooth in texture in thin and thick fabric at different concentrations.
- In term of luster of the fabric 2.5 per cent in medium weight fabric was highly preferred by the judges with a total score of 23 out of 25.
- Top two most preferred concentrations were 5 per cent and 7.5 per cent for medium weight fabric in term of stiffness with total marks of 21 out of 25.
- Thickness of the fabric was found good for medium and thick muslin fabric with all three concentrations. In term of thickness of the fabric thin muslin fabric showed poor results with different concentrations.
- In case of drapability of the fabric again medium weight muslin at 5 per cent was given the highest preference by judges.
- On the basis of total score medium weight muslin starched with 5 per cent concentration was highly preferred by the judges with a total score of 112 out of 125.

Effect of sizing material on quality parameters of cotton fabric:

- **Crease recovery:** It is evident from ANOVA table that there is significant difference in crease recovery angel for different starch concentrations in both warp and weft directions. Thick starched sample at 7.5 per cent concentration had maximum degree of crease recovery i.e. 158.33 in warp direction and 145.33 in weft direction.

- **Fabric stiffness:** Results showed that there is significancedifference between the calculated F value of the different fabric (A), with different concentrations (B) in warp and weft direction with the tabulated value of the same.

- **Tensile strength:** There is significant difference between the calculated F values of the different fabric sample (A) in warp and weft direction with the tabulated value of the same. It showed that there is no effect found of different starch concentrations in tensile strength of the fabric.

- **Fabric count:** The results revealed that there is increment found in warp direction after sizing in case of fabric count and very slight increment was found in weft direction. There is significance difference between the calculated F value of the different fabric (A), with different concentrations (B) in warp and weft direction with the tabulated value of the same so it was interpreted that all the concentrations cannot be applicable on all the fabric.

- **Yarn count:** There is significance difference in both warp and weft way of the fabric. Very slightly difference was observed in mean values of before and after in both warp and weft direction.

- **Fabric weight :** Based on the mean values obtained it can be inferred that weight of the fabric was slightly increases after application of size. There was significant difference between F calculated value and F tabulated value.

- **Fabric thickness:** Results showed that after application of size (starch) thickness of the fabric were increases in all the three fabric with different concentrations. Thick sample with 7.5 per cent starch concentration obtained highest mean value.

- **Fabric colour:** Colour strength of different starched sample at all the starch concentration was increased as compare to control or unstarched fabric sample. L* of the starched samples was slightly decreased. The l* value of different starched sample at 2.5 per cent and 5 per cent concentrations shows similar results. The L* value of 7.5 concentration is less which shows slightly more darkness of starched sample. The a* value indicates redness or greenness and b* value indicates yellowness and blueness.

Comparison of the fabric quality parameters of sample sized with *Cassia fistula* seed starch against commercial starch sample *(Arrowroot)*:

- Results showed that crease recovery was found good in *Cassia fistula* starched sample, it may be due to stiffness of the fabric which reduced the bending length. So it can be interpreted that both the starch concentration can be used for sizing with respect to crease recovery of the fabric.
- In term of tensile strength *Maranta Arundinacea (Arrowroot)* starched sample shows good strength with highest mean value the results depicts that there was no significant difference.
- Results indicate that very slight difference was found between both the starched samples in warp direction. It can be observed that very slight difference was found in mean values of both the starched samples in case of stiffness so both the starch can be used for sizing. *Cassia fistula* showed good results as compare to *Maranta Arundinacea (Arrowroot)*.
- In term of fabric weight *Maranta Arundinacea (Arrowroot)* starched sample found heavy as compare to *Cassia fistula* starched sample and there was significant difference between the t calculated values and t tabulated values.
- Results revealed that there was significant difference between the t calculated values and t tabulated values in weft direction. Both the starched sample shows similar results in warp direction in term of yarn count.
- Result indicated that there was significant difference between the calculated t values with the tabulated values so it was interpreted that *Cassia fistula* starched sample showed best results as compare to *Maranta Arundinacea (Arrowroot)* with respect to fabric count.

Comparison of the starched dupatta with *Cassia fistula* starch and *Maranta Arundinacea (Arrowroot)* starch on the basis of subjective evaluation

Thirty respondents who were using starched cotton dupatta were randomly selected from College of Home Science. The subjective evaluation of muslin fabric sample stiffened with both the *Cassia fistula* and *Maranta Arundinacea (Arrowroot)* starch was done by these post gradation student the evaluation was carried out to study the difference between *Cassia fistula* and *Maranta Arundinacea (Arrowroot)* starched dupatta on the basis of various parameters. Both starched dupatta was judged and ranked by each respondent for stiffness, texture, luster, drape, thickness and color by visual inspection and feel. Results revealed that

in terms of stiffness, thickness, drape and color *Cassia fistula* showed best results as compare to *Maranta Arundinacea (Arrowroot)* and rated as highly acceptable. But in case of texture and luster *Maranta Arundinacea (Arrowroot)* starched dupatta found more acceptable as compare to *Cassia fistula* starched dupatta. Majority of the respondents (86%) felt that *Cassia fistula* starched dupatta was best and only (68.66 %) obtained by *Maranta Arundinacea (Arrowroot)* starched dupatta.

Assessment of the acceptability of starched fabric by the consumer:

The developed *Cassia fistula* starch and commercially available arrowroot starch applied on cotton duppta and then this duptta was evaluated by 30 respondents to find its consumer acceptability with the help of five point rating scale.

It was found that in term of stiffness of the fabric was highly acceptable (96%) with a total score of 144 out of 150. Texture of the fabric was next favored with total marks of 140 out of 150. Following the same trend, thickness of the fabric and drapability of the fabric were next favored with a total score of 133 and 127 respectively. Among the all attributes luster of the fabric and color of the fabric were least favored by the respondents with a total score of 114 and 116 out of 150 respectively. Over all acceptability of the *Cassia fistula* starched duppata was found 86 per cent.

Conclusion

Thus, it can be concluded that developed starch showed batter results as compared to commercially available starch *(Arrowroot)*. There was improvement in the physical properties like yarn count, fabric count, GSM, fabric bending length and crease recovery when treated with *Cassia fistula* seed starch. Developed starch was highly appreciated and liked by the consumers. Use of *Cassia fistula* for sizing make new innovation in nature based sizing. Hence, *Cassia fistula* starch can be recommended as on eco-friendly and user friendly sizing agent.

RECOMMENDATION

- Study could be conducted on the other source of natural and biodegradable starch.
- Comparative study can be conducted on synthetic sizing agent and natural sizing agent available in local market.
- A similar study can be conducted to study the awareness preferences and satisfaction with the available natural sizing agent.
- An intervention can be done in villages on production of sizing agents from natural starch to establish micro enterprise and study its impact on economic empowerment of rural people.
- A study can be conducted using combination of starches and its effect on physical properties of fabric.
- The present research work can be extended for sizing of other silk, cotton blends and synthetic fabrics with natural starch.

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