

**Assessing the Dyeability of Khadi fabric using
Artocarpus heterophyllus Wood and Printing with
Lawsonia inermis leaves**

By

Vijayalakshmi, S

(14PTF012)

A Thesis submitted to the

**Avinashilingam Institute for Home Science and
Higher Education for Women,
Coimbatore – 641043**

In Partial Fulfillment of the Requirements for the

DEGREE OF MASTER SCIENCE IN TEXTILES AND FASHION APPAREL

APRIL, 2016

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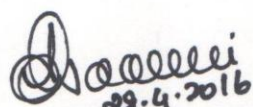
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Certified as Bonafide Research Work


29.4.2016

**Signature of the
Head of the Department**



**Signature of the
Supervisor**

ACKNOWLEDGEMENT

First and foremost, the investigator places her humble salutations at the feet of **GOD ALMIGHTY** who has given sound wisdom, knowledge, strength and the opportunity to do the investigation effectively.

The investigator expresses her immense gratitude and thanks to **THIRU.Dr.T.S.AVINASHILINGAM AYYA**, Founder and First Chancellor of Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, and **HONY.COLONEL PADMASHRI Dr.(Tmt) RAJAMMAL P. DEVADAS**, M.A., M.Sc., Ph.D. (Ohio State), Hon. D.Sc. (Azad Agri. University), (Kanpur), Former Chancellor, Avinashilingam Institute for Home science and Higher Education for Women, Coimbatore, for providing and shaping this temple of learning.

The investigator wishes to express her immense gratitude to **PADMASREE Dr.(Thiru) P.R.KRISHNAKUMAR**, Chancellor and **Dr.(Thiru) MEENAKSHI SUNDARAM**, M.A., M.Phil., Ph.D. (HonorisCausa), Anna Avl., Chancellor, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for the opportunity to conduct research in this esteemed university.

The investigator owes her deep sense of gratitude and thanks to **Dr.(Tmt) SHEELA RAMACHANDRAN**, M.Sc., P.G.Dip., Ph.D. (Avinashilingam), Vice-Chancellor and **Dr.(Tmt) PREMAVATHY VIJAYAN**, Vice Chancellor (i/c), Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for providing all the amenities required and for her immense support in the conduct of the study.

The investigator owes her respectful regards and sincere thanks to **Dr (Tmt) A.VENMATHI**, M.Sc., Dip. Ed., M.Phil., Ph.D., Registrar In Charge, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for her encouragement towards the research.

The investigator records her respectful regards and tribute to **Dr.(Tmt.) N. VASUGI RAAJA**, M.Sc., M.B.A., M.Phil. (Madras), Ph.D. (Avinashilingam), Dean, Faculty of Home Science, Avinashilingam Institute for Home Science and Higher

Education for Women, Coimbatore, for her encouragement and valuable help during the progress of her study.

She expresses her respectful regards and sincere thanks to **Dr.(Tmt) S.AMSAMANI**, M.sc, M.Phil, Ph.D Professor and Head of the Department of Textiles and Clothing, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for rendering all help needed for the successful completion of the study.

The investigator feels immensely indebted and extremely privileged to have worked under the supervision of her esteemed guide, **Dr. (Tmt.).R.PRABHA**, M.sc, M.Phil, Ph.D Assistant Professor, Department of Textiles and Clothing, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for her valuable guidance, technical support, timely help and constant encouragement throughout the study.

The investigator expresses her deep sense of gratitude to all the **STAFF MEMBERS** of the Department of Textiles and Clothing, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for being supportive, suggestive, understanding and their encouragement rendered towards the completion of her study.

The investigator expresses her special thanks to librarian for the facilities provided.

The investigator owes her sincere thanks and gratitude to her beloved parents, her sister and brother, for their enthusiasm, co-operation, love, care, support, constant encouragement, blessings, prayers and help rendered and moral support for the successful completion of the study.

Last but not the least, the investigator extends her thanks to her friends and their family members for their constant prayers, support and encouragement.

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1.INTRODUCTION

Textiles have such an important posture on our daily lives people have used textiles of various types of covering, warmth, personal adornment and even to display personal wealth. Today textiles are used for these purposes and everyone is an ultimate consumer (Vidhyasagar, 2008). On a present report our environment has been damaged by textiles processing methods by the way of water pollution by releasing some toxic chemicals, non bio- degradable dyes, total dissolved solids and sludge from effluent treatment plots. Throughout per annum the consumption of synthetic dyes has been predicted to be one million tons. Recent report on harmful effects of synthetic dyes on environment and human beings made the world to develop the eco friendly and safe dyes that may be used for textiles.

Awareness on environmental issues is increasing all over the World through discussions about the green house effect, ozone layer depletion, water pollution and water disposal. More than 40,000 years India has been producing textiles which also still foremost transmitter of design technology and tends to convey considerable social meaning and fulfill various purposes in our lives. The Indian textiles and clothing trade covers a broad scale of activities and processes ranging from production of fibre to the finished value added products such as apparel and fabric made ups (Thomas, 2008). Throughout the Worldwide issues on environment are becoming more crucial. Natural dyes are eco friendly which naturally serves higher assessment to textile material and apparel due to their characteristic of bio degradable nature which are safe to flora, fauna, ecology and to our skin (Jayalakshmi *et al.*, 2011).

Khadi or khaddar is a coarse hand woven poor grade fabric but it has some inherent qualities, it is very soothing in summer season and ample amount of ventilation is there. It has the capability to absorb moisture therefore it easily soaks the sweat and keeps wearer cool and dry (Bajpai *et al.*, 2010). A handloom is the handspun and hand woven cloth which is made on a machine Charkha used by hand to weave cloth for people living in the villages is known as “Khadi”. Clothing comfort as a tremendously complex occurrence has drawn the concentration of many textile research workers. The comfort characteristic of fabric mostly depends on the composition types of raw material used, moisture absorption, heat transmission and skin perception (Joshi, 2002).

Over the years Khadi has evolved from freedom fighters identity fabric to a fashion garment and at once it was regarded as fabric for farmer and rural wearer. But at present it has a great increasing demand for Khadi is in spite of million women workers involved in spinning all over the country and they are unable to meet the demand in the market (Tarlo, 1996). Now a days variants of Khadi like Muslin Khadi, matka khadi, poly khadi, tussar silk, raw silk khadi and many more different varieties and colours are available. Designers experimenting with the hand-woven khadi and make it suitable for all kinds of occasions. Many high profile personalities and economically sound people prefer to wear it. Once people start to wearing Khadi they become addict to it. It is

considered as one of the most beautiful Indian fabric. The khadi wearer gets a royal and distinguishable look due to its fall and style and symbolizes luxury and uniqueness, (Ahsaan, 2009).

People having more consciousness on environmental issues, in order to avoid some hazardous synthetic dyes; the practice of non-toxic and eco friendly natural dyes on textiles came into existence. The colouration of textiles has mainly been restricted to craftsman, small scale dyers and printers as well as small scale exporters and producers dealing with high valued eco-friendly textile production and sales through the usage of natural dyes. To conquer environmental pollution caused by synthetic dyes a huge number of small scale exporters started looking at the possibilities of using natural dyes for regular dyeing and printing on textiles. India is still a major producer of most natural dyed textiles (Rungruangkitkrail et al, 2012).

Currently, natural dyes has been greater demand because people having more concern and awareness on hazardous , toxic and allergic reactions connected with synthetic dyes. Natural dyes are acquired from natural sources like plants, minerals and insects. Plant based sources are bark, flowers ,seeds etc., dye sources are much more important for textile dyeing as it afford for both dye and fragrance(Singh et al ,2015). Dyes which set out for their beauty and ecological feature would never be employed on just any material but on noble fabrics such as wool, silk, linen or cotton, made to last more than one season. Natural dyes can be sub divided into dyes and pigments. Dyes lose their crystal structures during application by dissolution or vapourisation and are often used for textiles and food colourants. Pigments retain their crystalline or particulate structure throughout their application (Vishalakshi and Jawaharlal, 2013).

Some of the certain problems with the use of natural dyes are colour yield, complexity of dyeing process, reproducibility results, limited shades, blending problems and insufficient fastness properties. But these problems can be conquer by using mordants. A natural dye mordant could be any one of some metal salts capable of providing a chemical bond between fibre and dye (Kamel, 2011). Adequate time should be given for the mordant to thoroughly penetrate into the fibre creating a richer, brighter, stronger colour (Klaichoi, 2012).

Textile industries widely using synthetic printing pastes for designing the surface of the fabric. Each and every printing method requires a paste or thickening agent with unique characteristics which are difficult to dispose that create sedimentation to the water during disposal of its waste. Natural dyes are also used for printing. Printing is nothing but defined as dyeing in a localised and patterned area. The main objective in printing is to produce coloured design in one or more colours with sharp boundaries on textile material, without any of the dyes spreading beyond the boundaries of the design. In order to achieve this, a concentrated dye solution has to be prepared with minimum of water and thickened with a suitable thickening agent (Maulik and Agarwal, 2014).

Alternative to synthetic pastes, natural biodegradable materials developed from sago can be used during printing process. The advantages of this product are environmental friendly that is non-toxic fumes; production cost is lower, instance application and a creative process enhancement in textiles production. Arabic gum, guar gum, cereals starch and sea weeds sodium alginates are commonly used natural printing thickeners for textile printing (Kapoor, 2012).

The general procedure for fabric printing is to print the garment with suitable colour paste, dry and fix the colour at high temperature. Printing can be carried out using block, stencil or roller printing machine (Sain, 2012). Natural dyes provide more attractive and delicate natural colour tones, when it comparing natural dye printings with artificial dye printings and which does not harm to the environment and human beings (Yong, 2012).

Artocarpus heterophyllus is commonly called Jackfruit belongs to the family Moraceae (mulberry family) and subfamily Asteroideae. One of the most significant trees in tropical home gardens and medium-size evergreen tree typically reaching 8–25 m (26–82 ft) in height. . Jackfruit is known as kanthal in Bengal, panasa in Sanskrit, katahal in Hindi, pala in Tamil and chakka in Malayalam. The succulent, aromatic, and flavorful fruit is eaten fresh or preserved in myriad ways. It is also known for its remarkable, durable timber, which ages to an orange or red-brown color. The leaves and fruit waste provide valuable fodder for cattle, pigs, and goats. Many parts of the plant including the bark, roots, leaves, and fruit are attributed with medicinal properties. Wood chips yield a dye used to give the famous orange-red color to the robes of Buddhist priests. The bark is made into poultices. Heated leaves are placed on wounds. The wood has a sedative property; its pith is said to produce abortion. There is 3.3% tannin in the bark. When boiled with alum, wood chips, or sawdust, it yields a dye that is commonly used to give the characteristic color to the robes of Buddhist priests and in dyeing silk (Craig *et al*, 2006). Jackfruit wood is widely used in the manufacture of furniture, doors and windows, and in roof construction Jackfruit tree has a lot of economic values as well. The tree has some medicinal uses also. The timber named as Jack-wood is used for making furniture as it is termite-proof .
(http://www.indianetzone.com/4/the_jack_fruit_tree.html).

Lawsonia Inermis commonly called as Henna or Mehendi, belongs to the Lythraceae family. It is a conventional medicinal plant which is a middle sized shrub with several branches with a height of 1.8-7.6 m. The parts of henna shrub like roots, leaves, flowers, seeds are been extensively used. In India, it is scarcely present in dry deciduous forests and cultivated as hedge plant. Henna was used for the treatment of headaches, migraine, albinism, skin abrasions and ulcers, burns, smallpox, leprosy boils, wounds, some mycotic infections and cancers, treatment of scalp and hair infections and ailments. Henna has a wide spectrum of antimicrobial activity including antibacterial, antiviral, antimycotic and antiparasitic activities. Leaves are bitter, astringent, acrid, refrigerant, diuretic, expectorant, anti-inflammatory, constipating,

febrifuge and liver tonic. It is useful in wounds, ulcers, burning sensations, inflammations, scabies, leprosy, leucoderma, boils, amenorrhoea, dysmenorrhoea, fever, ophthalmia, haemorrhages, splenopathy and strangury. Potential use of *Lawsonia Inermis* as a natural antimicrobial textile dye has not been fully exploited (Gagandeep *et al.*, 2010).

Hence worldwide growing consciousness about organic value of eco friendly products is being generated and a renewed interest of consumers towards use of textiles preferably natural fibre products, dyeing and printing with eco friendly natural dyes is on rise as an alternative of hazardous synthetic dyes (Kumaresan *et al.*, 2011).

Considering the above criteria plant materials are used for dyeing and printing using natural mordant and natural thickener using on khadi cotton fabric, because it is traditional fabric used in textile industry which has more durability and also eco friendly material.

Hence the objective of the present study “**Assessing the Dyeability of Khadi fabric using *Artocarpus heterophyllus* Wood and Printing with *Lawsonia inermis* leaves**” is

- To select suitable fabrics and dyes
- To select the extraction method and dyeing method
- To colour the fabric with selected sources
- To select printing paste, thickening agent for printing
- To finish the fabric with selected printing techniques
- To study the dyed and printed fabric subjectively and objectively

2. Review of literature

The review of literature pertaining to the study entitled “**Assessing the Dyeability of Khadi fabric using *Artocarpus heterophyllus* Wood and Printing with *Lawsonia inermis* leaves**” is discussed under the following headings

2.1 Khadi

2.1.1 History of Khadi

2.1.2 Production of Khadi

2.1.2 Properties of Khadi

2.2 Natural Dye

2.2.1 Classification of natural dyes

2.3 *Artocarpus heterophyllus*

2.3.1 Introduction

2.3.2 Properties

2.3.3 Uses

2.4 Extraction Methods

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2.4.2 Solvent Extraction Method

2.4.3 Supercritical Fluid Extraction Method

2.4.4 Ultrasound Assisted Extraction (UAE) Method

2.4.5 Microwave Assisted Extraction Method

2.4.6 Enzymatic Extraction Method

2.5 Mordant

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2.5.1.1 Natural Mordants

2.5.1.1.1 Cream of Tartar

2.5.1.1.2 Myrobalan

2.5.1.1.3 Alum

2.5.1.1.4 Copper

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2.5.1.1.7 Iron

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2.6.2 History of Printing

2.6.3 Selection of Printing source

2.6.3.1 *Lawsonia inermis*

2.6.3.2 Properties and Uses

2.6.4 Different techniques of printing

2.6.4.1 Direct printing

2.6.4.2 Discharge printing

2.6.4.3 Resist printing

2.6.5 Methods of Printing

2.6.5.1 Block Printing

2.6.5.2 Screen Printing

2.6.5.3 Rotary Screen Printing

2.6.5.4 Roller Printing

2.6.5.5 Transfer Printing

2.6.6 Thickener

2.6.6.1 Indian Arabic gum

2.6.6.2 Guar gum

2.6.6.3 Gum Tragacanth

2.1 Khadi

Khadi can and should have only one meaning, viz, hand- woven cloth made from hand-spun thread. Khadi or Khaddar is a term for handspun and hand-woven cloth from India, Bangladesh and Pakistan primarily made out of cotton. The raw materials may sometimes also include silk, or wool, which are all spun into yarn on a spinning wheel called a charkha. It is a versatile fabric, cool in summer and warm in winter. In order to improve the look, Khadi/khaddar is sometimes starched to give it a stiffer feel. It is widely accepted in fashion circles(Mirsha, 2014).

2.1.1 History of Khadi

Khadi came into being around 1857 during the initial stage of India's struggle for independence and was considered a symbol of patriotism as it helped in avoiding foreign goods entering the market. Suppressing and replacing the Indian handloom cotton trade with mill made alternatives was a key factor of the British Industrial Revolution. That is the reason Gandhi made hand-spun khadi a symbol of the Indian Independence movement (Garima, 2013). Khadi was conceived in 1920's as a symbol of Swadeshi movement and self-reliance of the villages. The Gandhian ideas of simplicity, Swadeshi spirit and decentralization are embodied in Khadi. In 1919, when there was a movement to boycott foreign goods, Gandhiji appealed to his countrymen to adopt Khadi (Sekhri, 1992). Khadi became a symbol of freedom struggle. "Livery of Freedom" as Nehru described Khadi (Tarlo, 1997).

Even today millions of craftspeople all over India produce extraordinary traditional textiles that appeal to the International market. Khadi weaving gives employment opportunities in rural areas of India even today and approximately 9 million people are employed in the production of such natural fibre fabrics. Khadi before Independence was considered as the fabric for the political leaders and rural people. But now it has found its way into the wardrobe of fashion conscious people (Elangoran and Mohan, 2006).

2.1.2 Production of Khadi

Traditionally in the khadi industries, charkha, a small portable hand cranked wheel is ideal for spinning cotton and other fine, short-staple fibers through it can be used to spin other fibers as well. Mostly the process involved in these industries is hand operated and simplest in construction (Mirsha, 2014). The operation involved in the khadi fabric productions are fabric weaving, yarn winding, warp preparation, sizing, drawing in and denting, weft preparation, and weaving in the handloom. Khadi industry is non-polluting and does not recklessly destroy natural resources both in terms of raw materials and energy. Khadi has been essentially associated with Indian garments like kurtas and sarees. However, for more western silhouettes like dresses and skirts that need a flow fall, khadi with higher thread count is advisable (Namrata and Shailaja,2014).

2.1.3 Properties of Khadi

Khadi is a versatile fabric. It has the unique property of keeping wearer warm in winter as well as cool in summer season. During spinning of Khadi, the threads are interwoven in such a manner that it provides passage of air circulation in the fabric. In addition to it, khadi also provides warmth in winter season. Its easy adaptability to a range of designs makes it amenable to both formal and informal look as well as Indian and Western styles. It has a handcrafted self-texture making each khadi cloth unique and expensive. Its inherent strength makes it highly durable (Garima Upadhyay , Sangita Deodiya, 2013).

2.1.4 Uses of Khadi

Khadi cotton comes in plain as well as printed fabrics. The most common outfit made from khadi cotton is the “kurta”. Many types of apparel are manufactured from khadi cotton like saris, salwar suits, fabric yarns, western tops, shirts, trousers, skirts, handkerchief , etc. It is very durable fabric. Printing and dyeing these fabric with natural colours would add value to them and could be used in the apparel industry. Comfort and handmade nature of khadi seems to be perceived difference between khadi and other clothes

2.2 Natural Dye

The demand for natural dyes in the recent world is growing day by day. Such dyes are obtainable mainly from vegetable source. Global awareness is also set for the use of natural resources for saving the environment and the earth from pollution and ecological imbalances. Therefore it is an urge to utilize the vast diversity of natural resources of colour pigments. These resources have become important for their use in food materials, pharmaceuticals and textiles, instead of their synthetic counterparts. To use these resources it is safeguard human health, as well as to protect and prolong life on the earth. Accounting these facts it seems that the history is going to repeat. Really in these days to follow, there will be reintroduction of natural dyes (Patil *et al.*, 2012).

Natural dyes are gentle, soft, delicate, lustrous and generate restful effects as they are obtained from renewable sources. This dyes have therapeutic and antioxidant property which are non-carcinogenic in nature. Natural dyes have enhanced biodegradability, lack of toxicity and generally have higher compatibility with the environment (Grover and Patni, 2011). Most of these natural dyes are eco-friendly, non allergic to skin, less polluting as compared to synthetic dyes (Kulkari *et al.*,2011). Each natural dye source provides an amazing diversity of shades based on the dyeing procedure and the type of mordant is used. Along with the application of natural dyes it has potential to earn carbon credit by reducing consumption of fossil fuel based synthetic dyes (Vankar, 2007).

Now-a-days natural dyes are commonly used for textile industries, due to their risk-free effects and harmful consequences of synthetic dyes. Colours of natural dyeing

are constant and eco-friendly because of no irritating effects on human skin. Different parts of plant are widely using for colouring the yarn or fabric. Nature has provide a huge number of plants to use it in dyeing processes to lead a saver life. In the natural dyeing processes different mordants are used which can be natural plant products like lemon juice, tamarind pulp, pomegranate and some chemicals like alum, chrome, stannous chloride, copper sulphate, ferrous sulphate etc., In all the studies three mordanting techniques were mostly used as pre-mordanting, simultaneous and post-mordanting. The results of natural dyeing were found very encouraging, with their non toxic, non allergic and non-carcinogenic soothing harmless effects (Iqbal and Ansari Taiyaba N, 2013).

Dyeing is a technique which imparts gorgeousness to the textiles by applying various colours and their shades on a fabric for the purpose of value addition, aesthetic look, wish and want of the customers. It can be done at any phase of the manufacturing process of textiles such as fibre, yarn, fabric or a finished textile product including garments and apparels (Asare *et al.*, 2013). Vedas mentioned the spectrum of fine-looking natural colours ranging from yellow to black as foremost dyeing colour uttered that the ancient craftsmen dyed blue from indigo, yellow from turmeric, saffron brown from cutch, red from lac, safflower and madder (Teli *et al.*,2013). Compared to synthetic dyes cost of natural dyes are higher and thus have limited shades and availability. And it is complicated to produce shades by using natural colourants e.g., agro products vary from one crop season to another crop season, place to place and species to species, maturity period (Mohammad *et al.*, 2012).

2.2.1 Classification of natural dyes

Natural dyes are classified by various techniques. Ancient methods of classification were based simply on the alphabetical arrangements of dyes. Later on numerous other methods are adopted (Patel, 2011). Some of the common classifications of natural dyes are as follows:

Natural dyes are divided into two groups such as substantive and adjective dyes which are based on their natural affinity for textiles. Substantive dyes are also referred to as direct dyes such as indigo, turmeric. Substantive dyes posses a high affinity to textiles without the support of any other chemicals or additives which it will give high-quality colour to dye the fibers directly (Chakrobarty *et al.*, 2009).

Adjective dyes are also referred to as mordant dyes, such as logwood, madder. Large quantity of natural dyes have low affinity, which require an added substance known as mordant with a metallic salt to make the dyes colourfast (Tarafder, 2009). The monogenetic type produce only one colour irrespective of the mordant applied along with dye, where as the polygenetic dyes produce different colours according to the mordant employed (Soundarapandian, 2007). Soluble dyes can be dissolved in

water and applied. Insoluble dyes have no solubilizing group hence temporary solubilizing group is introduced e.g. indigo. As per sources natural dyes are divided as vegetable, animals and minerals. Dyes which are obtained vegetable sources from various parts of plants and herbs including stem, bark, root, wood, leaves, flowers, fruits which produce a distinct pale to dark shades. Some examples of vegetable dyes are indigo, logwood, turmeric, madder (Almahy, 2013).

In the colour manifestation the natural dyes are classified according to the hue. The majority of traditional natural colours representing the principle colours are the yellow, the red, black and the blue. Madder is popularly known as the 'Queen of natural dyes' it is the red colour producing natural dyes from the plants of various rubia species. (Kashkar and Mansour, 2013). Yellow is the liveliest and perhaps the most abundant of all hues in nature. About 90% of the yellow dyes are flavonoids. The plants which yield yellow dyes outnumber those yielding other colours. Generally, they produce pale shade with quicker fading except turmeric, which produce dull shade but considered to be susceptible to light as they emit fluorescence e.g., tesu, turmeric, kapila (Ashis and Adwaita, 2011)

2.3 *Artocarpus heterophyllus* (Jackfruit)

2.3.1 Introduction

Artocarpus heterophyllus is commonly called Jackfruit belongs to the family Moraceae (mulberry family) and subfamily Asteroideae. One of the most significant trees in tropical home gardens and medium-size evergreen tree typically reaching 8–25 m (26–82 ft) in height. . Jackfruit is known as *kanthal* in Bengal, *panasa* in Sanskrit, *katahal* in Hindi, *pala* in Tamil and *chakka* in Malayalam. The succulent, aromatic, and flavorful fruit is eaten fresh or preserved in myriad ways. It is also known for its remarkable, durable timber, which ages to an orange or red-brown color. The leaves and fruit waste provide valuable fodder for cattle, pigs, and goats. Many parts of the plant including the bark, roots, leaves, and fruit are attributed with medicinal properties. Wood chips yield a dye used to give the famous orange-red color to the robes of Buddhist priests (Craig and Harley, 2006).

2.3.2 Properties

All parts of the tree are said to have medicinal properties. Morton (1987) reports, "The Chinese consider jackfruit pulp and seeds tonic, cooling and nutritious, and to be 'useful in overcoming the influence of alcohol on the system'. The seed starch is given to relieve biliousness and the roasted seeds are regarded as aphrodisiac. The ash of jackfruit leaves, burned with corn and coconut shells, is used alone or mixed with coconut oil to heal ulcers. The dried latex yields artostenone, convertible to artosterone, a compound with marked androgenic action (having male hormone activity). Mixed with vinegar, the latex promotes healing of abscesses, snakebite and glandular

swellings. The root is a remedy for skin diseases and asthma. An extract of the root is taken in cases of fever and diarrhea.

2.3.3 Uses

Jackfruit tree has a lot of economic values as well. The fruit can produce rubber. The tree has some medicinal uses also. A fomentation obtained from the leaves can be applied to the injuries and their juice can relieve the puffiness of the glands. The timber named as Jack-wood is used for making furniture as it is termite-proof. The Nambudri Brahmins of Malabar produce sacred fire by the resistance of dry Jackfruit branches. Hence, it is clear that Jackfruit tree is one of the very popular and widely used Indian (Wikipedia).

2.4 Extraction Methods

As natural dyes-bearing materials contain only a small percentage of colouring matter or dye along with a number of other plant and animal constituents such as water-insoluble fibre, carbohydrates, protein, chlorophyll, and tannins, among others, extraction is an essential step not only for preparing purified natural dyes, but is also required to be carried out by users of crude dye-bearing materials. So, the nature and solubility characteristics of the colouring materials need to be ascertained before employing an extraction process. The different methods for extract ion of colouring materials are:

2.4.1 Aqueous Method

Aqueous extract is one of the traditional, conventional method of dye extraction from natural dye. Different of collected plant samples(1,2,3,4,5,6,7,8,9 and 10 gm) were taken in each beaker, and 100ml water was added in each and kept into dye bath at different temperatures (30,40,50,60,70,80,90,and 100°C). Extract samples were taken at different time (in mins) intervals (30, 60, 90,120, 150, 180, 210, 240 and 270). Then the dye solution extracted from the sources were filtered and used for dyeing purpose. Then the optical density of the sample was determined with the help of US-VIS spectrophotometer (Swami et al., 2012 and Chakraborty et al., 2009).

2.4.2 Solvent Extraction Method

When a compound of low solubility needs to be extracted from a solid mixture soxhlet extraction can be carried out using solvents such as acetone, petroleum ether, chloroform, ethanol, methanol, or a mixture of solvents such as mixture of ethanol and methanol, mixture of water with alcohol, and so on. Because sometimes colourants which are present in natural sources do not come in aqueous medium (Umale and Mahanwar, 2012). A sample powder 2.5 g was accurately weighed and put into 150 ml soxhlet thimble. The apparatus was fitted with 500 ml round bottom flask containing

200ml of extraction solvent. The extraction temperature was controlled at 80^o C with a regulator. The flask was heated for certain time and the solvent was refluxed. After extraction the extract was filtrated and transferred into volumetric flask. The solvent was used to rinse the distilling flask and the sediment three times. The process takes 4-6 hours (Kannadasan *et al*, 2013).

2.4.3 Supercritical Fluid Extraction Method

Supercritical fluid extraction is a two step process which uses a dense gas as a solvent usually carbon dioxide above its critical temperature that is 31^o C, and critical pressure which is 74 bar for extraction. The natural source is powdered and charged into the extractor. Carbon dioxide is fed to the extractor through a high- pressure pump that is working at 100-350 bars. The extract charged carbon dioxide is sent to the separator which is at a pressure 60-120 bar via a pressure reduction valve. At reduced temperature and pressure conditions the extract precipitates out in the separator. The extract free carbon dioxide stream is introduced several times for effective extraction of all the dye material from the natural products (Vanker, 2005).

2.4.4 Ultrasound Assisted Extraction (UAE) Method

The natural sources were collected and dried at 50^o C in tray drier. Methanol (15 mL/g of peals) was added in dried sources and then pH 2, 4, 8 was adjusted separately in three beakers. These beakers were then placed in ultrasonic bath and sonicated for 5 – 30 minutes at 27 – 30 MHz and 160 V (Mirsha *et al*, 2012). After sonication the contents of beaker were filtered through standard test sieve (BSS-36) to remove solid materials. The filtered coloured liquid was vacuum evaporated in a rotary vacuum evaporator to about half of the original volume. The concentrated coloured liquid was spray-dried. The inlet and outlet temperatures were maintained at 110^o C and 70^o C respectively and aspiration speed at 1200 rpm, while flow rate was 35 mL/min. The colour dye powder obtained was weighed, stored in desiccators and finally used directly for dyeing the yarn without further purification (Schinor *et al.*, 2004).

2.4.5 Microwave Assisted Extraction Method

In microwave extraction the natural sources are treated with a minimum amount of solvent in the presence of microwave energy sources. The process of microwave assisted extraction method was performed in experimental microwave equipment at a power of 330W. Different amounts of powdered sample (0.1 g, 0.2 g,..1 g) were weighed and transferred into 100 ml beaker and 50 ml of distilled water was poured. The effect of microwave on the yield of colourant was examined at different time intervals at different pH (1.96 – 9.5) (Sinha *et al.*, 2012).

2.4.6 Enzymatic Extraction Method

As plant tissue contains cellulose, starches and pectins as binding materials, commercially available enzymes including cellulase, amylase and pectinase have been used by some researchers to loosen the surrounding material leading to the extraction of dye molecules under milder conditions (Jing Liu *et al.*, 2009). Citric acid (2.1 g) and sodium citrate (2.9 g) is added into water (100 ml) and a citric acid-sodium citrate buffer should be prepared and the pH range is adjusted to 3.5-4.5. Natural dye sources should be washed and dried. It is added into water in material liquor ratio 1:50 and stirred for 60 min at 50^o C (Tiwari *et al.*, 2010).

2.5 Mordant

The dyeing industry these days pose severe environmental problems due to accumulation of synthetic dyes and mordants. Majority of these synthetic dyes and mordants are not bio degradable and consequently most of them are being banned. At this juncture the use of natural colouring material as mordants and dyes play a very important role and now-a-days the industry is trying out on natural forms to avoid environmental hazards (Lichtfouse, 2013). The word ‘mordant’ has been derived from the Latin word ‘modere’ which means ‘to bite’. The mordant ‘bites’ the surface of the substrate i.e. fibre thus creating an affinity between the fibre and dye molecules (Jayashree and Naik, 2014). Dyes do not interact directly with materials they are intended to colour. Natural dyes are adjective and require a mordant to fix with the fabric and prevent the colour from either fading with exposure to light or washing (Flint, 2008).

2.5.1 Types of Mordant

Different types of mordants yield different colours even for same natural dye. The choice of mordant depends upon the fabric. An alkali mordant, such as soda ash, works well with cotton, and acid mordant such as vinegar works well with wool. Mordants can be classified as follows (kumbasar, 2011).

2.5.1.1 Natural Mordant

Commonly used mordants for natural colour dyeing include tannic acid, alum, urine, chrome, alum, sodium chloride, and certain salts of aluminium, chromium, copper, iron, iodine, potassium, sodium, and tin. Containers, other than glass or stainless steel may also be used, and the metals from which they are made may be employed to exert an influence on the ultimate color of the dye in the form of a mordant.

Historically, stale urine was used a lot as a mordant. It is strongly alkali and also affects the final colour of several days. It is still a good one to use but not many people like working with these days (Clarke, 2013).

2.5.1.1.1 Cream of Tartar

It is used to soften wool, brighten shades, and point the color of some dyes. Cream of tartar works best with animal or protein fibres and is seldom used with plant or cellulose fibres (Vankar et.al,2008).

2.5.1.1.2 Myrobalan

This dyestuff consists of ground nuts of the Terminalia chebula tree. It may be classed as both a mordant and a dye, giving a light buttery yellow when applied. The color works well for over dyeing. Myrobalan is also the perfect color to lay down under a single indigo dip for teal (Vankar et. al,2008).

2.5.1.1.3 Alum (Aluminium Potassium Sulfate)

This is the most widely used mordant. It usually produces pale version of the prevailing dye color in the plant. It is usually considered a neutral mordant, in that it does not result in a color that is appreciably different than that of the dye bath. It is considered to have good color fast properties, though other mordants result in even more color fast shades (Kumbasar,2011).

2.5.1.1.4 Copper (Copper Sulfate/Bluestone)

This mordant is used to bring out the greens in dyes. It will also darken the dye colors, similar to using tin, but is less harsh. Copper is used to “sadden” color, as it tends to turn them blue-green. It can be used as both an after-bath to adjust an alum-mordanted color, or it can be used as a pre-mordant on its own. The colors dyed with copper are generally more colorfast than those dyed with alum (Kumbasar,2011).

2.5.1.1.5 Chrome (Potassium Dichromate)

Chrome brightens the dye colors and is more commonly used with wool and mohair than with any other fibre. Chrome is a mordant that tends to add a golden hue to dyes, and is considered to be quite color fast. Chrome has played an important historical role in dyeing very dark and colorfast blacks in conjunction with logwood. It is not used often now, due to health hazards (Kumbasar,2011).

2.5.1.1.6 Tin (Stannous Chloride)

Tin will give extra bright colors to red, oranges and yellows on protein fibres. Tin is considered to be a generally neutral mordant, yet it brightens colors causes them to pop a bit. Tin can be used as a pre-mordant in a separate step, like alum, through care must be taken to preserve the hand of the fibre (Kumbasar,2011).

2.5.1.1.7 Iron (Ferrous Sulfate/Copperas/Green Vitriol)

It dulls and darkens the dye colors. Iron can be used as a mordant on its own, but it's generally used as an afterbath, to modify color dyed on fibre that was initially mordanted with alum. Its "saddens" color, making it more greenish - brown. Protein fibres like wool are very sensitive to iron, and too much time can damage the fibre and or make it have a harsh feel (Kumbasar,2011).

2.5.1.2 Synthetic Mordant

2.5.1.2.1 Alum mordant

Alum is produced as white crystals which are non-combustible and soluble in water. It has been used by human since 2000 BC when the Egyptians used the mineral as alum as a mordant in dyeing (<http://nzic.org.nz/chemprocessesproduction/1F.pdf>). Alum or other metallic mordants fix dyes on fibre by chemically combining with the functional groups of the natural dyes to form covalent bonds, hydrogen bonds and other interactional force. Alum commonly called as aluminium sulphate is the most common mordant. It is classified as the brightening mordant because it produces a pale and bright colour. It does not affect the colour being produced. Moreover, it can easily obtain from most chemists and is safe as well as cheap to use (www.earthguild.com).

2.5.1.2.2 Iron Mordant

Iron mordant is known as ferrous sulphate which is a pale green crystal which is non-toxic and so it poses little problem for handling. Iron mordant can be made at home and used as an alternative to replace ferrous sulphate. Some water is put into a plastic or glass container and a cup of vinegar is added. The mixture is then slightly acidic. A few rusty nails are put into the mixture and keep for a week until the water appears rusty. It is a dulling mordant and can produce a darker shade.

2.5.1.2.3 Copper Mordant

Copper mordant is copper sulphate or cupric sulphate, sometimes it is called blue vitriol because it is available as a bright blue crystal. It is one kind of dull mordants. Copper mordant also reacts with water to form a mildly basic hydroxide (Crews, 1982). However copper mordant is less frequently used than the other mordants. In addition it is more toxic, the disposal of small amounts of copper mordant and well diluted can reduce the environmental hazard (Bohmer, 2002).

2.5.1.2.4 Tannin Mordant

Tannic acid extracted from the vegetable sources for natural dyeing is more natural than those metal salts or the chemical tannic acid. Myrobalan, oak galls, sumach, cutch and some barks are commonly used tannin mordant in the textile industry. Some of the tannic acid rich sources may also contain dyes, and it may affect the resultant colour after dyeing has taken place, resulting in darker and less brilliant colour (Bohmer, 2002).

2.5.2 Mordant Techniques

There are different methods when the mordant is added to the dye bath. Pre-mordanting, simultaneous or post-mordanting. In pre-mordanting the dyeing fabric is mordanted before the actual dyeing in a separated mordanting bath. It is the most frequently used method by natural dyes because large quantities of textile can be treated and stored until dyeing (Shivankaret *et al.*, 2011). In simultaneous mordanting the mordant is added to dye bath. This brings the risk that the dyestuff and the mordant bind together before either of them has attached to the fibre but its quick and saving resources as water and energy (Flint, 2008). The post-mordanting method is used to fixate the colours permanently and intensifies them. It is done in a separate mordant bath after dyeing process. But the process between dyeing and mordanting should be done within three weeks otherwise the dye strength will lose (Teli *et al.*, 2013).

2.6 Printing

2.6.1 Introduction

Textile fabric printing is part of the textile finishing industry. Printing is a method of depositing colour onto fabric and other various substrates. A range of imagery, pattern or design can be achieved in a variety of ways (Sain, 2012). Printing can be defined as localized dyeing, colour is applied to cloth, often in the form of a pattern. It is related to dyeing whereas in dyeing the whole fabric is uniformly covered with one colour, in printing one or more colours are applied to it in certain parts only, and in sharply defined patterns (Agarwal *et al.*, 2007).

2.6.2 History of Printing

Textile printing has existed in one form or another for over two thousand years and fabrics decorated with pattern have been found in Egyptian tombs. China and India were the first countries to develop and utilize textile printing using hand carved wood blocks, a process called “hand block printing” which was the forerunner to contemporary silk screen printing processes more commonly used today. It was the

Japanese who created the earliest stenciling techniques which later developed into silk screen printing. In fabric printing a decorative pattern or design is applied to constructed fabric by rollers, wooden blocks, engraved plates, stencils, flat screen, or rotary screen methods (Sinclair, 2014).

Colourants used in printing contain dyes thickened to prevent the colour from spreading by capillary attraction beyond the limits of the pattern. If the print is out of registration it is a serious fabric defect causing the final product to be considered off quality or second quality. It is also important that the printed colour uniform in depth and consistent in hue is known as colour clarity. Maximum penetration of the dye is required in order to obtain the best colour fastness for the printed pattern (Storey, 1992).

2.6.3 Selection of Printing source

2.6.3.1 *Lawsonia inermis*

Lawsonia inermis belonging to the Lythraceae family, is a very widespread medicinal plant and natural dye in the world. This herb which has interesting dyeing properties was used traditionally for centuries in Asia, in Africa for dyeing hair and painting skin and nails. Due to its natural and harmless characters, the Henna is used as a kind of natural dye, and is used as a raw material for natural hair dyes. In addition, Henna can be used as dyes for textile and tattoo material. The medicinal value of *Lawsonia inermis* is very high and it is used for treatments of headache, jaundice, leprosy (Fatiha *et al* 2013).

2.6.3.2 Properties and Uses

Henna is a flowering plant that produces a red-orange dye molecule that has the affinity for bonding with protein (think skin, hair, leather, silk, wool).It's been used widely on leather. the leaves of Henna, that is, *Lawsonia inermis L.*, is used frequently in hair coloring. It is the chemical *lawsone* that is responsible for the reddish brown color. Its content makes it a substantive dye for dyeing the textile materials. The plant is famous for its anticancer and anti-inflammatory activities. Its bark and seeds are used in the Unani and Ayurveda. Henna leaves are soaked in water and drunken to cure cracking of nails and adds nutrition to the body. *Lawsonia inermis* powder with butter cures scabies, mange and swelling. It acts against hair loss and strengthens hair. Hence, [henna is used as a natural agent for baldness](#). Because of the astringent nature of Mehendi leaves, it is used to cure sunburn and other rashes in the body. It is also used as a fabric dyer including silk, wool and leather (Mahabub Hasan, 2015).

2.6.4 Different techniques of printing

While many different methods of printing have been developed, these can be divided into three different classes. They are direct, discharge and resist.

2.6.4.1 Direct printing

Direct printing in which colourants containing dyes, thickeners and the mordants or substances necessary for fixing the colour on the cloth are printed in the desired pattern. Pigments rarely coat the surface of the fabric, unlike dyes which penetrate and stain the actual fibers. Direct dyes are usually dissolved in limited amount of water to which a thickening agent has been added to necessary viscosity to the print paste (Wilson, 2001).

2.6.4.2 Discharge printing

In discharge printing bleaching agent is printed previously dyed fabrics to remove some or all the colour. Nowadays colour discharges are produced using dyestuffs that are unaffected by the chemical discharging agent. Combining these with the discharge paste means that the original colour can be removed and a new one put in its same printing process. The usual method of producing discharge prints to print the design such as polka dots, with a paste containing reducing agent (Sain, 2012).

2.6.4.3 Resist printing

In resist printing technique a substance that prevents the cloth from taking up the dye is applied to the areas of the cloth. The cloth is then dyed. The areas treated with the resist are not coloured retaining the colour of the ground or undyed fabric. The best example of resist printing is batik printing wherein the resist material such as wax is applied onto the fabric at preliminary stage and then the fabric dyed to get the pattern (Lawler and Wilson, 2002).

2.6.5 Methods of Printing

The printing is done on fabric form or in garments. When fabric comes out from mills, power loom or others means it is generally grey in colour. To make fabric and cloths attractive and valuable dyeing and printing are done on fabric surface. There are different methods of fabric printing including block printing, roller printing, screen printing and transfer printing.

2.6.5.1 Block Printing

Block printing is a centuries old art from first practiced in Japan, China, India, Korea and elsewhere. It can be used to create fine art prints, illustration, etc., while it can be done on fabric as well. Block prints have a distinctive look and spirit, from simple and bold to delicate filigreed (Allison and Craig, 2011). It is a traditional handicraft form of printing that uses wooden printing blocks. The design is cut into the block form a relief pattern. The block is pressed onto a pad the raised areas on the block

pick up the printing paste from the pad and the block is pressed onto the surface of the fabric. A separate block is required for each different colour in the finished design. The majority of blocks are made largely wood, but metal may be used to reinforce parts of the design. The main advantage of this block printing method is simple to operate and does not require elaborate and expensive equipment. This method are slow and therefore low output and its cost also high compared to other printing method (Clarke, 2004).

2.6.5.2 Screen Printing

Screen printing was first done by hand. The printing room contains long, heavy tables topped with a thick layer of felt which in turn was covered with washable cotton cloth. Iron tables with concrete tops resting on metal stands are almost universally used (Kipphan, 2001). Screen printing is a relatively simple method of printing which can be carried out without the use of complicated and expensive equipment. In this method paste is pushed through a fine mesh onto the fabric. Areas of the mesh are blocked off using a stencil or by painting on a special paste. The dye paste can only penetrate the mesh where it is not blocked. A different screen has to be prepared for each colour in the design. A squeegee is used to push the dye paste through the mesh. Industrial flat screen printing is produced in a similar way but the fabric, screens and squeegees are machine-operated (Shenai, 1995).

2.6.5.3 Rotary Screen Printing

In this a cylindrical screen that rotates in a fixed position rather than a flat screen that is raised and lowered over the same print location. The machines are designed for roll-to-roll printing on flexible materials ranging from narrow web films to wide formal roll textiles (Lawler and Wilson, 2002). It is developed from flat screen printing, is quicker and more widely used which the most popular production technology. A typical rotary screen print machine would have an inline configuration with upwards of seven or eight print stations available, each printing one colour. The cylindrical printing screen itself is a very fine “honey combed” type mesh. The mesh is formed into rollers and design prepared using acetate film. The printing paste is fed into the rollers, which have squeegees inside them (Sinclair, 2014). In rotary printing the web travels at a consistent speed between the screen and a steel or rubber impression roller immediately below the screen. As the web passes through the rotary unit the screen spins at a rate that identically matches the speed of substrate movement. The main advantage of rotary screen printing are they give colour depth that is similar to or good as that of flat screens (Board, 2003).

2.6.5.4 Roller Printing

Roller or cylinder printing is the same as block printing developed in 1785 where it an industrial process. The fabric is carried on a rotating central cylinder and pressed by a series of rollers each bearing one colour. Each roller is polished for uniform smoothness so that the dye will spread evenly on the raised areas (Murmman, 2003). The number of rollers used depends upon the number of colours in the design up to 16 rollers can be employed. However it difficult to adjust so many rollers and usually not more than 4-6 rollers are used. The design is engraved on the copper rollers by hand or machine pressure by pantograph or photoengraving methods. The colour paste is applied to the rollers through feed rollers rotating in a colour box the colour being scraped off the sooth portion of the rollers with knives. As the fabric is passed under the rollers the colour is printed onto the fabric (Colussy, 2007).

2.6.5.5 Transfer Printing

It is the term used to describe textile and related printing processes in which the design is first printed on to a flexible non textile substrate and later transferred by a separate process to a textile (Dupree, 2011). In this printing method dyes are first printed on a paper. The dye is transferred to the fabric using heat and pressure at about 400 F. Under this high temperature the dye on the printed paper sublimates and is transferred onto the fabrics (AATCC, 1995).

2.6.6 Thickeners

The major difference with regard to dye application classes for textile printing compared to textile dyeing is the use of various thickeners to localize the print and produce clear and well defined designs on the fabric. The printing thickeners used depend on the printing technique, fabric and dyestuff used. Thickeners used in textile printing are high molecular weight compounds giving viscous pastes in water. These impart stickiness and plasticity to the printing paste so that it can be applied to a fabric surface without spreading and are capable of maintaining the design outlines even high pressure. Their main function is to be holding the dye particles in the desired place on the fabric until the transfer of the dye into fabric and its fixation are complete (Thalouth *et al.*, 2012).

Thickening agents produced from vegetable raw materials is called natural thickening agents. For textile printing the thickening agents must be soluble in water. The natural thickening agents are safe to use compared to synthetic thickening agents (Solangi *et al.*,2012). Some of the commonly used thickeners in textile printing are explained below:

2.6.6.1 Indian Arabic gum

Indian Arabic gum is extensively used in the textile. It also finds some use as an emulsifying agent and demulcent in medicine. It is obtained from the bark of *Acacia Nilotica* trees. The gum extrudes in the form of pale yellow or dark brown coloured, rounded drops which hardens on exposure to air. It is slowly but completely dissolves in cold water and is endowed with the high degree of adhesiveness and viscosity. It is expensive when compare to other natural thickener and which it gives sharp print and good penetration in the cloth (Pandey and Chadha, 2013).

2.6.6.2 Guar gum

Guar gum is naturally occurring non-ionic polysaccharide which is derived from the guar seed "*Cyamopsis Tetragonolobus*" and commonly called as "Gawar phalli". The most important property is its ability to hydrate rapidly in cold water to attain uniform and very high viscosity at relatively low concentrations. These are not very stable due to biodegradation that is why guar gum is rarely used in its natural forms (Sharma, 2005).

2.6.6.3 Gum Tragacanth

Gum Tragacanth is a mucilaginous product obtained naturally or after puncturing the bark of *Astragalus gummifer* Labill. The gum is formed by the transformation of the cells of the pith and medullary rays into a mucilaginous substance that extrudes out after puncturing the bark. The gum is allowed to dry on the bark, collected and cleaned. It is one of the most indispensable thickening agents possessed by the textile printer. The gum is variously used in calico printing and as adhesive agent for pills and as a suspension of insoluble powders. It may be mixed in any proportion with starch or flour and is equally useful for pigment colours and mordant colours (Digolo and Mazuri, 2008).

3. Experimental Procedure

The experiment pertaining to the research entitled “*Artocarpus heterophyllus* Wood and Printing with *Lawsonia Inermis* leaves” is discussed under the following headings

3.1 Selection of the Fabric

3.2 Selection of Natural source

3.3 Pre –treatment of the Fabric

3.3.1 Desizing

3.4 Mordant

3.4.1 Selection of Mordant

3.4.2 Selection of Mordanting Techniques

3.5 Dyeing parameters

3.5.1 Optimization of high yield of dye

3.5.2 Optimization of dyeing temperature

3.5.3 Optimization of dyeing time

3.5.4 Optimization of material liquor ratio

3.6 Printing

3.6.1 Selection of Printing source and style

3.6.2 Block printing

3.6.3 Selection of design

3.6.4 Selection of thickener

3.7 Nomenclature

3.8 Evaluation of the dyed and printed samples

3.8.1 Subjective Evaluation

3.8.1.1 Visual inspection

3.8.2 Objective Evaluation

3.8.2.1 Fabric Weight

3.8.2.2 Fabric Thickness

3.8.2.3 Fabric Stiffness Test

3.8.2.4 Tensile Strength and Elongation

3.8.2.5 Drop Test

3.8.2.6 Sinking Test

3.8.2.7 Wicking Test

3.8.2.8 Colour Fastness

Colour Fastness to Sunlight

Colour Fastness to Washing

Colour Fastness to dry and wet Pressing

Colour Fastness to dry and wet Crocking

3.1 Selection of the Fabric

Handspun and handwoven process gives Khadi an extra ordinary texture and finish that can't be found in any machine made fabric. The loom used in weaving of khadi interlaces the threads in a manner that allows maximum air permeable and soothes the body better than any other fabrics does. It is warm in winter, cool in summer, very light, soft feel texture and versatile fabric. This fabric gets easily crumpled and starch is to be added to keep it firm and stiff. They are friendly to the body and does not cause any allergies or irritations to the body(Elangoran and Mohan, 2006). The hundred percent khadi cotton fabric was procured from Khadi shop, Coimbatore was selected and used for the study.

3.2 Selection of Natural source

In recent years, concern for the environment has created a depth interest on natural dyes. The uses of natural dye offer less pollution and non toxic, eco-friendly but also possess better biodegradability. *Artocarpus heterophyllus* commonly called Jackfruit tree its wood were found to be yellow in colour. The wood chips or saw dusts are soaked for 24hours for dye extraction process Plate I & II. There is 3.3% tannin in the bark. When boiled with alum, wood chips, or sawdust, it yields a dye that is commonly used to give the characteristic color to the fabric(Craig and Harley, 2006). The wood chips or saw dusts are collected from Shiridi Sai Baba Timbers & Saw mill, Alandurai.

3.3 Pre-treatment of the Fabric

The aim of the preparatory process is improving the quality by removing impurities and foreign matters thoroughly and uniformly from the fabric and makes the fabric suitable for follow-up processes. The natural fibers contain impurities which causes adverse effect during dyeing and printing is removed in pre-treatment process (Saini, 2004). Therefore investigator planned to pretreat the chosen fabric.

3.3.1 Desizing

Sizing agents stay on warp yarn surface and penetrate between the fibers of the yarn. These discontinuous spot-welded yarn protection or continuous polymer films hinder the subsequent dyeing, printing and finishing processes. For example, the presence of starch hinders the penetration of the dye into the fibers during dyeing. Therefore they have to be removed to ensure the uniform fabric treatment(Showell, 2005). Hence the selected khadi cotton fabric was desized following the procedure.

Recipe of desizing:

Fabric weight	- 15g
Soap oil	- 1%
Time	-15 minutes
Temperature	-100°C

Desizing of khadi cotton fabric was carried out by boiling the fabric in acidified water for 15 minutes. The soap oil degrades the sizing materials present in the fabric to water soluble products. The sample was then washed thoroughly in hot water to remove the remaining acid present in the sample (Shad *et al.*, 1998). The detailed of desized material is given in the Appendix I

3.4 Mordant

3.4.1 Selection of Mordant

Mordant is a fixing agent which prevent the color from fading with exposure to light or washing. A mordant is a substance used to set dyes on fabric by forming an insoluble compound with the dye. Mordants are the materials that cause the natural dyes to bond chemically with the cloth. A mordant is a chemical which forms unison between the dye and the substance to be dyed. It is a colour fixative. It is a metallic salt that is used to fix the dye on the substrate. Metallic mordants are often used for dyeing of natural dyes. While the natural dyes are themselves harmless, the metallic mordants are not generally eco-friendly. In order to develop a totally eco-friendly natural dyeing process, it is necessary to replace the metallic mordants with more eco-friendly bio-mordants (Ammayappan *et al.*, 2013).

Keeping the above points in mind the investigator selected bio-mordant guava leaves powder for the study Plate III.

3.4.2 Selection of Mordanting Techniques

Three processes of mordanting were used; they are pre-mordanting, simultaneous mordanting and post mordanting. Pre-mordanting is a technique in which the fabric is first soaked in mordant and then boiled in the dyestuff. Simultaneous mordanting is a technique in which the mordant as well as the dye is mixed together and then fabric is soaked and boiled. Post mordanting is a technique in which the fabric is first boiled in the dyestuff and then soaked in the mordant.

All the three types of mordanting were carried out and among these three mordanting techniques, the pre-mordanting technique was found to give better shade. Hence pre-mordanting technique was followed for the present study.



PLATE - 1



PLATE - II



PLATE - III

3.5 Dyeing parameters

3.5.1 Optimization of high yield of dye

To determine the optimum concentration of the dye source, saw dust was carried out at various concentration such as (1, 2, 3, 4, 5, 6, 7, 8, 9 & 10 %), were taken individually and placed in water bath for one and a half hour at 100°C. The optical density of the dye solution was analysed spectrophotometrically at 298 nm. Five percent dye concentration gives better result. Hence, 5 % concentration was selected for the study.

3.5.2 Optimization of dyeing temperature

When a cellulosic fabric is dyed with natural colourant, the amount of dye absorbed on the fabric depends upon its temperature. At low temperature dye molecules are not activated to absorb on to fabric while at high temperature either colourant may be degraded or clusters of dye molecules gather on surface may start desorbing and give poor shades. To determine the dyeing temperature, dyeing was carried out at difference 60, 70, 80, 90, 100 and 110°C. based on visual evaluation colour obtain from 100°C was excellent. Hence, 100°C is the optimum dyeing temperature was selected.

3.5.3 Optimization of dyeing time

In dyeing process time is very important parameter because long and short time dyeing gives the same effect as the variation of temperature. Dyeing for low time causes absorption of less amount of colourant onto fabric, while dyeing for long time may shift the equilibrium from the fabric to dye bath. For this reason the optimum time dyeing was carried out at different time intervals 60, 120, 180, 240, and 300 minutes. Based on visual evaluation colour obtain from 180 minutes time interval was excellent. Hence, 180 minutes is the optimum dyeing temperature was selected for the study.

3.5.4 Optimization of material liquor ratio

Too low amount of dye may cause unevenness due to presence of insoluble materials while too high concentration may cause gathering or cluster of dye molecule onto fabric resulting in unevenness. For this reason, optimization of material liquor ratio was carried out at different ratio 1:10, 1:20, 1:30, and 1:40 of M: L. The optimum dye concentration was selected based on the shade produced on the cotton fabric. The optimized parameters for dyeing the selected cotton fabric are as follows:

Dyeing concentration	: 5 %
Material: liquor ratio	: 1:20
Dyeing time	: 90 min
Dyeing temperature	: 100°C

3.6 Printing

Applying coloured patterns and designs to decorate finished fabric is called 'Printing'. In a proper printed fabric, the colour is affixed to the fibre so that it may not be affected by washing and friction. Whether a fabric is dyed or printed can be known by examining the outline of the design. On a printed fabric, the outline of a design is sharply defined on the outer side. The designs generally do not penetrate to the back of the cloth. However the design may show up on the reverse side of transparently thin fabrics. These fabrics may be confused with the woven designs where yarn dyed warp and filling are used. If the design is printed on such a fabric, the yarns will show some areas on which colour is not equally distributed(NirBoard, 2004).

3.6.1 Selection of Printing source and style

Lawsonia inermis belonging to the Lythraceae family, is a very widespread medicinal plant and natural dye in the world. This herb which has interesting dyeing properties was used traditionally for centuries in Asia, in Africa for dyeing hair and painting skin and nails Plate IV & V. Due to its natural and harmless characters, the Henna is used as a kind of natural dye, and is used as a raw material for natural hair dyes. In addition, Henna can be used as dyes for textile and tattoo material. The medicinal value of *Lawsonia inermis* is very high and it is used for treatments of headache, jaundice, leprosy(Fatiha *et al*, 2013). Textile printing is called localized dyeing. Unlike dyeing, in printing the dye penetrates into the selective area of the substrate. A distinction is usually made between printing methods and printing styles. There are various methods of printing in which one of the above three techniques is used – block printing, roller printing, duplex printing, stencil printing, screen printing, transfer printing, jet spray printing, etc., Among these printing techniques the investigator selected direct printing method using block printing for the study because block printing is the most traditional method still using today (Lawler and Wilson, 2002).

3.6.2 Block printing

Block printing is a centuries old and traditional art first practiced in Japan, China, India, Korea and elsewhere. It can be used to create fine art prints, illustration, greeting cards, gift wrapping, posters, advertisement and numerous other graphics works on paper. It can be done on fabric as well, while many block prints have distinctive look and spirit, they can vary widely, from simple and bold to delicate and filigreed(Allison and Craig, 2011). It is a traditional handicraft form of printing that uses wooden printing blocks. The design is cut into the block form a relief pattern. The block is pressed onto a pad the raised areas on the block pick up the printing paste from the pad and the block is pressed onto the surface of the fabric. The block is carefully placed on the blanket so that it picks up an even layer of paste which is then transferred to the cloth, the block being struck by the handle of a small but heavy mallet to effect and through penetration. The size of the block is limited by the weight that the printing

can handle for long periods without under fatigue. A separate block is required for each different colour in the finished design. The majority of blocks are made largely wood, but metal may be used to reinforce parts of the design. Such blocks are used to apply thickened dyestuff pastes at normal room temperatures. The main advantage of this block printing method is simple to operate and does not require elaborate and expensive equipment. This method are slow and therefore low output and its cost also high compared to other printing method(Clarke, 2004).

3.6.3 Selection of design

In order to select a suitable design ten designs were hand drawn by the investigator and the designs were ranked by twenty students of textiles department. Based on the ranking order the designs were selected plate VI and VII, then it was converted into block. The ranking sheet used for ranking was included in the Appendix II.



PLATE -IV



PLATE -V



PLATE -VI

3.6.4 Selection of thickener

Direct style printing is the most common approach to apply a colour pattern on fabric. It can be done on white or a coloured fabric. The desired pattern is produced by imprinting dye on the fabric in a paste form. The proper selection of thickening agents was subject to great importance to the printer. There should also be some thickening agents will enable the colour to be conveyed to the fabric easily and evenly. To prepare the print paste, a thickening agent is added to a limited amount of water and dye is dissolved in it. Earlier corn starch was preferred as a thickening agent for cotton printing. Nowadays gums or alginates derived from seaweed are preferred because they are easier to wash out, do not they absorb any colour and allow better penetration of colour. For this purpose, Arabic natural gum and sodium alginate- modified natural thickener are selected as thickening agents for printing paste preparation which are removed from the fabric without affecting the colours.

Arabic gums was first soaked in small amount of water overnight at room temperature then mix it with natural colour and heat it until the proper correct viscosity of printing paste obtained. Sodium alginate was also soaked in small amount of water overnight at room temperature before preparing the printing paste. The natural colour were then added on the thickener. Then two samples were printed using Arabic and Sodium alginate thickener. From the visual evaluation of two printed samples the colour was excellent in the sample were Sodium alginate thickener was used. Sodium alginate thickener printed samples produce brighter shades and sharp boundries than Arabic thickener. Hence, Sodium alginate thickening agents are used for printing paste.

3.7 Nomenclature

Nomenclature of the sample are given in the Table I

NOMENCLATURE OF THE SAMPLES

TABLE I

SAMPLES	ABBREVIATION
O	ORIGINAL
D	DESIZED
ND	NATURAL DYED
NP	NATURAL PRINTED

3.8 Evaluation of the dyed and printed samples

The dyed and printed samples were evaluated subjectively and objectively for their essential properties.

3.8.1 Subjective Evaluation

3.8.1.1 Visual inspection

To evaluate the aesthetic appeal of the fabrics in terms of depth of colour, evenness of dyeing, lustre and overall appearance of the dyed and printed samples were evaluated visually. The dyed and printed samples were evaluated by 20 judges comprising of Post Graduate Students of Textiles and Clothing Department, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore. The evaluation sheet was prepared and given to the judges which are included in the Appendix. The sample which was rated as high by the judges were subjected to further evaluation and used for further study.

3.8.2 Objective Evaluation

Objective evaluation is the process of inspecting, measuring, evaluating, characteristics and properties of textile materials physically. The following tests were carried out for the original, desized, natural dyed and natural printed fabrics.

3.8.2.1 Fabric Weight

Fabric weight is the relative weight of the fabric and expressed as the weight of a particular size of piece as grams per square meter or ounces per square yard. Weight of the fabric is determined as weight per unit area. A sample 10 cm x 25 cm was cut using a GSM cutter Plate VIII and electronic weighting balance was used to find out the weight of the samples. The inference obtained is calculated using the formula:

$$\begin{aligned} \text{Grams per square meter (GSM)} &= \frac{\text{Weight of the fabric} \times \text{square meter}}{\text{Area of square}} \\ \text{Weight of the fabric} &= \quad \quad \quad \times \text{g} \\ \text{Square of the fabric} &= 100 \text{ cm} \times 100 \text{ cm} = 10000 \text{ cm}^2 \\ \text{Area of square} &= \text{length} \times \text{breadth square unit} \end{aligned}$$

The same procedure was followed to find out the fabric weight of different samples from original, desized, natural dyed and natural printed fabrics were carefully recorded and mean value was calculated.

3.8.2.2 Fabric Thickness

Fabrics are liable to compress during measuring. Therefore the measurement of fabric thickness demands accuracy. Thickness in textile fabric is the distance between the upper and lower surface of the material, measure under the specific pressure. The differences in thickness of the samples were found out by using the thickness tester Plate IX to measure up to accuracy of 0.01 mm. For measuring the thickness no specimen preparation was required but selvedge and creased areas should be avoided. The thickness was measured at different places and the mean value was calculated. The same procedure was adopted to find out the thickness of original, desized, natural dyed and natural printed samples.

3.8.2.3 Fabric Stiffness Test

Fabric stiffness is defined as the measure of fabric to bending. Bending length is a measure of the interaction between fabric weight and fabric stiffness Plate X as shown in the way in which a fabric bends under its own weight view. The fabric stiffness tester is used to measure the fabric stiffness. The test is carried out in the standard testing atmosphere. Specimens were cut to the size of 6 x 1 inch. Four specimens in warp way and weft way were prepared for the test. The tester is set on a table so that the horizontal platform and the index lines are at eye level. The specimen was placed on the platforms with the template at the top of it, so that the leading edges coincide. The bending length can be read from scale opposite a datum line engraved on the side of the platforms. Four readings were taken from each specimen. In this the samples of original, desized, natural dyed and natural printed fabrics were calculated and recorded.

3.8.2.4 Tensile Strength and Elongation

Tensile strength is the force required to break a fabric when it is under tension. It is the resistance of the fabric to a tensile load or stress in either the warp or filling directions. Elongation is to extent to which the fabric under tension extends, till it cut off. The percent strength loss and percent change in elongation at break were determined by the tensile testing method using tensile strength tester Plate XI according to the procedures. The specimen was cut about 12 inches long and one and half inch wide and the sample were tightened between the clamps. The load was applied until the sample was broken. The breaking strength was recorded in kilograms and elongation in inches and in pendulum was returned to the zero position. This method was repeated for different samples of original, desized, natural dyed and natural printed fabrics and the results were taken. Simultaneously the elongation of the fabric was recorded on the elongation scale and mean value was found out by using the formula:

$$C = A/B \times 100$$

Where, C = Average elongation

B = Original length of the fabric

C = Percentage of elongation

3.8.2.5 Drop Test

The ability of a fabric to take up moisture is determined as absorbency. Wettability is the time taken in seconds for a drop of water to sink into the fabric. If it takes more than 200 seconds to absorb the water through fabric is considered as un-wettable. The burette filled with distilled water was clamped in a stand. The sample was mounted in a embroidery frame and was placed at the base of the stand. The distance between sample and nozzle of burette was kept constant. The nozzle of the burette was opened just allow a drop of water to fall on the sample. The stop watch was started and simultaneously and the time was noted Plate XII. The same procedure was repeated for five samples of original, desized, dyed and printed fabrics. The mean value were calculated and recorded.

3.8.2.6 Sinking Test

Sinking test is used to determine the degree of hydrophilicity, it is a simple test of wettability of fabric. In this test five small square specimens about 5cm x 5cm were cut from each of the original, desized, dyed and printed samples. In a glass beaker distilled water is taken and few drops of wetting agent were added. Fabric sample is dropped into the beaker and the stop watch was started when the fabric struck the surface of water and stopped when the last corner sank below the water surface plate and the time required to sink the sample was noted. The same procedure was repeated for all and the mean value was calculated Plate XIII.

3.8.2.7 Wicking Test

Wicking test is the test that helps to measure the rapidity of absorption. Five samples were developed with the size of 15 cm and 3 cm width. The one end of the sample strip was pasted with a glass rod which was placed on heavy wooden blocks, at the ends 2 cm of the sample was allowed to immerse in a glass beaker of distilled water. The rise of water level in the strip was measured after 30 minutes. The same procedure was repeated for how many. And then mean value was calculated. Higher wicking results indicate the greater liquid transport into the fabric ability Plate XIV.



PLATE - VIII



PLATE - IX



PLATE - X



PLATE - XI



PLATE - XII



PLATE - XIII



PLATE - XIV

3.8.2.8 Colour Fastness

Colour fastness is the resistance of the coloured materials to colour change or loss as the result of exposure to different agencies. These agencies that will affect the coloured materials include the light, water, washing, bleaching agents, dry-cleaning solvents, abrasion etc. The coloured materials are normally exposed to these agencies during the manufacturing process and in daily subsequent use. Therefore the fastness methods must stimulate the end use and performance expected by different customers for the materials. The major types of colour fastness test are colour fastness to washing, colour fastness to washing to light, colour fastness to washing to rubbing.

Colour Fastness to Sunlight

The colour fastness to light is the most important properties of dyed and printed fabric needed to fulfil its utilization purpose over a period of time. It's referring to the ability of the fabric to withstand colour change when exposed to sunlight. A sample piece of 1x1 inch was cut from the material. It was divided into eight divisions of 2cm width each. The strip was covered with black chart. On the first day, I- division was cut and exposes, consecutively, II- division was cut on the second day and so on. Finally, the first division, after exposing of seven days was evaluated with the help of grey scale for the natural dyed and printed samples.

Colour Fastness to Washing

The loss of colour during laundering is referred to as lack of wash fastness or bleeding. During wet treatment such as washing and dry cleaning, adjacent analysed material may take up colour due to the transfer of dye from the original dyed material as staining in wet treatments. The test samples 5 x 5 size were cut from the coloured materials. Each sample was sandwiched between the undyed cloth which was desized. For wash test, soap solution of about 5gm/100ml was prepared and test samples were removed. Later the samples were rinsed in cold water thoroughly, squeezed well and dried. The colour change and staining of the specimen were assessed using grey scale.

Colour Fastness to dry and wet Pressing

This method was intended for the determination of colour fastness of textile material of all kinds and in all forms to ironing and to processing on hot cylinders. A piece of coloured fabric was placed between two pieces of white cloth. The fabrics were placed under heat for 30 seconds, at a particular temperature. The specimen was removed from the heat and compared for colour change and staining with the grey scale. The same procedure was adopted adding moisture to the white material for wet processing.

Colour Fastness to dry and wet Crocking

Crocking test is designed for determining the degree of colour which may be transferred from the surface of coloured textile material to other surface by rubbing. The crockmeter consists of a platform over which the fabrics to be tested is fixed using fabric holder. The centre of the fabric holder has rectangular slot through which the crank arm rubs the standard white fabric of size 2 x 1 inch was cut against the fabric to be tested. A load was applied on the crank such that rubbing takes places at a particular load. The instrument had automatic counter which can be set for predetermine to and from stokes for the crocks. After completion if test cycle the rubbed area and the grey area are compared with ASTM grey scale. Grades are classified as 1, 2, 3, 4 and 5 were grade 1 indicates poor rubbing fastness and grade five indicates good rubbing fastness. To determine the rubbing colour fastness test in wet condition the white fabrics was wetted and the test procedure was the same. In this manner the crocking fastnesses both in wet and dry condition for dyed fabrics were noted. The results were tabulated for both dry and wet crocking separately.

4. RESULTS AND DISCUSSION

The result pertaining to the study entitled “*Artocarpus heterophyllus* Wood and Printing with *Lawsonia Inermis* leaves” is discussed under the following headings

4.1 Visual inspection

4.2 Objective evaluation

4.1 Visual inspection

The result of visual inspection are presented in the Table II.

TABLE II
PERFORMER FOR VISUAL ASSESSMENT OF DYED AND PRINTED
SAMPLE (%)

S. No	Sample	General Appearance			Brilliancy of Colour			Evenness			Texture			Lustre		
		Excellent	Good	Fair	Good	Medium	Dull	Even	Partially	Uneven	Soft	Medium	Course	High	Medium	Low
1	ND	90	10	-	85	15	-	90	15	-	95	5	-	20	80	-
2	NP	100	-	-	40	60	-	100	-	-	90	10	-	35	-	65

The Table II portrays ninety percent of the judges ranked the general appearance and evenness of the natural dyed cotton fabric as excellent. Eighty five percent rank good regarding brilliancy of colour whereas ninety five percent ranked natural dyed fabric as soft for texture and eighty percent ranked natural dyed fabric was medium in lustre. All the judges ranked natural printed cotton fabric as excellent for general appearance. Sixty percent rank medium regarding brilliancy of colour. Hundred percent of the judges expressed the evenness of the printed fabric as excellent. Ninety percent of the judges ranked the texture of the printed cotton fabric as soft and sixty five percent ranked that the printed fabric has low lustre. Therefore it could be concluded that *Artocarpus heterophyllus* and *Lawsonia inermis* is an effective dye source.

4.2 Objective Evaluation

4.2.1 Fabric Weight

The fabric weight and analysis of variance of original cotton fabric, desized, natural dyed and natural printed fabric is shown in the Table III and Figure 1.

TABLE III
Fabric weight

S.No	Sample	Mean Value (g)	Loss or Gain over original	% loss or gain over original	Standard Deviation	'F' Test
1	O	1.08	-	-	0.00	45.85**
2	D	1.10	0.02	1.85	0.01	
3	ND	1.22	0.11	12.96	0.02	
4	NP	1.02	0.04	5.55	0.05	

Values are mean and SD of 5 samples in each group

** - Significant at 1% level

From the Table III and Figure , it is clear that the weight of the sample O was 1.08 grams and the fabric samples (D, ND) had shown a consistent increase in weight by 1.85, 12.96 and (NP) has decrease in weight by 5.55 percent respectively. The reason for increase and decrease in weight of natural dyed and natural printed samples may be due to presence of dye compounds absorbed by the fabric. From the values it is clear that there is closeness in the weaves which could be the reason for decrease in fabric weight. From the results, it is evident that ANOVA value of 45.85 is significant at one percent level.

Hence it could be concluded that natural dyeing increased and natural printing with *Artocarpus heterophyllus* and *Lawsonia inermis* decreased fabric weight compared to original and desized fabric.

4.2.2 FABRIC THICKNESS

The fabric thickness and analysis of variance of original cotton fabric, desized, natural dyed and natural printed fabric is depicted in the Table IV and Figure 2.

TABLE IV
Fabric thickness

S.No	Sample	Mean Value (mm)	Loss or gain over original	% Loss or gain over original	Standard Deviation	'F' Test
1	O	0.39	-	-	0.02	15.94**
2	D	0.42	0.03	7.69	0.02	
3	ND	0.46	0.04	17.94	0.03	
4	NP	0.49	0.04	25.64	0.03	

Values are mean and SD of 5 samples in each group

** - Significant at 1% level

From Table IV and Figure, it is noticed that among natural dyed and natural printed samples, the fabric thickness has increased when compared to the original fabric by 17.94 and 25.64 percent in the natural dyed and natural printed fabric respectively. The reason for increase in thickness of dyed and printed samples may be due to presence of dye compounds which are absorbed by the fabric and the compact placement of yarn. This implies that the *Artocarpus heterophyllus* and *Lawsonia inermis* dye extract has good penetration properties with reference to cotton fabric. The statistical analysis shows that there is one percent significant level with ANOVA value of 15.94 in the comparison made between the original and treated sample.

Hence it could be concluded that natural dyeing and natural printing with *Artocarpus heterophyllus* and *Lawsonia inermis* increases fabric thickness.

Figure 1
Fabric Weight

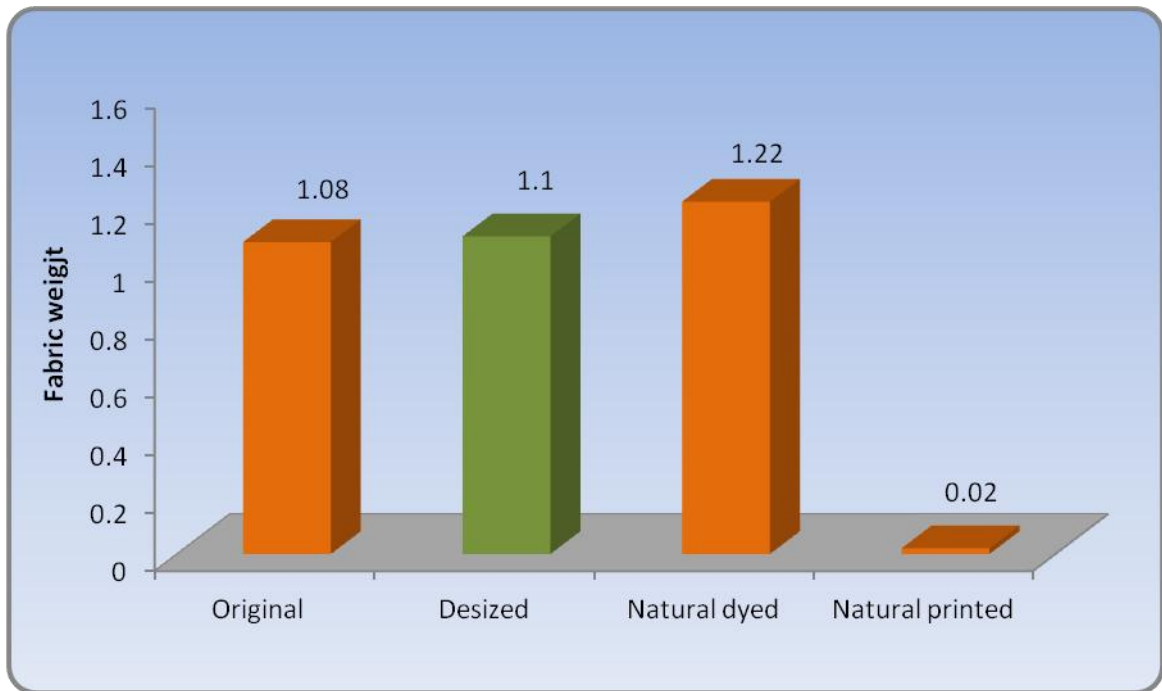


Figure 2
Fabric Thickness



4.2.3 Fabric Strength (Warp)

Fabric strength and analysis of variance of original cotton fabric, desized, natural dyed and natural printed fabric is presented in the Table V and Figure 3.

TABLE V
Fabric strength (warp)

S.No	Sample	Mean (lbs)	Loss or gain over original	% Loss or gain over original	Standard Deviation	'F' Test
1	O	87.60	-	-	1.67	9.43**
2	D	83.60	-4.00	-4.56	2.07	
3	ND	80.60	-3.00	-7.99	2.70	
4	NP	83.00	2.40	-5.25	1.87	

Values are mean and SD of 5 samples in each group

** - Significant at 1% level

The Table V and Figure, show that the tensile strength of the sample O was 87.60 g and desized, natural dyed and natural printed sample were 83.60, 80.60 and 83(g) resulting to a decreases in strength by -4.56, -7.99 and -5.25 percent respectively. Therefore it is clear that, the strength of the samples (D,ND and NP) has decreased when compared to original sample (O) this may be due to the presence of starch in the original fabric which gives a strong binding. The statistical analysis shows that there is a one percent significant level with ANOVA value of 9.43 in the comparison made between the original and treated sample.

Hence it could be concluded that natural dyeing and natural printing with *Artocarpus heterophyllus* and *Lawsonia inermis* decreased the fabric strength in warp direction.

4.2.4 Fabric Strength (Weft)

Fabric strength and analysis of variance of original cotton fabric, desized, natural dyed and natural printed fabric is portrayed in the Table VI and Figure 4.

TABLE VI
Fabric strength (weft)

S.No	Sample	Mean Value (lbs)	Loss or gain over original	% Loss or gain over original	Standard Deviation	'F' Test
1	O	82.80	-	-	2.68	17.69**
2	D	77.60	-5.20	-6.28	1.82	
3	ND	75.20	-2.40	-9.17	2.39	
4	NP	72.40	-2.80	-12.56	2.41	

Values are mean and SD of 5 samples in each group

** - Significant at 1% level

The Table VI and Figure, represent a deduction in tensile strength of the desized, natural dyed and natural printed samples by -6.28, -9.17 and -12.56 percent respectively. Therefore it is clear that the strength of the samples (D, ND and NP) has decreased when compared to the original samples (O) this may be due to the presence of starch in the original fabric. From the results, it is evident that ANOVA value of 17.69 is significant at one percent level.

Hence the weft direction shows a decrease in strength when naturally dyed and printed with *Artocarpus heterophyllus* and *Lawsonia inermis*.

Figure 3

Fabric Strength Warp

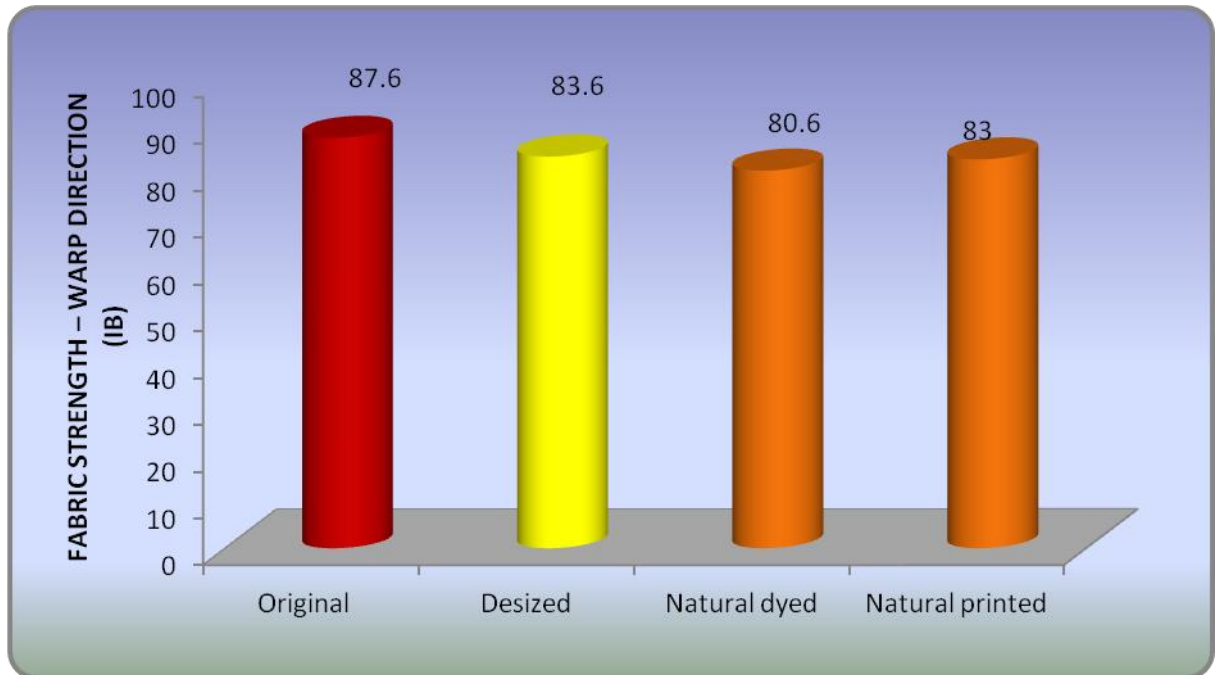
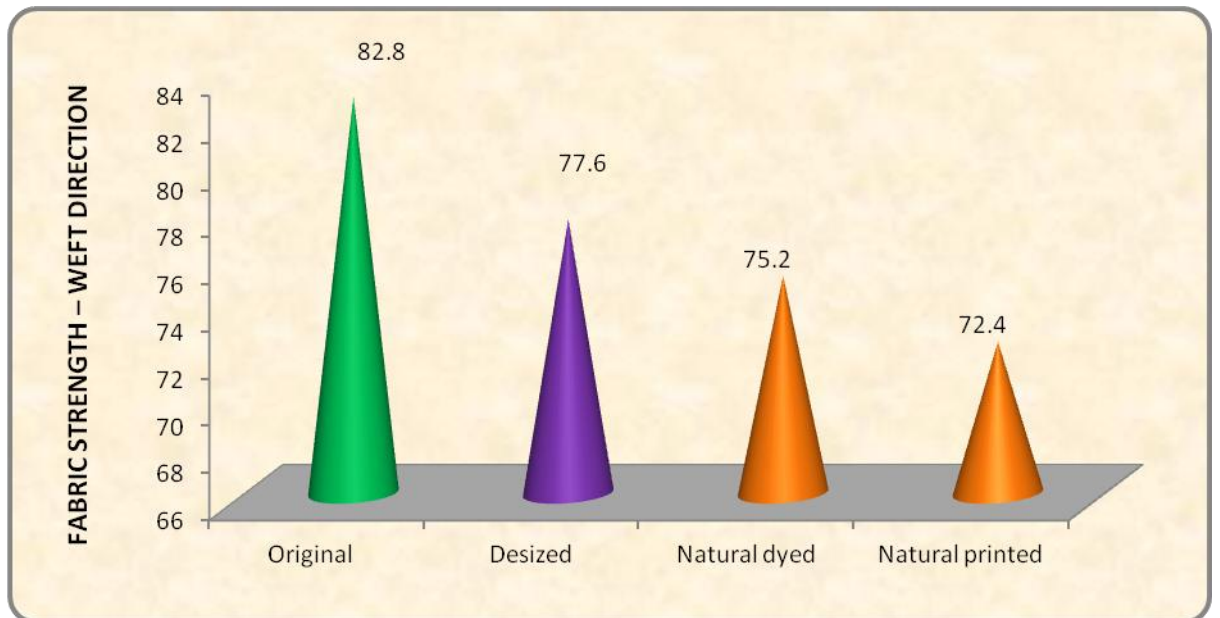


Figure 4

Fabric Strength Weft



4.2.5 Fabric Elongation (Warp)

Fabric elongation and analysis of variance of original cotton fabric, desized, natural dyed and natural printed fabric is portrayed in the Table VII and Figure 5.

TABLE VII
Fabric elongation (warp)

S.No	Sample	Mean (angle)	Loss or gain over original	%Loss or gain over original	Standard Deviation	'F' Test
1	O	28.40	-	-	1.14	4.67**
2	D	27.20	-1.20	-4.22	1.79	
3	ND	30.20	3.00	6.33	0.84	
4	NP	28.60	-1.60	0.70	1.14	

Values are mean and SD of 5 samples in each group

** - Significant at 1% level

From the Table VII and Figure it is perceptible that the fabric elongation (warp) of the sample O, D, ND and NP was 28.40, 27.20, 30.20 and 28.60 inch thereby showing an decrease in the desized samples by -4.22 and increase by dyed and printed samples 6.33 and 0.70 percent respectively. Therefore it is clear that elongation of the samples (O) has increased and decreased when compared to original sample. The statistical analysis shows that there is a one percent significant level with ANOVA value of 4.67 in the comparison made between the original and treated sample.

Hence the warp direction shows an increase in elongation when naturally dyed and printed with *Artocarpus heterophyllus* and *Lawsonia inermis*.

4.2.6 Fabric Elongation (Weft)

Fabric elongation and analysis of variance of original cotton fabric, desized, natural dyed and natural printed fabric is represented in the Table VIII and Figure 6.

TABLE VIII
Fabric elongation (weft)

S.No	Sample	Mean (angle)	Loss or gain over original	%Loss or gain over original	Standard Deviation	'F' Test
1	O	24.00	-	-	1.58	7.07**
2	D	21.40	-2.60	-10.83	1.14	
3	ND	26.20	4.80	9.16	1.92	
4	NP	23.20	-3.00	-3.33	1.92	

Values are mean and SD of 5 samples in each group

** - Significant at 1% level

As per the Table VIII and Figure it is clear that the fabric elongation (weft) of the sample O, D, ND and NP was 24.00, 21.40, 26.20 and 2 and 3.20 inch thereby showing an increased in, dyed and decreased in desized and printed samples -10.83, 9.16 and -3.33 percent respectively. Therefore, it is clear that elongation of the samples has increased when compared to original samples (O). The statistical analysis shows that there is a one percent significant level with ANOVA value of 7.07 and the comparison made between the original and treated sample.

Hence it could be concluded that natural dyeing is increased and reduction was found in printing with *Artocarpus heterophyllus* and *Lawsonia inermis* fabric elongation in the weft direction.

Figure 5
Fabric Elongation Warp

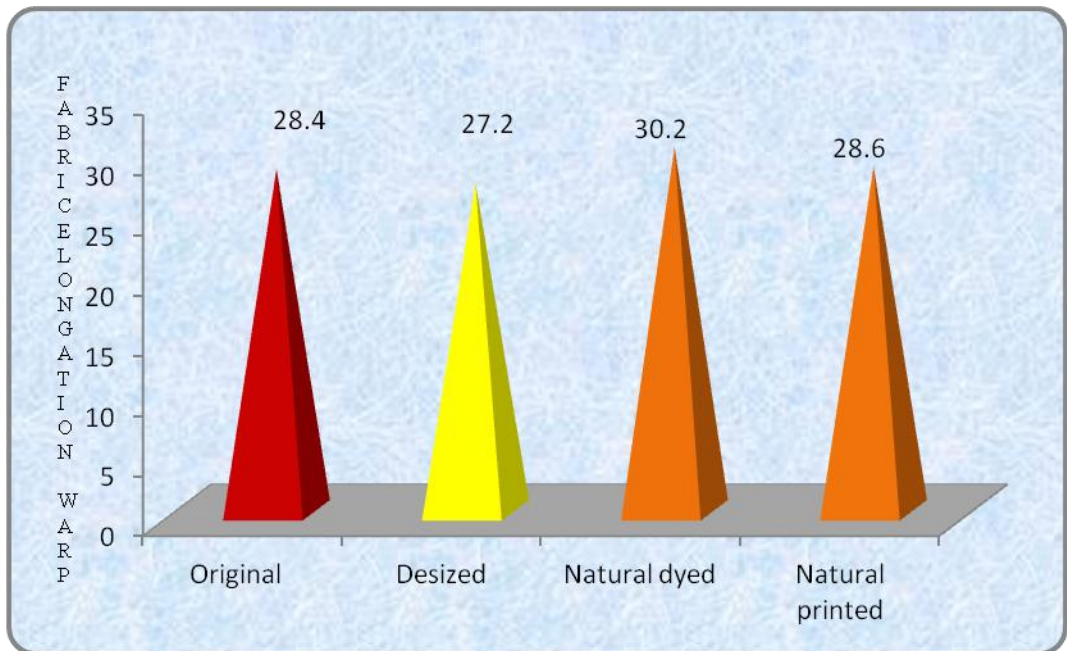
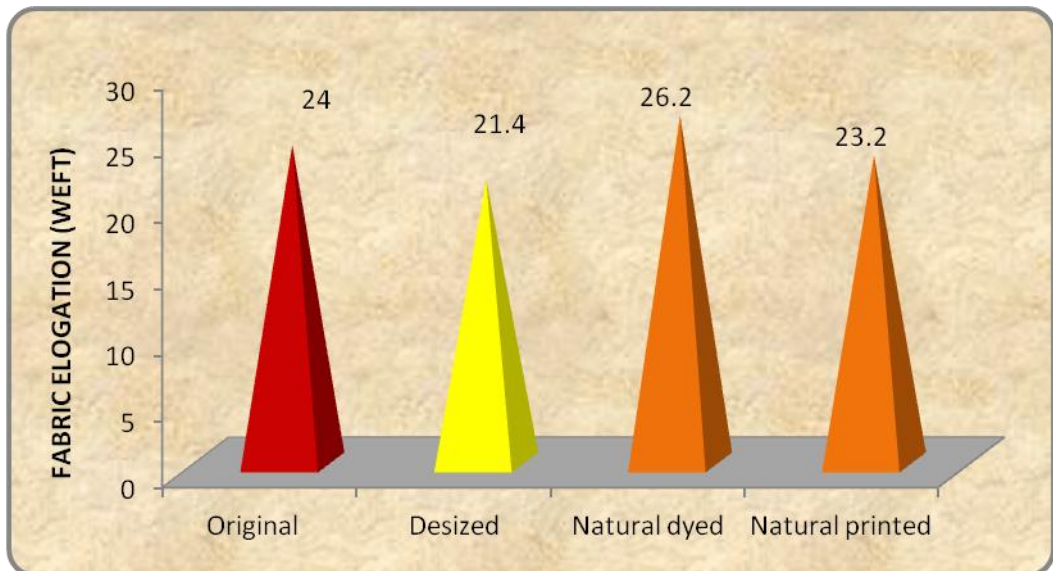


Figure 6
Fabric Elongation Weft



4.2.7 Fabric Stiffness (Warp)

Fabric stiffness and analysis of variance of original cotton fabric, desized, natural dyed and natural printed fabric is represented in the Table IX and Figure 7.

TABLE IX
Fabric stiffness (warp)

S.No	Sample	Mean value (cm)	Loss or gain over original	%Loss or gain over original	Standard Deviation	'F' Test
1	O	2.84	-	-	0.09	44.33**
2	D	2.60	-0.24	2.60	0.16	
3	ND	2.16	-0.44	2.16	0.15	
4	NP	1.90	-0.26	1.90	0.16	

Values are mean and SD of 5 samples in each group

** - Significant at 1% level

It is obvious from the Table IX and Figure that the fabric stiffness of desized, natural dyed and natural printed samples has decreased by 2.60, 2.16 and 1.90 cm when compared to sample O which was 2.84 cm. The percentage loss of the samples (D, ND and NP) over original was calculated to be 2.60, 2.16 and 1.90 percent respectively. The maximum reduction in fabric stiffness is seen in the dyed sample. This decreased in fabric stiffness may be due to removal of starch in the original that hasn't undergone any pretreatments. The statistical analysis showed that there was the significant one percent difference with ANOVA value of 44.33 in the comparison made between the original and treated sample.

Hence it could be concluded that natural dyeing and printing with *Artocarpus heterophyllus* and *Lawsonia inermis* decreased fabric stiffness in the warp direction.

4.2.8 Fabric Stiffness (Weft)

Fabric stiffness and analysis of variance of original cotton fabric, desized, natural dyed and natural printed fabric is presented in the Table X and Figure 8.

TABLE X
Fabric stiffness (weft)

S.No	Sample	Mean Value (cm)	Loss or gain over original	%Loss or gain over original	Standard Deviation	'F' Test
1	O	2.40	-	-	0.16	13.72**
2	D	2.20	-0.20	-8.33	0.16	
3	ND	1.94	-0.26	-19.16	0.18	
4	NP	1.78	-0.16	-25.83	0.16	

Values are mean and SD of 5 samples in each group

** - Significant at 1% level

It is obvious from the Table X and Figure that the fabric stiffness of desized, natural dyed and natural printed samples has decreased by 2.20, 1.94 and 1.78 cm when compared to sample O which was 2.40 cm. The percentage loss of the samples (D, ND and NP) over original was calculated to be -8.33, -19.16 and -25.83 percent respectively. This decreased in fabric stiffness may be due to removal of starch in the original that hasn't undergone any pretreatments. The statistical analysis showed that there was the significant one percent difference with ANOVA value of 13.72 in the comparison made between the original and treated sample.

Hence it could be concluded that natural dyeing and printing with *Artocarpus heterophyllus* and *Lawsonia inermis* decreases fabric stiffness in the weft direction.

Figure 7
Fabric Stiffness Warp

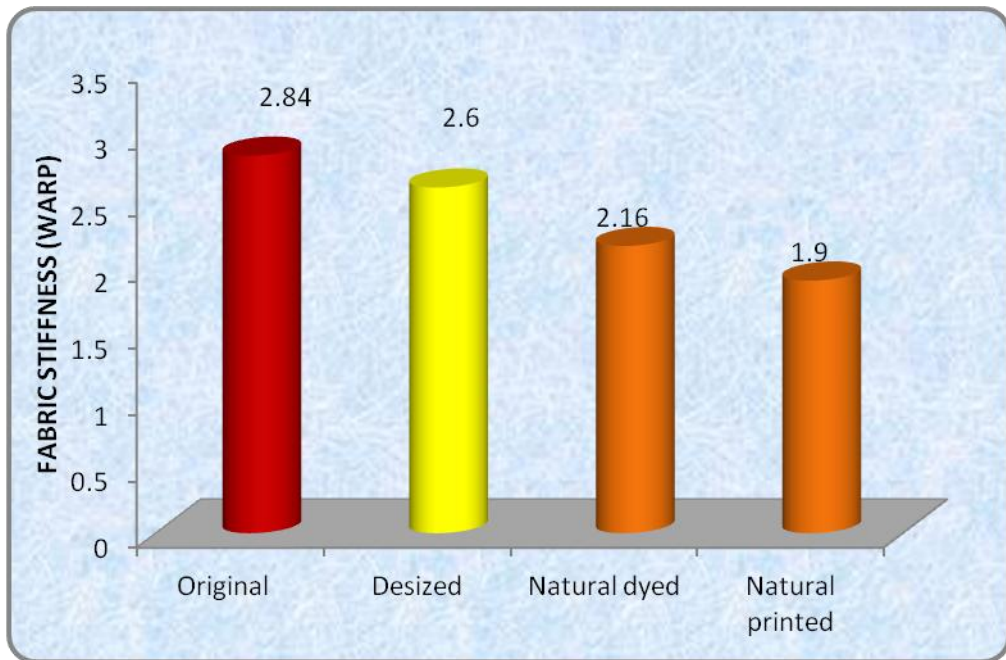
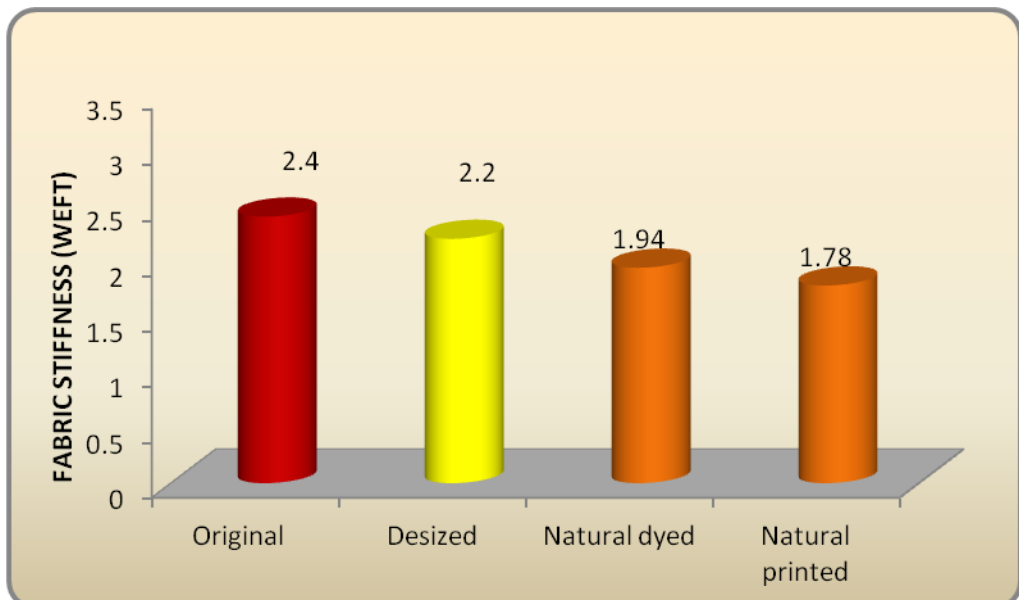


Figure 8
Fabric Stiffness Weft



4.2.9 Sinking Test

The result of the sinking test is presented in Table XI and Figure 9.

TABLE XI
Sinking test (seconds)

S.No	Sample	Mean value (sec)	Loss or gain over original	%Loss or gain over original	Standard Deviation	'F' Test
1	O	2.93	-	-	0.29	29.64**
2	D	2.09	0.84	28.66	0.26	
3	ND	2.54	0.39	13.31	0.38	
4	NP	1.7	1.23	41.97	0.70	

Values are mean and SD of 5 samples in each group

** - Significant at 1% level

From the Table XI and Figure it is obvious that the liquid penetration level of the samples O, D, ND and NP was 2.93, 2.09, 2.54 and 1.7 sec. The table represents a decrease in value when compared to original, it could actually be implied that the penetration rate is inversely proportional to time. Therefore, the sample D, ND and NP shows an increase in absorbency by 28.66, 13.31 and 41.97 percent respectively. Thereby concluding that the absorbency of the treated samples has decreased compared to original sample (O). The statistical analysis showed that there was a significant one percent difference with ANOVA value of 29.64 in the comparison made between the original and treated sample.

Hence it could be concluded that the natural dyed samples exhibited an increase in absorbency and natural printed samples exhibit decrease in absorbency as it took the longest time for sinking.

4.2.10 Drop Test

The result of the drop test is presented in Table XII and Figure 10.

TABLE XII
Drop test (seconds)

S.No	Sample	Mean value (sec)	Loss or gain over original	%Loss or gain over original	Standard Deviation	'F' Test
1	O	4.6	-	-	0.17	12.41**
2	D	3.2	-1.4	-30.43	0.12	
3	ND	2.11	-0.04	-54.13	0.13	
4	NP	2.14	-2.46	-53.47	0.12	

Values are mean and SD of 5 samples in each group

** - Significant at 1% level

From the Table XII and Figure it is obvious that the absorbency of the samples O, D, ND and NP was 4.6, 3.2, 2.11 and 2.14 sec. Through the table represents a decreased in value when compared to original, it could actually be implied that the absorbency rate is inversely proportional to time. Therefore the sample D, ND and NP show decreased in absorbency by -30.43, -54.13 and -53.47 percent respectively. Thereby concluding that the absorbency of the treated samples has increased compared to original sample (O).

From the results, it is evident that ANOVA value of 12.41 is significant at one percent level.

Figure 9
Sinking Test

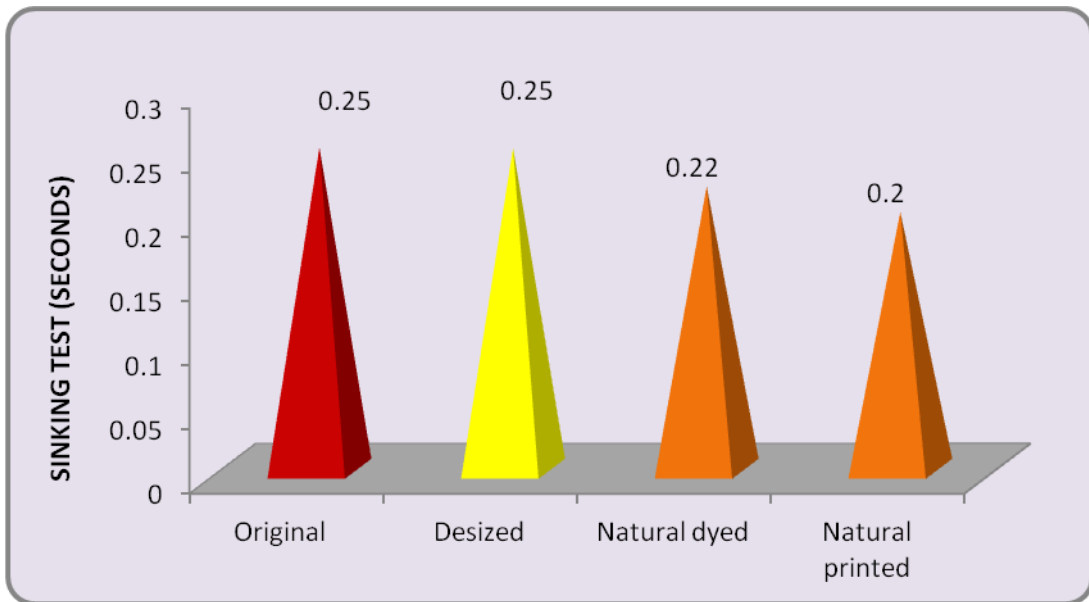
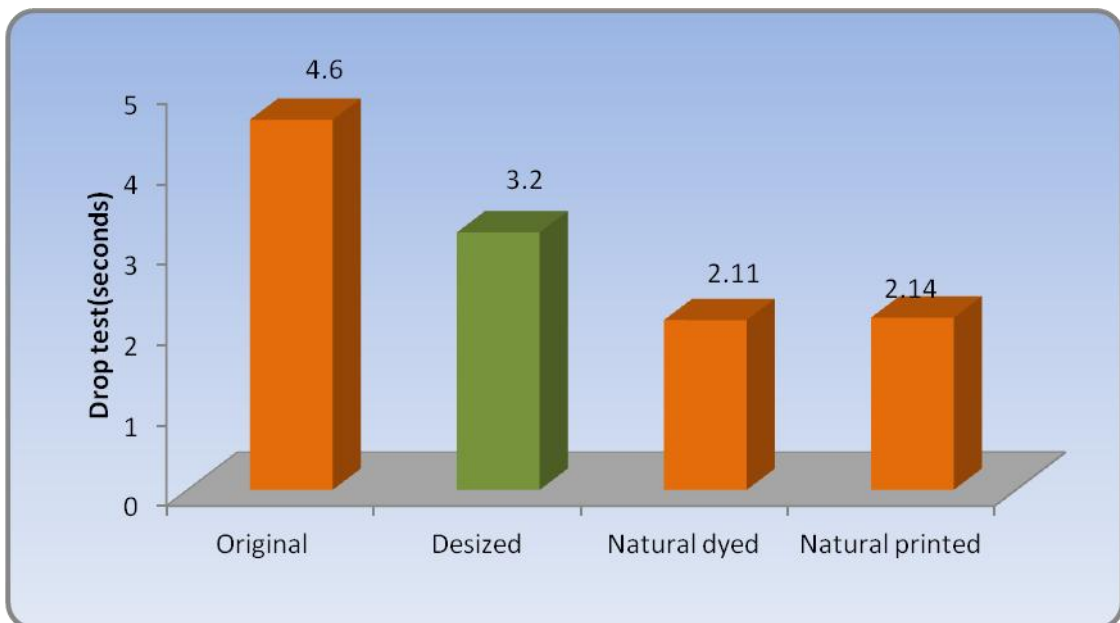


Figure 10
Drop Test



4.2.11 Wicking Test

The result of the Wicking test is presented in Table XIII and Figure 11.

TABLE XIII
Wicking test

S.No	Sample	Mean value(const.30 min in cm)	Loss or gain over original	%Loss or gain over original	Standard Deviation	'F' Test
1	O	3.6	-	-	0.35	221.17**
2	D	5.43	-1.83	50.83	0.31	
3	ND	4.47	-0.87	24.16	0.23	
4	NP	4.84	1.24	34.44	0.10	

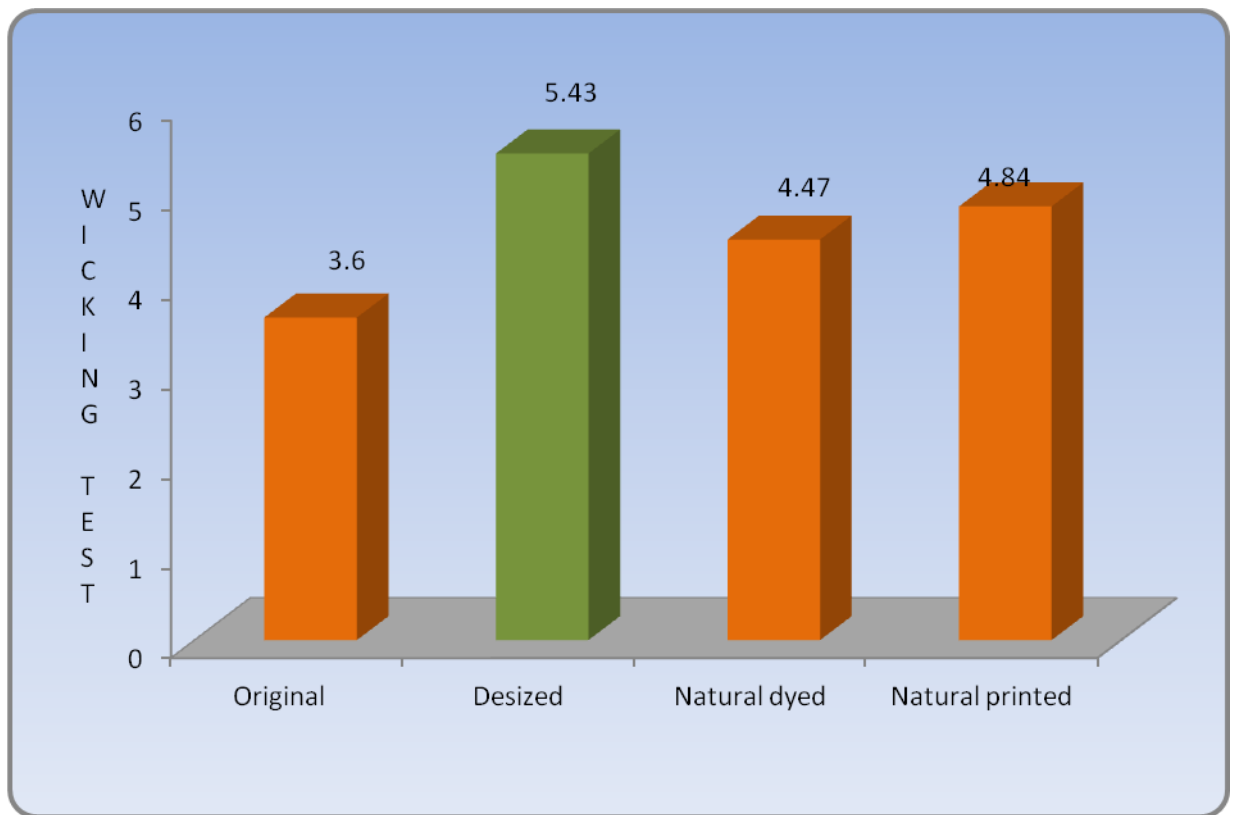
Values are mean and SD of 5 samples in each group

** - Significant at 1% level

From the Table XIII and Figure it is obvious that the absorbency of the sample O from wicking test was 3.6 cm whereas the absorbency has increased in the desized, natural dyed and printed samples. From among the samples (D, ND and NP) sample D showed the maximum rise of 50.83 % followed by sample ND of 24.16% and NP of 34.44%. Therefore it is clear that the absorbency of the samples (D, ND and NP) has increased when compared to the original sample (O). The statistical analysis showed that there was a significant one percent difference with ANOVA value of 221.17 in the comparison made between the original and treated sample.

Hence it could be concluded that the desized, natural dyed and natural printed samples show an increase in absorbency rate.

Figure 11
Wicking test



4.2.12 Colour Fastness Test

Colour fastness of the dyed and printed samples to sunlight, crocking and washing were determined and the results are presented in Table XV and Figure

TABLE XV

Colour fastness to crocking, pressing, washing and sunlight

S.No	Sample	Colour Fastness to Crocking		Colour Fastness to Pressing		Colour Fastness to Washing	Colour Fastness to Sunlight
		Dry	Wet	Dry	Wet		
1	ND	5	4/5	5	5	5	4/5
2	NP	5	4/5	5	4/5	5	5

5- Excellent; 4/5- Very Good; 4- Good; 3- Fair; 2- Poor; 1- Very Poor.

From the Table XV, it is clear that the dyed sample expressed excellent and printed samples expressed very good colour fastness to crocking with ratings of 5 in dry condition, whereas it slightly decreased in wet condition to 4/5 (very good). With regard to pressing in both dry and wet conditions the colour fastness was observed to be 5 (excellent) in the dyed and printed samples. As per the colour fastness to washing it was noted to be excellent in the dyed and printed samples. The colour fastness to sunlight was related as 5 in the printed samples but slightly lower in the dyed sample with 4/5. Hence it could be concluded that the colour fastness was excellent in the dyed and printed sample.

Hence it could be concluded that the natural dyed and printed samples had good colour fastness against crocking, pressing, washing and sunlight.

5.SUMMARY AND CONCLUSION

The words ‘go-green’ and ‘eco-friendly’ have become dominant across the world because of global warming, and increase in pollution. India is constantly looking for ‘green solution’ which can help in mitigate global warming. Textiles is not only one of the largest industry providing economical growth but also one of the most pollutants releasing industries of the world which are continuously doing unimaginable harm to the environment. Compare to these harmful of synthetic dyes, natural dyes are non-toxic, least pollutant and less hazardous. These factors have revived our interest once again towards the use of natural dyes and trace back their producing.

The term Khadi or khaddar means cotton, it is an exclusive Indian versatile fabric, purely hand spun and hand woven from genuine natural cotton using the traditional and manually operated “Charkha” the spinning wheel. The loom used in weaving of Khadi interlaces the threads in a manner that allows maximum air permeable and soothes the body better cloth than any other fabric does. Khadi is acknowledged as an all weather fabric, but still its usage has declined from its high fame as freedom fabric to mere cotton cloth. One should uplift the looks of khadi and hold its pride high using natural resources such as natural dyeing and natural printing it.

Natural dyes are present in plants, insects, animals and minerals which have molecules containing aromatic ring structure coupled with a side chain which are required to impart colour. Harmony of colour hues obtained from nature enriches the textile material and gives it a new dimension, warmth and quality by dyeing and printing processes which also give soft colours that are pleasing to the human eye and quite consistent with today’s fashion. Natural dyes have also been used for printing. Printing is defined as dyeing in a localised and patterned area. The main objective in printing is to produce coloured design in one or more colours with sharp boundries of the design. Thickeners used in textile printing are high molecular weight compounds giving viscous paste in water. These impart stickiness and plasticity to the printing paste so that it can be applied to the fabric without spreading and are capable of maintaining the design outlines even under high pressure. Arabic gum, guar gum, cereals starch, and sea weeds-sodium alginate are commonly used natural printing thickeners for textile printing.

Artocarpus heterophyllus is commonly called Jackfruit belongs to the family Moraceae (mulberry family) and subfamily Asteroideae. Jackfruit tree has a lot of economic values as well. The fruit can produce rubber moreover the tree has some medicinal uses also. It is also known for its remarkable, durable timber, which ages to an orange or red-brown color. Many parts of the plant including the bark, roots, leaves, and fruit are attributed with medicinal properties. There is 3.3% tannin in the bark, when boiled with alum, wood chips or sawdust; it yields a dye that is commonly used to give the characteristic color to the robes of Buddhist priests and in dyeing silk. Wood chips yield a dye used to give the famous orange-red color to the robes of Buddhist priests.

Lawsonia inermis commonly called as Henna or Mehendi, belongs to the Lythraceae family. The parts of henna shrub like roots, leaves, flowers, seeds are been extensively used.

Considering the above criteria plant materials are used for dyeing and printing using natural mordant and natural thickener using on khadi cotton fabric, because it is traditional fabric used in textile industry which has more durability and also eco friendly material. Hence the objective of the present study “**Assessing the Dyeability of Khadi fabric using *Artocarpus heterophyllus* Wood and Printing with *Lawsonia inermis* leaves**” is

- To select suitable fabrics and dyes
- To select the extraction method and dyeing method
- To colour the fabric with selected sources
- To select printing paste, thickening agent for printing
- To finish the fabric with selected printing techniques
- To study the dyed and printed fabric subjectively and objectively

Experimental procedure

Among the various textiles fabrics 100 percent khadi cotton fabric plain weave material was selected which has excellent moisture absorbency, soft texture, lustre and affinity to dyes. The fabric was desized with soap oil to remove the sizing material. The barks or wood dust of the trees (*Artocarpus heterophyllus*) were soaked in water for 24 hours, which it was used for dyeing. The dye and bio-mordant were extracted. The optimization for various parameters namely dyeing temperature, time and material liquor ratio were done. The three mordanting methods namely pre-mordanting, simultaneous mordanting and post mordanting were adopted for the study using the optimized parameters from which pre-mordanting technique was selected as the best based on the brighter shade obtained on the sample. Dyeing was carried out at 110°C for 90 minutes based on the optimized parameters. Finally the samples were taken out from the dye bath, washed and dried in shade.

Printing was carried out using the leaves of *Lawsonia inermis* (Henna) were cleaned, washed, shade dried and ground into powder which was used for printing. The direct printing method using block printing was selected for the study. Based on the ranking order the designs were selected among the ten hand drawn sketches, then the designs were converted into blocks. Indian Arabic gum was selected as a thickener for printing paste preparation. The optimization of thickener concentration and dye concentration was done. Fifty gm of thickener and 100 ml of dye solution were mixed well for 45 minutes at 90°C for preparing the printing paste.

Then based on the optimization of printing paste were prepared. Then the fabric to be printed was spread on the table without crease. Finally the fabric was printed

using the carved wooden blocks. Then the printed samples were then dried and the samples were then rinsed with cold water and air-dried at room temperature.

The dyed and printed samples were evaluated subjectively and objectively. In subjective evaluation, visual inspection was carried out. In objective evaluation fabric weight, fabric thickness, fabric stiffness, drape test, tensile strength and elongation, drop test, sinking test, wicking test, colour fastness test such as colour fastness to sunlight, washing, pressing and crocking were evaluated. The results were analysed by ANOVA.

Findings of the study

Visual inspection: The samples ND and NP exhibited the best evenness in dyeing, brilliancy in colour, texture, lustre and general appearance.

Fabric Weight: The weight of the D, ND samples have increased and NP samples have decreased when compared to original fabric. ANOVA value shows significant at one percent level.

Fabric Thickness: The thickness of the fabric has increased in ND and NP, when compared to original fabric.

Fabric strength: The assessment of the tensile strength of treated fabric in warp and weft direction showed that the strength of D, ND and NP had decreased. The value of ANOVA shows significant at one percent level.

Fabric elongation: The elongation results in warp and weft direction confirmed that the D, ND and NP samples increased in elongation when compared to the original sample. The ANOVA value is significance at one percent level.

Fabric stiffness: The stiffness of the fabric decreased in both warp and weft direction of D, ND and NP in comparison to original fabric with one percent significance.

Sinking test: Its result shows the absorbency of the D, ND and NP to have increased compared to original sample. The ANOVA value is significance at one percent level.

Drop test: The drop test results showed the maximum absorbency in treated fabrics D, ND and NP compared to its original sample. The ANOVA result shows significant at one percent level.

Wicking test: The absorbency of the fabric has increased in D, ND and NP compared to its original fabric. The ANOVA result shows significance at one percent level.

Conclusion

The present study shows that, wood chips or saw dust of *Artocarpus heterophyllus* natural dye source was used for colouring the Khadi fabric. The whole process of extraction and dyeing method are ecologically safe. The obtained results have shown the dyeing potential of *Artocarpus heterophyllus* had good fastness exhibited by the dyed fabric is because of the bio mordants used. The concept of printing of *Artocarpus heterophyllus* dyed Khadi fabric with natural dye source in powder form was successfully carried out using the leaves of *Lawsonia inermis*. The dye extract of *Lawsonia inermis* for printing the dyed fabric using direct style of printing technique has been studied. The fastness properties were fair to good. There is a lot of scope to use the *Artocarpus heterophyllus* wood chips dye for obtaining various colour shades using safe mordants under eco- friendly textile dyeing. The process and production of *Artocarpus heterophyllus* dye was found to be cost effective as compared to the cost of dyes in local market. In research it has a strong foundation to enhance Khadi in an eco friendly manner, even enhance the export market.

Recommendation of the Study

- Future study to be carried which are related to printing techniques.
- For extraction of natural sources could carried out different types of extract techniques.

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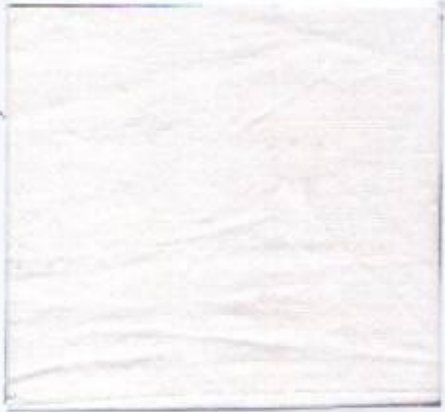
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Appendix – I

Original, Desized, Dyed and Printed Samples



Original Sample



Desized Sample



Dyed Sample



Printed sample

APPENDIX – II

SELECTION OF DESIGNS

JUDGES	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

APPENDIX –III

**PERFORMER OF VISUAL ASSESSMENT OF DYED AND PRINTED
SAMPLES**

S.No	Sample	General appearance			Brilliancy of colours			Evenness			Texture			Luster		
		Excellent	Good	Fair	Good	Medium	Dull	Even	Partially	Uneven	Soft	Medium	Course	High	Medium	Low
1	ND															
2	NP															

APPENDIX – IV

**COLOUR FASTNESS TO CROCKING , PRESSING WASHING AND
SUNLIGHT**

S.No	Sample	Colour Fastness to Crocking		Colour Fastness to Pressing		Colour Fastness to Washing	Colour Fastness to Sunlight
		Dry	Wet	Dry	Wet		
1	ND						
2	NP						

5- Excellent; 4/5- Very Good; 4- Good; 3- Fair; 2- Poor; 1- Very Poor.