The Effect of Enzymatic Softening on Aloevera - Cotton Mixture Fabric

Nandhini, S

(12PBX002)

Thesis Submitted to the
Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore - 641 043.

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Bio-Textiles

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Signature of the
Head of the Department

31.3.14
Signature of the
Supervisor

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1. INTRODUCTION

The textile industry is nearly as old as mankind but is pretty much alive and kicking. It has been one of the oldest and most important sectors of the Indian economy. It is the second largest employment provider in the country, next to the agriculture (Goyal and Deshpande, 2006). Textile industry is an independent industry involved in the production of basic rawmaterials to the final products with huge value addition at everystage of processing (Pandya and Manek, 2011). It is also a challenging industry because it is diversified and is constantly developing new products and changing the old ones, thus opening up new opportunities everyday (Amsamani and Ranganathan, 2007).

Textile products are particularly important in the effort to enhance comfort. They can give mental satisfaction by decorating the body, by providing enhanced status, or by maintaining modesty (Senthilkumar *et al*., 2010). Natural fibres are the essential alternatives in ever expanding horizon of textile fibres. They have high length to diameter ratios and they are bonded together by natural gums and resins. In textiles, natural fibres are mostly used in different areas and for different applications mainly clothing, home furnishing, industrial textiles and technical textiles (Singh *et al*., 2010).

Among the natural fibres, seed and fruit fibres (cotton and coir), bast fibres (jute, ramie, kenaf (mesta) and hemp etc.), leaf fibres (Sisal, pineapple, banana, caroa, raffia, palm etc.) and animal fibres (wool, hair and silk) are important in terms of production volume, industrial activity and usage patterns (Ghosh and Graw, 2004).Natural fibres present important advantages such as low-density, appropriate stiffness and mechanical properties and high disposability and renewability. Moreover they are recyclable and biodegradable (Das and Gon, 2012).

Cotton a most popular amongst natural fibre is admired by consumers the world over for its fascinating feel, comfort and versatility. It is the backbone and basic foundation of the world textile trade and industry (Malik, 2007). Cotton is characterized by properties like absorbency, biodegradable, heat testing, high wet strength, insulating properties, non allergenic renewable sources, softness and water retaining capacity (Watze and Eizenaches, 2002).

Cotton is blended with many other fibres so that certain of the desirable properties of cotton, that other fibres may lack, will contribute to the general characteristics of the blended yarns and fabrics (Singh, 2008). Cotton blends are widely used in the garment industry. Each of the blend has its own distinctive characteristics, processabiltiy, versatility, application areas and end uses for the apparels. It is possible to use a range of cotton blends in conjunction with special finishes to meet requirements and needs of the garment market (Shilpa *et al*., 2007).

Aloe vera is an another natural fibre that has gained importance in recent era. The aloevera plant is about 2-3 feet high. The leaves are fleshy tapering to a blunt point, smooth, pale green, having horny prickles on their margins (Pandey, 2012). Aloe vera is grown in most countries, but does best in warmer climates or indoors, although Aloe vera plants kept indoors are not likely to bloom at all. Occasionally these house plants may produce flowers if they receive a great deal of sunlight, but most will not. Aloe vera plants are not fragrant.

Aloe vera is a perennial cactus-like plant whose prickly leaves contain both gel and latex and is classified as a succulent because it is composed mainly of water. The viscous liquid from the Aloe vera leaf is used to make both Aloe vera juice and Aloe vera gel. This nourishing gel possesses wonderful soothing qualities unmatched by anything man-made and it is used to create salves, juices, creams and even pills. Aloe vera has been widely used for its soothing and clearing properties, some individuals may experience serious side effects from prolonged use. Aloe will reduce the sensation that is causing the itch.

The most oftenly used substance from this herb is the aloegel, a thick viscoid liquid found in the interior of the leaves. Moreover, aloevera has an antiseptic effect (by destroying the bacteria, viruses and fungi), disinfectant capabilities and can also stimulate the cell-renewing process. Aloevera has proved its efficiency from the simplest allergies to the treatment of wounds and skin infections and even to its usage in alleviating more serious afflictions (Ahmedkhan and Aftab Iqbal, 2011).

Now-a-days, people have become more eco-conscious. In these circumstances, textile wet processors are looking for eco-friendly alternatives for chemicals/auxiliaries and dyes used in textile industry. Recently it has been observed that enzymes are safe to use, easy to control and biodegradable. Hence, enzymes can be an alternative for harsh chemicals but require mild conditions for their operation and application (Mishra and Rani, 2007). Enzymes and enzyme technology are widely touted as the way of the future for many processing industries. Enzymes have been used in textile processing for about 30 years, since enzymatic desizing was launched in the late 1960's (Krishnamurti, 2007).

The enzymes are large protein molecules made up of a long chain of amino acids which are produced by living cells in plants, animals and microorganisms such as bacteria and fungi (Shyam Sundar *et al*., 2007).

Cellulase enzymes have gained industrial acceptance for finishing processes of cotton goods due to their capability of softening the fabrics and improving their appearance. In general, enzymes are nontoxic, environmentally friendly biocatalysts. Cellulase are protein molecules of high molecular weight, which catalyze the cleavage of the 13-glucosidic bonds of the cellulose substrate in accessible areas and at internal and external surfaces (Lenin *et al*., 2009).

Comfort is defined as "a pleasant state of physiological and psychological and physical harmony between a human being and the environment". Thermo physiological wear which concerns the heat and moisture transport properties of clothing helps to maintain the heat balance of the body during various levels of activity. Body movement comfort which concerns the ability of a textile to allow freedom of movement, reduced burden and body shaping, as required. Aesthetic appeal which concerns with the subjective perception of clothing to the eye, hand, ear and noise, which contributes to the overall well-being of the wearer.

Comfort is one of the most important aspects of all clothing. Several studies have used these methods to measure the effect of fabric construction or finishes on changes in hand and correlations were generally good between these mechanical properties and sensory hand responses (Devi *et al*., 2013). The softness of the fabrics is an essential criteria for the consumer acceptability mainly because of the fact that the soft feel of the fabric makes it comfortable for the skin. Any harsh feel of even small order makes it difficult for the user to sustain the fabric on the skin. The softness of the fabric depends on several factors but the most important one pertains to the chemical structure as also to the chemistry of the fibre materials (Gogoi et al., 2009). Therefore an attempt has been made to carry out study on **"THE EFFECT OF ENZYMATIC SOFTENING ON ALOEVERA-COTTON MIXTURE FABRIC"** with the following objectives to:

- study the effect of Enzymatic Softening on Aloevera-Cotton mixture fabric.
- optimize the parameters for enzymatic softening.
- evaluate the comfort properties of Aloevera-Cotton mixture fabric.

2. REVIEW OF LITERATURE

2.1. Enzymes and Textile Sector

Textile industry in India is facing a challenge to maintain quality and productivity comparable to international standards, due to the globalization of the world market. Further it has become the prime concern of the textile processors to be conscious about quality and ecology as ecological parameters are becoming more stringent (Rakisht, *et al.*, 2012).In modern textile wet processing operations, biotechnology finds widespread uses due to it's environment friendly nature of enzymatic processing and to some extent, economic viability, within the purpose of all textile processing, to modify fiber and fabric so that garments are comfortable, wearable and fashionable (Lal, 2001).

Many chemical reactions used in the textile industry are usually non specific reactions, often leading to unwanted byproducts and may require harsh conditions, such as high temperature, strong acid or alkaline pH, large volume of water etc. Enzyme technology is much older than genetic engineering. The history of identifying enzymes is over a hundred years old, while that of using purified enzymes commercially is about 60 years old (Mishra and Rani, 2007).

2.1.1. Enzymes

Enzymes are applied to several fields in human's daily life. Enzymes are added to cause particular reaction in the fields as they are natural, non-toxic, catalyze specific reactions, active under low concentrations, can be controlled and can be deactivated when required (Mal and Ganguly, 2013).

Enzymes are proteins, which catalyze specific chemical reactions and are known as "Bio catalysts". Chemical enzymes are defined as being a bio-catalyst made of protein complex compounds containing a sequence of approximately 200 – 250 amino acids and are present in all biological systems.

The term enzyme is derived from the greek word "Enzymes" and it literally translated means "cell" or "ferment" (Saravanan *et al.*, 2008). An enzyme is a natural product, from natural sources, and works on natural substrates. This is being challenged nowadays, and there is a search for enzymes that can act on man-made substances as well. Enzymes are highly specific, acting only on one kind of substance, and just a few molecules of enzymes can do so much work that only very small doses are required in any application (Krishnamurti,2007).

They are being introduced in various stages of wet processing of textiles as these are biodegradable and eco-friendly and do not cause any effluent problems. The enzymes generally reduce the time of treatment, considerably saving energy and chemicals, substantially increasing production (Pant and Tayal, 2000).

Enzymes have a number of distinct advantages over conventional chemical catalysts. Enzymes work under generally mild processing conditions of temperature, pressure and pH. This decreases the energy requirements, reduce the capital costs due to corrosion resistant process equipment and further reduces unwanted side-reactions (Sabale and Rane,2012).

2.1.2. Mechanism of Enzymes

Enzymes accelerate chemical reaction. A specific region on the enzyme also known as the active site fits with specific substrate molecules. Enzymes bind one or more specific substrates at its active site. The enzyme and the substrate form a complex (Mal and Ganguly, 2013).

Enzyme forms an intermediate complex with the substrate. The compound on which the enzyme acts is called the substrate. All enzymatic reactions involve a temporary union of the substrate with the enzymes (Veerakumari, 2004). The mechanism of conversion of a substrate to a product by the enzyme appears to be the same as for a catalyst, except that it is very specific. It is known that the enzyme combines with substrate to form a complex (Rajvaidya and Markandey, 2005).

2.1.3. Factors influencing enzyme activity

Basic enzyme kinetic theory is important in enzyme analysis inorder both to understand the basic enzymatic mechanism and to select a method for enzyme analysis. The conditions selected to measure the activity of an enzyme would not be the same as those selected to measure the concentration of it’s substrate (Kour and Tandon, 2009).

The reaction depends on various independent and dependent variables involved in the formation of enzyme – substrate system and the parameters include, enzyme concentration, concentration of substrate, incubation period, temperature of reaction, pH of the system, presence of activators, presence of inhibitors (Saravanan *et al*., 2008).

2.1.4. Application of enzymes in Textile industry

The textile industry has used enzymes to remove starch sizing of over 50 years. Over the last 10 years, the textile industry has become familiar with the use of celluloses for stone washing of blue jeans and more recently for finishing of fabric and garments made on cotton, linen, lyocel and other cellulosic fibres (Sakthivel *et al*., 2010).

The enzymes mainly applied in textile processing are amylases, cellulases, proteases, esterases, nitrilases, catalases, peroxidases, laccases, lipases and pectinases.Some of the hydrolase enzymes used in fabric preparations are amylase, cellulase, pectinase, catalase and lipases and some of the oxidoreductose used in fabric preparations are laccase, peroxidase and glucase (Kumar, 2007). Enzymes are biological catalysts mediating in virtually all of the biochemical reactions that constitute metabolism in living systems. They accelerate the rate of chemical reaction through catalysis without undergoing any chemical change in themselves. Enzymes are generally active at moderate temperature range to maintain their folded state to operate (Chakraborty *et al*., 2013).

2.2. Cellulase enzyme

Cellusases are derived both from fungal and bacterial sources. Cellulases are mixtures of endo – 1, 4 β – glucanases, randomly attacks the internal β – 1,4 linkages and the exo part attacks the non-reducing end of the cellulose chain and removes single glucose unit (Butola and Srivastava, 2009).

Cellulases are the most successful enzymes used in textile wet processing. Biopolishing or bio-finishing includes the action of cellulose enzyme to give a partial hydrolysis of cellulosic microfibrils at fabric surfaces along with mechanical agitation, simultaneously or sequentially, to remove the weak protruding fibre ends at the surface.Cellulose is one of the most widely available polymers in the nature. It is generally accompanied by hemi-cellulose and lignin. Currently the cellulases enzymes are most applied in textile industry, but they are also used for the stone washing of jeans-wear, as well as for finishing processing of cotton fabrics (Todorova *et al*., 2007).

Cellulase is used in textile processing mainly for depilling, to obtain stone wash effects, as part of detergent formulations to enhance detergency, to improve brightness and to remove micro fibrils. Beside, cellulose is nowadays used for improving the colour yield on cotton (Chakraborty *et al*., 2013).Cellulases can be used to finish treatments of cotton pertaining to fabric softness, good performance and fashionable looks as well as the potential to simplify and cheapen manufacturing processes. Cellulases show great promise in terms of effectiveness and the entire pre-treatment processes do not appear to be beyond the bounds of possibility in the future.

Treatment with cellulase enzyme eliminates superficial microfibrils of the cotton fibre. This is obtained by the controlled hydrolysis of cellulose and results in permanent improvement of fabric softness and smoothness. The treated samples were tested for changes in its physical, chemical and mechanical properties, loss of strength and handle properties (Yadav *et al*., 2004).

Native cotton contains maximum amount of cellulose in its purest form. Cellulose is composed of glucose molecules, which are arranged in stearic manner. In cotton fibre, cellulose is not combined with lignins or pectins, cotton cellulose contains about 12000 to 18000 glucose, residues in its macro molecule. The molecular weight of the cellulose present in cotton is approximately 2 million (Mishra , 2000).

Fabrics are rendered smoother and soften on enzyme treatment and simultaneous application of enzymes and softener enhances the performance properties of the fabric. The concept of treating fabric with enzyme to improve their surface properties was first developed in Japan in 1989 (Raje *et al*., 2001).

2.2.1. Importance of microbial enzymes

Microorganisms are the most significant convenient sources of commercial enzymes. They can be made to produce quality of enzymes under suitable growth conditions. It is easy to manipulate microorganisms in genetic engineering techniques to increase the production of desired enzymes (Satyanarayana, 2010).The ability of microorganisms on a large scale has made fermentation, the method of choice for production of enzymes on large scale. Many yeast, fungi and bacteria are used for production of various enzymes (Mahapatra, 2007).

2.3. Cotton

Cotton is the backbone of the world's textile trade. It is also known as "King of fibers" and white gold" (Bhat and choudhari, 2012). Cotton, also known as king cotton, remains the fibre produced and used in the highest quantity to date. Hence, processing of cotton occupies an important place in the textile sector (Butola and Srivastava, 2009).Cotton is a universal textile fibre offering excellent comfort, aesthetic and substrate properties. The fabric made out of cotton yarns lose considerable tensile and tear strengths and abrasion characteristics (Ramachandran, *et al.,* 2013).Cotton is a soft, staple fibre that grows in a form known as a ball around the seeds of the cotton plant (Gossypium Sp.), a shrub native to tropical and subtropical regions around the world, including the Americans, India and Africa (Rastogi, 2009).

2.3.1. History of Cotton

Cotton is grown in more than sixty countries of the world, but United States, India, Russia, Brazil, Egypt and China are some of the largest producers. Cotton cultivation practices vary from country to country (Shenai, 2000).Cotton has been cultivated for more than 5000 years. Archeological findings indicated that cotton was grown and used for textile purposes in the Indus valley well before 2100 BC., Mexico by 3500 B.C., in Peru by 2500 B.C., and in the South Western United States by 500 B.C.,

Cotton fabrics have been so well known and so extensively used throughout the world for hundreds of years that the spinning of the cotton fiber into yarns, the weaving of cotton yarn into fabric and many of the finishing processes used for cotton goods come first to mind and naturally serve as foremost examples in a study of fiber and fabric (Sharma and Goel, 2011).

2.3.2. Properties of Cotton

The quality of cotton, as determined on the basis of its color, length, strength, fitness and most of all the degree of contamination, significantly affects its price. Cotton fiber is increasingly facing competition from artificial fibers, notably polyester, cotton, being a natural product, varies widely in its fibre characteristics, both physical and chemical, because of genetic, environmental, harvesting and ginning factors (Satish and Khanna, 2013).

Cotton has medium strength, is a good conductor of heat and very absorbent but does not dry very quickly. Cotton lacks appreciable resilience and it is relatively inelastic (Ola and Pant, 2000).Cotton has high value due to its aesthetics, its pleasant texture and matte look. Because of its high capacity to absorb, hold and dry moisture, cotton offers maximum comfort under extreme heat and humidity. Cotton fiber is relatively strong due to the intrinsic structures of layers of crisscrossed, minute, spiraled fibrils that compose the fiber cell. Cotton fiber has very little natural elasticity (Singh, 2008).

Cotton fabrics are easy to launder. They can also be dry cleaned. Cotton fabrics can be readily dyed or printed with almost all the classes of dyes. They can be resin finished to given them wrinkle resistance (Singh, 2007).Cotton fabric is soft and comfortable to wear close to skin because of its good moisture absorption qualities (Kaplan, 2002).

2.4. Aloevera

The aloevera plant has been known and used for centuries for its health, beauty, medical and skin care properties. The name Aloevera derives from the Arabic word “Alloeh” meaning “Shining bitter substance”, while “vera” in Latin means “true”. Two thousand years ago, the Greek Scientists regarded Aloevera as the universal panacea. The Egyptians called Aloe as “the plant of immortality” (Surjushe *et al*., 2008).

Aloe vera is a succulent, almost sessile perennial herb. Its leaves are 30–50 cm long and 10cm broad at the base; colour is pea-green (when young they are spotted with white) and has bright yellow tubular flowers, 25–35 cm in length arranged in a slender loose spike. It contains a colourless mucilaginous gel called A. vera gel (Bruneton,1995). A. vera is grown commercially, especially in the Netherlands Antilles, for the latex which is used medicinally (Christman, 2005). It is frequently used in herbal medicine and can be grown as an ornamental plant. Preliminary evidences have shown that A. vera extracts (bitter yellow A. vera latex) are useful in the treatment of fungi and bacterial infections in humans and as laxative (Boudreau and Beland, 2006).

2.4.1. History of aloevera

The botanical name of Aloevera is Aloe barbadensis miller. It belongs to Asphodelaceae (Liliaceae) family, and is a shrub or arborescent, perennial, xerophytic, succulent, pea-green color plant (Surjushe *et al*., 2008).

Aloe veraLinne or Aloe barbadensis Miller is a succulent from the Aloe family (400 different species) with its origin in African continent. Its thick leaves contain the water supply for the plant to survive long periods of drought (Foster, 1999). When a leaf is cut, an orange-yellow sap drips from the open end. When the green skin of a leaf is removed a clear mucilaginous substance appears that contains fibres, water and the ingredient to retain the water in the leaf. Aloevera gel consists of 99.3% water. The remaining 0.77% is made up of solids with glucose and mannose constituting for a large part. These sugars together with the enzymes and amino acids in the gel give the special properties as a skin product (Agarry *et al*., 2005).

Aloe vera is a perennial, drought- resisting, succulent plant belonging to the Lily (liliaceae) family which has been used for a variety of medicinal purposes (Agarwal *et al*., 2012). The aloe constituents are derived from the aloe leaf which consists of two primary sections.

- The kind (Photosynthesis takes place here with sap contained in the pericyclic transport tubules – xylem and phloem).
- The mucilage (container) layer and parenchyma or gel fillet (storage) layer (Srivastava, 2010).

2.4.2. Properties of aloevera

Aloevera has excellent skin care properties which includes anti inflammatory and anti-aging (Raghav Bhala *et al*., 2012). It is an excellent moisturizer that keeps the skin flexible by giving oxygen to the cells, which in turn increases the strength and synthesis of the skin tissue. It contains the highest concentration of healing agents, which is beneficial for the skin and has been utilized for cosmetic uses (Srivastava, 2010).

2.5. Blending

Blending of different fibres is a very common practice in the spinning industries. The blending is primarily done to enhance the properties of resultant fibre mix and to optimize the cost of the raw material. The properties of blended yarns primarily depend on the properties of the constituent fibres and their compatability. Moreover, the proportion of fibres in the blend also plays a significant role (Majumdar *et al*., 2011).

The term 'Blending' is used by the yarn manufacturer to describe specifically the sequence of processes required to convert two or more kinds of staple fibres into a single yarn composed of an intimate mixture of a component fibers. This is necessary to obtain a uniform yarn from different varieties of the same fibrous polymer (Shilpa *et al.*, 2007).

A blend is an intimate mixture of fibers of different composition, length, diameter and color spun together into a yarn. Blending enables technicians to combine fibers so that the good qualities are emphasized and poor qualities minimized (Ola and Pant, 2000).

2.5.1. Advantages of blending

The major advantages of comber sliver blending are

- Produces a very intimate blend.
- Trouble free running and higher productivity at the cards.
- Less yarn imperfection due to better fibre individualization because of reprocessing of cotton component.
- Reduced number of draw frame passage.
- Lower end breaks due to fewer slabs
- Better uniformity of dyeing due to more intimate blend.

(Ravi and Zope, 2009).

- Expensive fibers can be extended by blending them with more plentiful fibers.

- To produce fabrics with a better combination of performance characteristics in the product.
- To obtain better hand or fabric appearance.
- To obtain cross dyed effects or create new color effects such as heater, when fibers with unlike dye affinity are blended together and then piece dyed.
- To improve spinning, weaving and finishing efficiency for uniformity of product as with self blends of natural fiber to improve uniformity (Charankar*et al*., 2007).

Blended yarns are increasingly being used for the production of quality fabrics, and with the advent of many spinning systems and techniques, the quality of these yarns has also been enhanced (Ramachandran *et al*., 2013).Any blend must have acceptable properties for the spinner. Important factors include the relative diameters, staple lengths, and extensibilities of the fibres present. A mismatch can create a blend that has lower strength than that of either of the component fibre types (Menezes, 2008).Uniform blending is the key factors to a staple process and a uniform product. In end products, fabrics such as fabric barre, dimensional irregularity and poor appearance can result from poor blending (Basra, 2002).

2.6. Softening of Textiles

Textile softeners are organic compounds consisting of atleast one hydrophobic long chain fatty groups – R containing carbon atoms more than C16, attached to a hydrophilic water soluble group (Goyal and Deshpande, 2006).

Softeners give the handle, which is a subjective feeling or sensation in the finger tip when a fabric is touched. The softness of a textile is due to various sensory phenomena, such as smoothness, resilience and bulk. Preparatory treatment can also cause textiles to become brittle, because it removes natural waxes and fats or lubricants. The soft-handle finish can make up for or over-compensate this shortcoming (Malik *et al*., 2004).

The use of fabric softeners has been increasing over the years. Nowadays an increasing number of households are also using fabric softeners in washing garments and various items of hometextiles (Deshpande and Indi, 2013).

2.6.1. Properties

Softener property is very much desired and required in final fabrics as they are deprived of their softeners during the process like scouring, bleaching etc. Therefore it is necessary to apply some chemical auxiliaries which can impart softeners, smoothens, fullness and suppleness to the fabric. Aesthetic finishes are important to achieve looks and create excitement in the minds of consumers. Aesthetic finishes improves the look and feel of the fabric such as,

- Hand feel improvement
- Visual enhancer and
- Surface smoothness (Goyal and Deshpande, 2006).

The attraction of fabric softener is that it improves the fabric hand, fabric softness and drape. However, there is an opposite side to these benefits. That is, fabric softners are also responsible for altering the thermal comfort of the fabric like flammability, air permeability, etc. Softners contain oil, wax, emulsion, petroleum products and compounds containing a higher number of carbon atoms. Their application on textiles may enhance the fabric's flammability (Deshpande and Indi, 2013).

2.6.2. Purpose of softeners

The main purpose of a softener is to improve the aesthetic properties of textiles, such as:

- It gives the fabric desired handle; usually with imaginative descriptions such as soft, smooth, full, super soft, elastic, firm, dry, sludgy etc.
- It positively influences the technological properties such as antistatic, hydrophilic behaviour, elasticity, sewability, abrasion resistance, etc.
- It gives synthetic fibres a certain degree of natural feeling and improves the handling effects (smoothness, moisture regulation etc.) (Malik *et al*., 2004).

2.6.3. Characteristics of softeners

- Must be readily dispersible, soluble or miscible water.
- Must have good exhaustion property.
- Must import softness, fluffiness and fabrication.
- Should have ability to absorb water.
- Should not adversely affect the shade and hue.
- Should be compatible with resins, optical brightner, various softener etc.
- Trouble free application
- No dermatological effect
- Should enhance physical property of fibre and fabrics.

  e.g. tear strength, abrasion etc. (Goyal and Deshpande, 2006).

2.7. Comfort

Clothing is an integral part of human life and has a number of functions like adornment, status, modesty and protection. To be competitive, modern clothing besides having good mechanical and technological properties and being of easy care, must possess good comfort characteristics. Comfort has totally replaced the durability as far as the selection of garments or fabrics is concerned (Mhetre *et al*., 2012).

Comfort is a fundamental and universal need for consumers. Comfort is defined as a pleasant state of physiological and psychological and physical harmony between a human being and the environment. Comfort is a human being related to human perception of various sensations such as visual, thermal, pain and touch. Body clothing interactions play important roles in determining the comfort state of a wearer (Senthilkumar *et al*., 2010).

Comfort properties are an essential aspect of textile performance and its presence is especially important for clothing worn for any kind of activity and close to the body. Comfort encompasses psychological, sensorial and thermophysiological comfort. The type of fiber, application of chemicals through finishing and various other such factors affect the comfort properties of textiles. The factors contributing to the comfort properties include fabric hand, thermal comfort, air permeability and wicking. (Rai and Bai,2013).

2.8. Pretreatments

The term”pre-treatment” summarises all types of wet finishing processes like scouring, desizing, mercerizing, bleaching etc. of the fibres, fabric or yarn (Smith, 2006). Process of fabric involves various processes which gives the fabric, its final state with aesthetic values in terms of appearance, handle, feel and the technological properties as per the requirement of the customer (Goyal and Prabhu, 2007).

The aim of pretreatment is to remove all natural and added impurities from cotton, impart uniform and instant absorbency and uniform whiteness required for dyeing or optical brightening (Saref and Alat, 2005). Fabric preparation is a complex and composite process to be completed selectively from various steps, such as desizing, scouring, bleaching etc. in relation to type and end use of fabric (Adivarekar *et al*., 2012).

2.8.1. Desizing

For fabrics made from cotton or blends, the warp threads are coated with an adhesive substance know as ‘size’ to prevent the threads breaking during weaving. Although many different compounds have been used to size fabrics, starch and its derivatives has been the most common sizing agents. After weaving, the size must be removed again inorder to prepare the fabric for dyeing and finishing (Kashyap and Mishra., 2011).

The process of desizing is mainly responsible for the removal of the added sizing materials, the so called added impurities. (Sanjeev and Shukla., 2006). Traditionally, desizing was carried out by treating the fabric with water (Rot steeping) or by chemicals such as acids and oxidizing agents. (Vasavada *et al*., 2000). PVA and CMC can be removed in a boiling bath containing an alkali such as caustic soda or sodium carbonate. In either case, a surfactant is always added to the bath to promote the penetration of the liquor and to prevent the reattachment of the sizing agent (Mahapatra, 2010).

2.8.2. Advantages of desizing

- Effective solubilisation and removal of starches.
- Excellent biodegradability.
- No aggressive chemicals needed, thus maintaining the Tensile strength of the substrate.
- Safe handling and operation.
- Improved wettability.
- Improved fabric quality.
- Reproducible performance and ease of use. (Athalye., 2012).

2.8.3. Scouring

Grey textiles contain various non-cellulosic impurities (natural and added) such as wax, fat, minerals etc. The presence of wax and fats make the fibre hydrophobic and hinders the dyeing and other finishing operations. Therefore, a pretreatment is required to make the fibre hydrophillic through removal of impurities like fat and waxes. The step of removal of wax and fats also known as scouring uses alkali that also attacks cellulose, leading to strength and weight loss. (Mal and Ganguly., 2013). Traditional scouring requires the use of sodium hydroxide and high temperature to ensure efficient removal of impurities, making the fabric suitable for subsequent process like bleaching and dyeing. (Parvar *et al*., 2002),

2.8.4. Advantages of bio-scouring

Bioscouring produces lower weight loss; they results in less pollutant to the waste water, reduction in COD, BOD and TDS. It has lower energy consumption; It is less aggressive for the fabric and for the environment, complete removal of non-cellulosic impurities, uniform and high absorptive pretreated goods; high accessibility of cotton substrate for dyestuff (Roda, 2008).

2.8.5. Bleaching

Bleaching of textile is done to remove the colouring material from the fibre. Bleaching either use reducing agents that reduces the natural colouring material into colourless material or by oxidation in which the colouring material breaks down into soluble material that is washed off subsequently. Mainly hypochlorite, peroxide and chlorite bleaching agents are used to bleach textile. (Mal and Ganguly, 2013).The bleaching of textile cotton and its blend is mainly done by hydrogen peroxide, which is not fully eliminated after the bleaching process. The presences of peroxide left in the bleached fabrics create severe problems to the subsequent processes. (Mahapatra, 2010).

2.9. Dyeing

Dyeing is the process of importing color to a textile material in loose fibre, yarn, cloth or garment form by treatment with a dye. The dye is generally applied in an aqueous solution, and may require a mordant to improve the fastness of the dye on the fiber (Kapoor, 2012).

2.9.1. Synthetic dye

A dye or dyestuff may be defined as a coloured organic compound which is used for imparting colour to a substrate. Thus a dye should fix itself on the substrate to impart it a permanent coloured appearance (Sine, 2003).

2.9.2. Reactive dye

"A reactive dye is a coloured compound that has a suitable group capable of forming a covalent bond between a carbon atom of the dye ion or molecule and an oxygen, nitrogen or sulphur atom of a hydroxyl, and amido or a mercap to group respectively of the substract" (Yadav, 2008).

The reactive dyes contain dichlorotriazinyl group. These dyes were made by condensing a dye containing amino group with cyanuricchlorides. Cyanuric chlorides is cheap and readily available. The reactivity of chlorine atom in cyanuric chloride is due to the electron with drawing properties of the nitrogen atoms. Procion red dye is obtained by coupling diazotized amiline with M acid. The resulting product is then condensed with cyanuric chlorides in the presence of sodium carbonate at low temperature (Singh,2002).

2.9.3. Application of reactive dyes

The application of reactive dyes involves the formation of a covalent bond between the dye molecule and the polymer of the particular fibre. The process of applying reactive dye is considered below for cellulosic, protein and nylon fibres (Gohl and Vilensky, 2003).

3. METHODOLOGY

3.1. Selection of the fabric

The fabric selected for the investigation was Aloevera-Cotton mixture fabric. Cotton has specialized properties such as absorbency, softness, smooth and comfortness. Aloevera soothes and revitalizes our body with exceptional softness and providing anti-bacterial features. Aloevera is a renewable resource, and also have good blending property of both fibers. Hence Aloevera – Cotton mixture fabric is eco-friendly which was considered as the most applicable property for the present investigation. Aloevera–Cotton mixture fabric was procured from "Anakapudhur Weavers Association " Chennai at the cost of Rs.700/- per meter for this study.

3.2. Selection of Enzymes

Enzymes are biocatalysts. They catalyze a particular reaction or a group of closely related reactions with or without the aid of co-factors. All the functions of the body such as digestion, synthesis and breakdown of carbohydrates, proteins, fats and nucleic acids are catalyzed by specific enzymes. They are protein nature (Asokan, 2003).

Cellulosic fibers are treated with cellulase enzyme inorder to hydrolyze its surface and remove the fuzzy surface produced from spun yarns of cellulose and its blends. This is a permanent finish and the fabric gets a soft and smooth appearance (Arora, 2010).

Cotton and other natural and man-made cellulosic fibres can be improved by an enzymatic treatment. Cellulases hydrolyze the microfibrils protruding from the surface of yarn because they are most susceptible to enzymatic attack. Enzymatic treatment reduces facing up, which significantly improves the pilling performance of garments and increase softness. Therefore cellulase enzyme is opted for the study and was procured from "Resil chemicals Pvt. Ltd", Tirupur, for the enzymatic softening treatment on Aloevera-Cotton mixture fabric.

3.3. Pretreatment of the Fabric

3.3.1. Desizing

The aim of preparatory process is to improve the quality of the fabric. It is the process for removing sizing compounds applied to yarns. Sizing compounds are necessary for controlling of friction and electrostatic charging. After solubilization, the size is discharged and the fabric is washed and rinsed (Smith,2006). Hence the fabric is desized with recipe given in the Table –I.

TABLE – I

RECIPE FOR DESIZING

S.No	Particulars	Parameter
1.	Detergents (gms)	4
2.	Water (ml)	5000
3.	Temperature (°C)	80°
4.	Time (hr)	1
5.	Material(gms)	180

Four grams of detergent powder was mixed thoroughly in 5000ml of water and was heated upto 80° C. Aloevera-Cotton mixture fabric was dipped into this solution and stirred gently for 1 hour. After that it was taken out, squeezed and then rinsed using soft water until it was free from traces of detergent. Later, fabric was dried in shade.

3.3.2. Scouring

In a textile processing unit, a very important process is scouring. In this process, non cellulosic components from native cotton are completely or partially removed. (Kashyap and Mishra,2011). Hence the desized fabric was scoured with recipe given in the Table – II.

TABLE – II

RECIPE FOR SCOURING

S.No	Particulars	Parameters
1.	Sodium hydroxide (gms)	45.0
2.	Soda ash (gms)	15
3	Water (ml)	7500
4.	Temperature (°c)	95°
5.	Time (hr)	1
6.	Material(gms)	150

The amount of chemicals required was calculated on the basis of weight of fabric. Chemicals were mixed together thoroughly in 7500ml of water. Then the fabric was fully immersed in the vessel and boiled for 1 hour. After 1 hour of scouring, the fabric was thoroughly washed, and rinsed 4 to 5 times in tap water and dried.

3.3.3. Bleaching

Bleaching with hydrogen peroxide is pretreatment process of cellulose fabrics. It is the process for improving the whiteness of the fabric (Spicka and Taveer, 2013). Therefore the selected fabric was bleached as per the recipe given in Table-III.

TABLE – III

RECIPE FOR BLEACHING

S.No	Particulars	Parameters
1.	Hydrogen Peroxide (gms)	6 gms
2.	Water (ml)	3000
3.	Termperature (°c)	80°
4.	Time (hr)	½
5.	Material (gms)	140

Scoured fabric was treated with bleaching solution containing 6g of hydrogen peroxide in 3000ml of water. Then the fabric was fully immersed in the vessel and boiled for ½ hour. After that the bleached fabric was taken out and washed under the tap water thoroughly for 2 to 3 times and dried completely.

3.4. Optimization of Selected Parameters for Enzymatic Softening

Several combinations of different parameters were used to optimize important physical conditions for enzymatic softening. Some of the essential parameters such as enzyme proportion, time, temperature and material liquor ratio were optimized to obtain the best results for enzymatic softening of Aloevera – Cotton mixture fabric.

3.4.1. Effect of Enzyme concentration

The optimum concentration of enzyme source was determined by taking different concentration of cellulase enzymes such as 3, 4 and 5 grams. One gram of selected fabric was taken in three different beakers containing different concentration of the enzyme to water proportion of 1:20. This was kept in water bath at optimized temperature and time. The fabrics were removed and rinsed thoroughly with cold water and dried. The optimum enzyme concentration was obtained by calculating the weight loss of the fabric before and after softening. Electronic weighing balance was used to measure the weight.

3.4.2. Effect of Incubation time

Softening of 1gmof selected fabric was carried out in an incubation time for20, 25 and 30 minutes at optimized temperature individually. After incubation period, this was removed and washed thoroughly and weighed for calculatingthe weight loss of fabric.

3.4.3. Effect of pH

To determine the effect of pH on enzymatic softening. The liquor was adjusted to different pH such as 5, 6, 7 using IN HCL or 1N NaOH. The solution was maintained at optimum temperature and enzyme concentration. Based on the weight loss of the fabric the optimum pH was selected and fixed for further study.

3.4.4. Effect of Temperature

The optimum temperature was obtained by softening the pre – weighed fabric samples with different temperature of 35°C, 40°C and 45°C. After incubation period, the weight loss of the selected fabric was noted.

3.5. Selection of Synthetic dye

Reactive dyes utilize a chromophore containing a substituent that is capable of directly reacting with the fiber substrate. The Covalent bonds that attach reactive dye to natural fibers make it among the most permanent of dyes "cold" reactive dyes, such as procion MX, Cibacron F, and Drimarene k, are very easy to use because those dye can be applied at room temperature. Reactive dyes are the best choice for dyeing cotton and other cellulose fibers (Kapoor, 2012).

3.5.1. Selection of dyeing parameters for the study

The details of selected proportions of dyeing parameters for dyeing Aloevera – Cotton mixture fabric are given in Table- IV.

TABLE – IV

DYEING PARAMETERS

S.No	Particulars	Parameter
1	Reactive dye	2%
2	Sodium chloride	1%
3.	Sodium carbonate	1%
4.	Temperature	Room Temperature
5.	Time	30 min.

Enzymatically softened fabric is weighed and the amount of chemical needed is calculated. The dye stuff is mixed with water and, sodium chloride and sodium carbonate were added into the beaker containing dye solution. Then the fabric is immersed in the dye solution and kept at room temperature for 30 minutes. After that it was taken out, squeezed and then rinsed using soft water and dried. Electronic weighing balance was used to measure the weight of the fabric.

3.6. Nomenclature

Nomenclature of enzymatically softened and dyed fabric is given in the Table V.

TABLE- V

NOMENCLATURE

S.No	Nomenclature	Sample Code
1.	OF	Original Fabric
2.	PF	Pretreated Fabric
3.	EsF	Enzymatic Softened Fabric
4.	EsdF	Enzymatic Softened Dyed Fabric

3.7. Evaluation of the fabric

The fabrics were evaluated subjectively and objectively for their properties.

3.7.1. Subjective evaluation

Visual inspection was done for the subjective evaluation.

3.7.2. Objective evaluation

Standard fabric tests such as weight loss, comfort property test, physical property test and mechanical property tests were carried out for the original sample, pretreated sample and enzymatically softened sample.

3.8. Physical property test

3.8.1. Fabric Weight

Fabric weight is an important component when comparing two similar fabric constructions, it refers to the relative weight of the fabric it may be expressed as the weight of particular size such as gram per square meter (Paul, 2005). Weight of the fabric is determined as weight per unit area (Stoker *et al.,* 2005). A Sample was cut using a GSM cutter (Plate-I) and Electronic weighing balance (Plate-II) was used to find the weight of the samples. Then the fabric weight is calculated using the formula :

$$\text{Grams Per Square Metre (GSM)} = \frac{\text{Weight of the fabric X Square meter}}{\text{Area of Square}}$$

Weight of the fabric	=	x (g)
Square of the fabric	=	100cm x 100cm = 10000cm^2
Area of Square	=	length x breadth square unit

The same procedure was followed to find the fabric weight of original, pretreated and enzymatically softened fabrics. They were carefully recorded and the mean value was calculated.

3.8.2. Fabric Thickness

Thickness is the distance between the upper and under surface of the material, measured under a specified pressure expressed in mm and the readings were taken by Shirley's Thickness Tester (Plate-III). It is a hand operated instrument, which has a dial that reads the thickness of the fabric. Two clamps are attached to the dial. Each of the samples was placed between the two clamps and pressed. Thickness was measured at random. The mean value was calculated and recorded (Sunita *et al*., 2010).

3.9. Mechanical Property test

3.9.1. Fabric Tensile strength and Elongation

Breaking strength is a measure of resistance of the fabric to tensile load in a warp or weft direction (Angappan, 2002). The Eureka model Tensile Strength Tester was used for the study (Plate-IV).

The rate of transverse and capacity of the machine was 45cm per minute. The gauge length was kept as 25cm and the dial of the machine is calibrated in pounds and kilograms using ASTM Standards. The samples were taken for testing. The length and width of the sample was 33cm and 7cm respectively. Each sample was clamped firmly between the two jaws. Care was taken that the fixed sample was perpendicular to the load. The load was applied until the sample is broken.

The dial reading in kilograms and elongation in centimeters were noted. Five readings were noted for each category.

3.9.2. Pilling Test

Pilling is an undesirable phenomenon that affects the hand and the appearance of garments. The pills formation on fabric surface follows four stages, fuzz forming, fuzz entanglement, pill forming and pill wear-off (Lilong and Zhouwei, 2004).

For this test, four specimens each 125mm x 125mm were cut from the fabric. A seam allowance of 12mm was marked on the back of each square. The samples were then folded face to face and a seam was sewn on the marked line. Each specimen was turned inside out. The fabric tubes made were then mounted on rubber tubes. The specimens were then placed in the pilling box. The usual number of revolution used in the test was 18000 which take 5 hours (Plate-V).

Fabric samples were assessed by comparing them with a set of photographic standards (ASTM).

3.9.3. Abrasion Resistance

Abrasion is the ability of the fabric to resist the action of abrasive force (Basu, 2006). The Martindale Abrasion Resistance Tester (Plate-VI) was used to determine abrasion resistance of the sample. Five samples were cut from different places of the same material at random using the template. The initial weight of the each sample was found out, recorded and then the sample was mounted on the sample holder. The sample holder with 200gms weight was used for this test. The rubs were standardized to 10 rotations. The Samples were made to rub against the abrasive surface. After 10 rotations, the samples was removed and the final weight of the sample was found out. Weight loss due to abrasion was calculated. The test was repeated for five samples and one mean weight loss was calculated.

Calculation

$$\text{Weight loss} = \frac{\text{Weight of sample before abrasion} - \text{Weight of sample after abrasion}}{\text{Weight of sample before abrasion.}}$$

3.10. Comfort Property Test

3.10.1. Fabric Stiffness

Cloth stiffness is the resistance of the fabric to bending. Bending length is the length of the fabric that bends under its own weight to a definite extent. This parameter is one of the factors that determine the manner in which fabric drapes i.e., the cloth having high bending path tends to drape stiffly (Sunita *et al*., 2010). The stiffness of the sample is determined by Shirley Stiffness Tester (Plate-VII).

The specimens from pretreated sample and enzymatically softened fabric of six inch were cut using template provided with the tester. Each rectangular strip was mounted over a horizontal plate form until the edge of the fabric co-inside with the index line, the reading was noted in centimeters pointed in the template. Five readings were taken from each specimen with each slide up, first at one end than the other. The mean value of the five readings was calculated as single readings. Five specimens from original fabrics, pretreated fabrics and enzymatically softened fabrics were tested for five times and the mean value is calculated.

3.10.2. Crease Recovery

Crease recovery is the ability of a fabric to recover from unwanted creases. Creasing of textile material is a complex effect involving tensile, flexing, compressive and other stresses (Seine, 2004). Creasing of a fabric during wear is not a change in appearance that is generally desired. The ability of a fabric to resist creasing is in the first instance dependent on the type of fibre used in its construction (Saville, 2004). Shirley Crease Recovery Tester (Plate-VIII) was used for the study.

The instrument consists of a circular dial, which carries the clamp for holding the sample. A knife edge and an index line are seen directly under the centre of the dial to measure the recovery angle. Fabric of 5 x 2.5cm size were cut both in the warp and weft directions randomly using a template from original sample, pretreated samples and enzymatically softened samples. Each sample was transferred to the fabric clamp on the instrument and allowed to recover from the crease. After two minutes, the dial was rotated to keep the free edge of the sample coincide with the knife edge. The crease recovery angle in degrees was read directly from the engraved scale. The mean values were calculated and recorded for the original sample, pretreated samples and enzymatically softened samples.

3.10.3. Drapability

Drape is one of the subjective performance characteristics of fabrics that contribute to aesthetic appeal. It is complex property involving bending and shearing deformations.

A circular specimen about 10 inches in diameter is supported on a circular disc about 5 inches in diameter and the unsupported area drapes over – gramophone record. The drape co-efficient, F, is the ratio of the projected area of the draped specimen to its undraped area after deduction of the area of the supporting disk (Arora,2010) (Plate-IX).

It is calculated by determining the following

A_D = the area of specimen

Ad = the area of supporting disc

A8 = the actual projected area

$$F=\frac{A8-Ad}{AD-Ad}$$

3.11. Absorbency Test

3.11.1. Drop Test

A burette filled with distilled water was clamped in a stand. The sample was mounted in an embroidery frame and was placed at the base of the stand. The distance between the fabric and burette nozzle was kept constant (Plate-X). The nozzle of the burette was opened just to allow a drop of water to fall on the sample. The stop watch was started simultaneously and it was stopped when the drop of water fully sank into the material, the time taken for this was noted. The same procedure was repeated for five times for the original fabric, pretreated fabric and enzymatically softened fabric. The mean value was calculated and recorded.

3.11.2. Sinking Test

Sinking test involves a simple test of wettability of fabric and the test was carried out (Jewel, 2005).

The treated fabric was cut into an equal sized squares of 1” x 1” and it was put into the beaker containing 1000ml of water. The stop watch was started when the fabric struck the surface of water and stopped when the last corner sank below the water surface. The time taken for the specimen to sink below the surface is observed (Plate-XI).

3.11.3. Capillary Test

The capillary travel method measures the rapidity of absorption, (Paul, 2005). Five fabrics were cut into sizes of 15cm length and 2.5cm width from the original fabric, pretreated fabric and enzymatically softened fabrics. One end of the sample strip was pasted with a glass rod which was placed on heavy wooden blocks and at the other end, two grams weight was attached to keep the fabric straight. At the weighted end 2 cm of the sample was allowed to immerse in a tray of distilled water. The rise of the water level in the strip was noted by keeping length of the fabric as 5cm constant (Plate-XII). The same procedure was repeated for five samples from the same fabric and the mean value was calculated and the capillary rise of each fabric was recorded carefully.

3.12. Colour Fastness Test

Colour fastness is defined as the resistance of a material to change in any of its color characteristic, to transfer of its colourants of adjacent material or both, as a result of the exposure of the material to any environment that might be encountered during the processing, testing or use of the material (AATCC, 2001) (Well, 2000). Change in colour fastness is assessed with the help of gray scale.

3.12.1. Washing fastness

Evaluation of colour fastness to washing was carried out using ISO II method. A solution containing 5g/L soap solution was used as the washing liquor. The samples were treated for 45 min at 50°c using liquor to material ratio of 50:1 in rota machine. After rinsing and drying, the change in colour of the sample and staining on the undyed samples were evaluated on the respective gray scale rating.

3.12.2. Light fastness

Dyed fabric was tested for colour fastness to light according to ISO 105/B02. The samples of the textile material were exposed to day light under prescribed condition including protection from rain. The fastness was assessed by comparing the change in colour of the specimen with that of the standard patterns. An area of textile product not less than 1cmx6cm should be used so that each exposed portion is not less than 1cmx2cm. The specimen may be a strip of cloth parallel to the machine direction. The specimen and the standard pattern were simultaneously exposed to day light every day from sunrise to sunset. Until the contrast between the posed and the unexposed portions of the specimen or the standard pattern was equal to gray scale.

3.12.3. Rubbing fastness

Determination of colour fastness of textile material of all kinds and their staining on other materials were carried out with crock meter applying 1S:766 method for dry and wet rubbing. The staining of the rubbing fabric was assessed with gray scale. Dyed fabric was wrapped lengthwise on rectangle card board of size 5cmx5cm was fixed to the finger of rubbing device of crockmeter and wrapped test specimen of size 14cmx5cm was fixed at the base of rubbing device (Plate-XIII). The specimen were rubbed to and fro with undyed sample with a downward force straight line along a track of 10cm for 10 minutes. The test samples were graded for the change in colour and staining using gray scale. The test was carried in both dry and wet conditions.

3.13. Statistical Analysis

The result of the tests was analysis statistically by selecting appropriate test. The difference between the samples and within the sample was analyzed ‘F’ test and ‘ANOVA’ and the significance rating were discussed further.

Plate I GSM Cutter

Plate II Electronic Weighing Balance

Plate III Fabric Thickness Tester

Plate IV Fabric Tensile Strength and Elongation Tester

Plate V Pilling Tester

Plate VI Martindale Abrasion Resistance

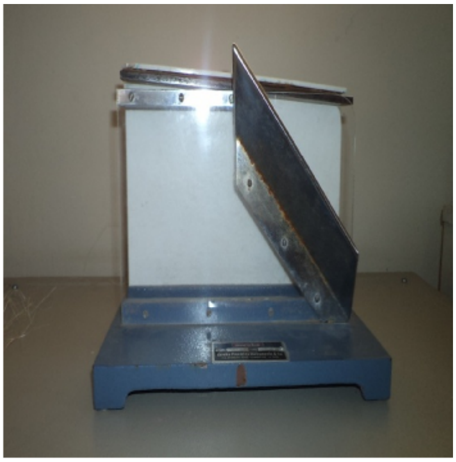

Plate VII Shirley Stiffness Tester

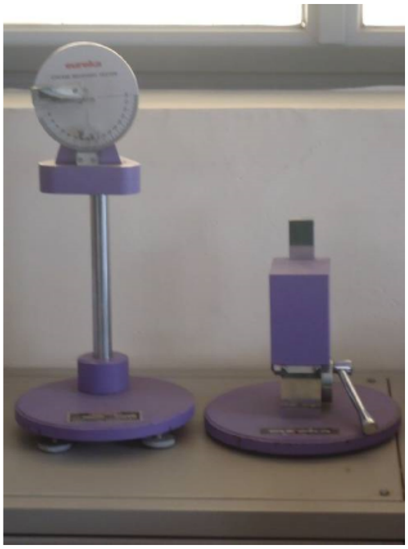

Plate VIII Crease Recovery Tester

Plate IX Drape Meter

Plate X Drop Test

Plate XI Sinking Test

Plate XII Capillary Rise Test

Plate XIII Crockmeter

4. RESULTS AND DISCUSSION

The results of the present study on "**The EFFECT OF ENZYMATIC SOFTENING ON ALOEVERA-COTTON MIXTURE FABRIC"** are discussed under the following headings:

4.1. Optimization of Selected Parameters for Enzymatic Softening

4.1.1. Optimization of Enzyme Concentration

The results of different enzyme concentration on the enzymatically softened Aloevara-Cotton mixture fabric are tabulated in Table-VI and Figure-1.

TABLE – VI

OPTIMIZATION OF ENZYME CONCENTRATION

S.No.	Enzyme concentration (gms)	Weight of the original fabric (gms)	Weight of the enzymatically softened fabric (gms)	Percent weight loss/gain
1.	3	1	0.82	18
2.	4	1	0.77	23
3.	5	1	0.79	21

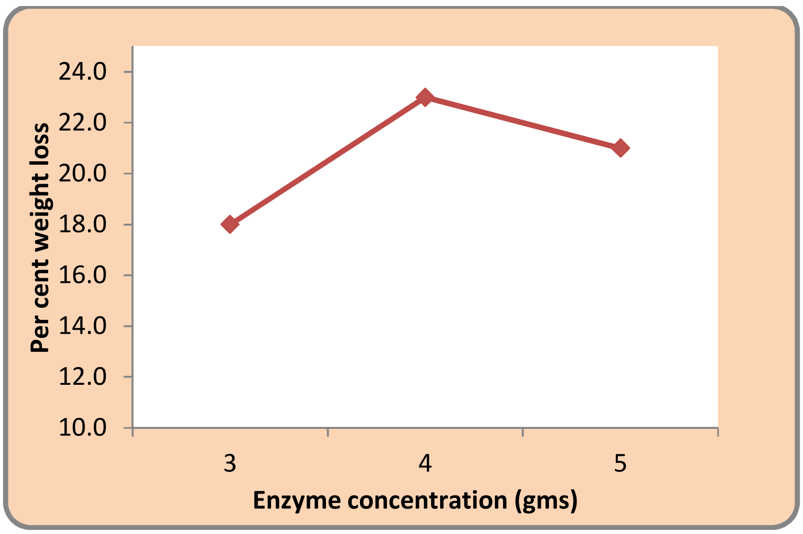

FIGURE – 1

ENZYME CONCENTRATION

From Table VI and Figure 1, it is apparent that as the concentration of cellulase enzyme source increased from 3 to 4 grams, the percent weight loss of aloevera-cotton mixture fabric had also increased from 18 to 23. Twenty one percent weight loss is recorded when 5 grams of enzyme is used. The maximum amount of weight loss is observed when 4 grams of cellulase enzyme is used. Optimum concentration was determined based on the texture of the fabric. Therefore the standard weight of the source was taken as 4 grams.

4.1.2. Optimization of Incubation Time

The effect of different incubation time on enzymatic softening of Aloevera-Cotton mixture fabric using Cellulase enzyme was determined and presented in the Table-VII and Figure-2.

TABLE – VII

OPTIMIZATION OF INCUBATION TIME

S.No.	Incubation time (mins)	Weight of the original fabric (gms)	Weight of the enzymatically softened fabric (gms)	Percent weight loss/gain
1.	20	1	0.80	20
2.	25	1	0.75	25
3.	30	1	0.77	23

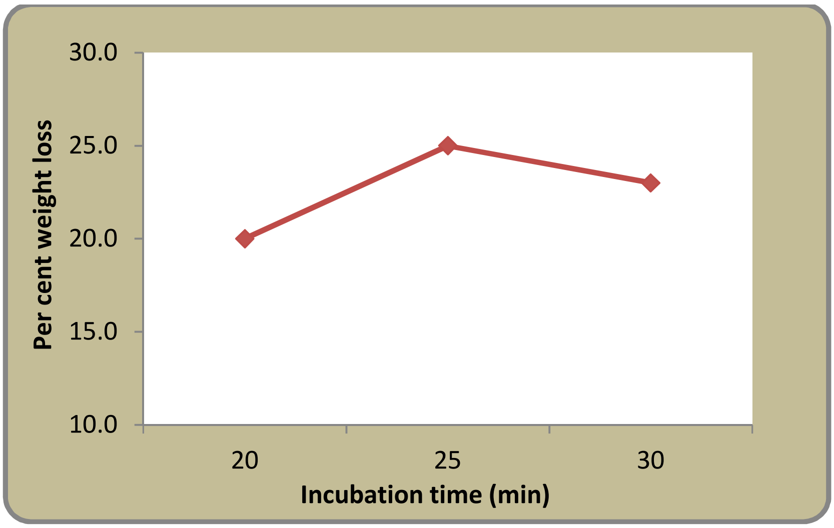

FIGURE - 2

INCUBATION TIME

From Table VII and Figure 2, it is obvious that weight loss increased in incubation period when the time is increased from 20 to 25 minutes. 23 percent weight loss is noted when kept in 30 minutes of incubation time. Based on the texture/feel of the fabric, 25 minutes of incubation time is opted for the study.

4.1.3. Optimization of Temperature

The effect of different temperature in enzymatic softening efficiency was determined and the values are tabulated in Table-VIII and Figure-3.

TABLE - VIII

OPTIMIZATION OF TEMPERATURE

S.No.	Temparature (°C)	Weight of the original fabric (gms)	Weight of the enzymatically softened fabric (gms)	Percent weight loss/gain
1.	35	1	0.79	21
2.	40	1	0.74	26
3.	45	1	0.72	28

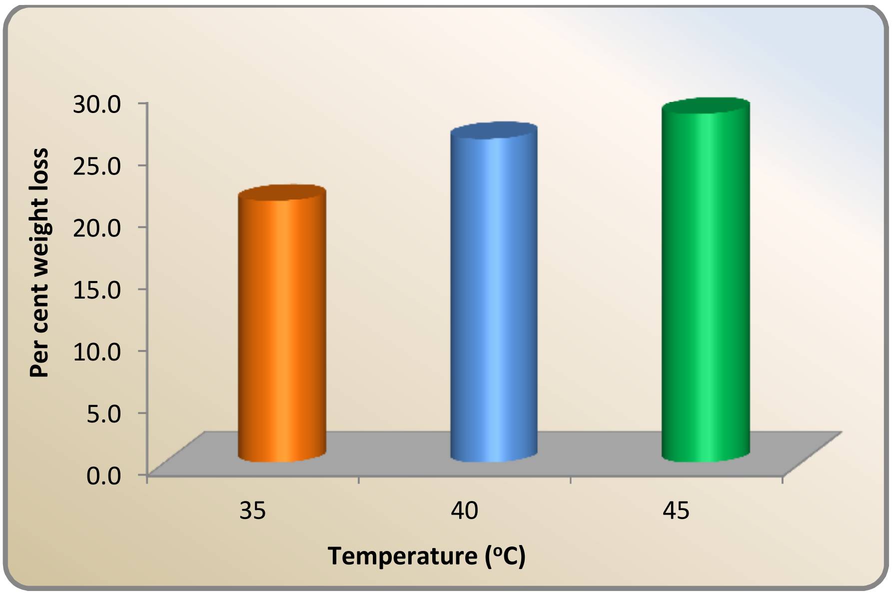

FIGURE-3

EFFECT OF TEMPERATURE

From Table VIII and Figure 3, it is clear that maximum weight loss (28 percent) was observed at 45°C. Below 45°C,there was a decrease in weight loss. However considering the texture/feel of the fabric 45°C was taken as the optimum temperature.

4.1.4. Optimization of pH

The result of pH in enzymatic softening efficiency was determined and the values are tabulated in Table-IX and Figure-4.

TABLE - IX

OPTIMIZATION OF pH

S.No.	pH	Weight of the original fabric (gms)	Weight of the enzymatically softened fabric (gms)	Percent weight loss/gain
1.	5	1	0.78	22
2.	6	1	0.71	29
3.	7	1	0.72	28

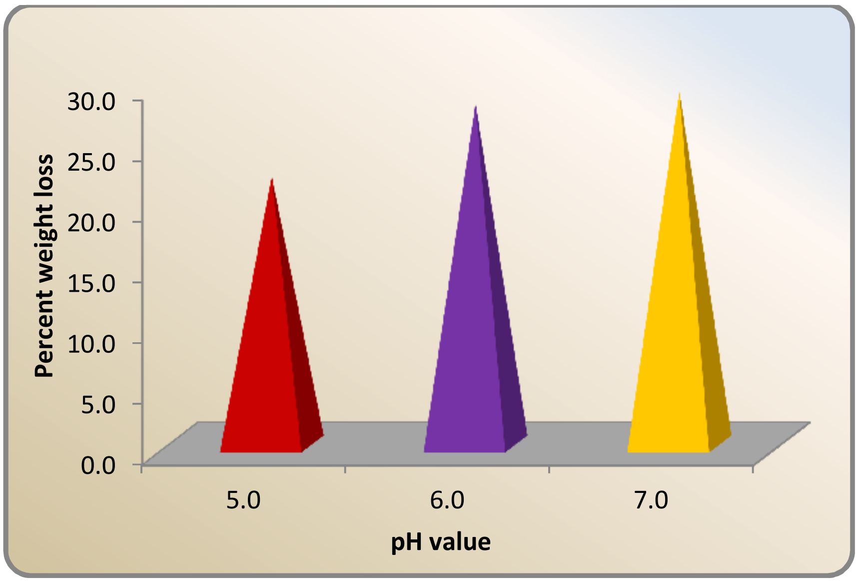

FIGURE – 4

OPTIMIZATION OF pH

From Table IX and Figure 4, it is clear that enzyme activity on softening was good at pH 7 and the percent weight loss was recorded as 28. Though enzymatic softening of sample show better efficiency at an optimum pH of 6 and 7, pH 7 was taken as standard for this study.

4.2. Evaluation of Enzymatically Softened Fabric

4.2.1. Subjective Evaluation- Visual Evaluation

The subjective evaluation of Aloevera-Cotton mixture fabric was done through visual inspection and the findings are given in the Table X.

TABLE – X

SUBJECTIVE EVALUATION OF ORIGINAL AND TREATED FABRICS

Samples	General appearance			Texture			Luster		
	Excellent	Good	Fair	Coarse	Rough	Smooth	High	Medium	Low
OF	-	25	25	-	50	-	-	10	40
PF	5	25	20	20	20	10	-	40	10
EsF	30	20	-	5	5	40	35	15	-
EsdF	35	15	-	5	-	45	40	10	-

From the Table X, it is concluded that 0F was rated to be both good and fair by 25 judges. The samples PF was rated to be good by 25 judges. EsdF and EsF were rated to be smooth textured as expressed by 45 and 40 judges. While looking for luster, the sample EsdF and EsF rated to be highly lustrous by 40 and 35 judges. Hence it could be concluded that Aloevera-Cotton mixture fabric using cellulase enzymes was good in general appearance, luster and texture.

4.2.2. Objective Evaluation

4.2.2.1. Physical Property Test

Fabric Weight

The weight of the original and treated fabric samples are analysed and the values were depicted in the Table-XI and Figure-5.

TABLE – XI

FABRIC WEIGHT

S.No.	Sample	Mean fabric weight (gms)	Loss/Gain over original	Percent Loss/Gain
1.	OF	0.77	-	-
2.	PF	0.78	0.01	1.29
3.	EsF	0.81	0.04	5.19
4.	EsdF	0.83	0.06	7.79
		‘F’ value		**17.64****

** Significant at one percent level.

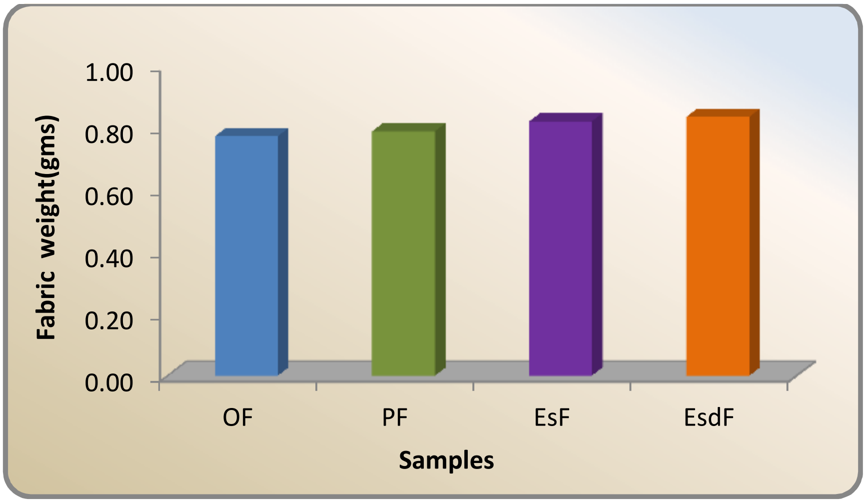

FIGURE – 5

FABRIC WEIGHT

From the Table XI and Figure 5,it is evident that the weight of the fabric had increased in all the treated fabric samples. Among the samples, the enzymatically softened and dyed fabrics (EsdF) recorded 7.79 percent more weight than the original fabric.

Statistical analysis for the data relating to fabric weight reveals that there was one percent significant difference between original and treated samples with ‘F’ value of 17.64.

Fabric Thickness

The fabric thickness of original and treated fabric was analysed and the mean values were shown in Table-XII and Figure-6.

TABLE – XII

FABRIC THICKNESS

S.No.	Sample	Mean fabric thickness (mm)	Loss/Gain over original	Percent Loss/Gain
1.	OF	0.34	-	-
2.	PF	0.35	0.01	2.94
3.	EsF	0.32	-0.02	5.88
4.	EsdF	0.32	-0.02	5.88
'F' value				**1.14NS**

NS-Not significant.

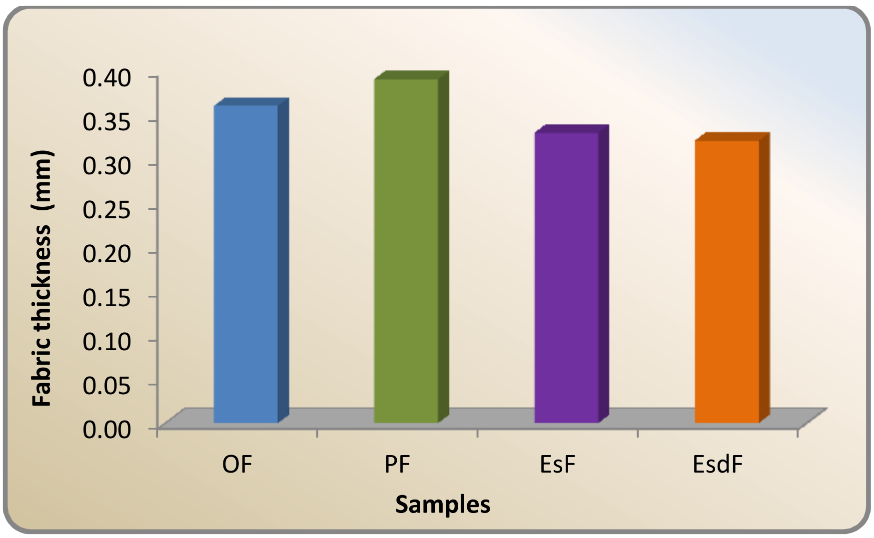

FIGURE-6

FABRIC THICKNESS

From the Table XII and Figure 6, it is obvious that the thickness of the treated fabrics increased when compared to original. Thickness was maximum in both EsF and EsdF samples of 5.88 percent and minimum as 2.94 in pretreated fabric (PF).

Statistical analysis of data pertaining to fabric thickness proves that there was a no significant difference between the processes such as original and treated fabrics as the calculated 'F' value is 1.14.

4.2.2.2. Mechanical Property Test

Tensile Strength (warp)

Tensile strength in warp direction for both original and treated fabrics were determined and the results are depicted in Table-XIII and Figure-7.

TABLE – XIII

FABRIC STRENGTH (WARP)

S.No.	Sample	Mean fabric strength (lbs)	Loss/Gain over original	Percent Loss/Gain
1.	OF	21.4	-	-
2.	PF	20.4	-1	4.67
3.	EsF	16.4	-5	23.36
4.	EsdF	21.2	-0.2	0.93
		'F' value		**11.40****

** Significant at one percent level.

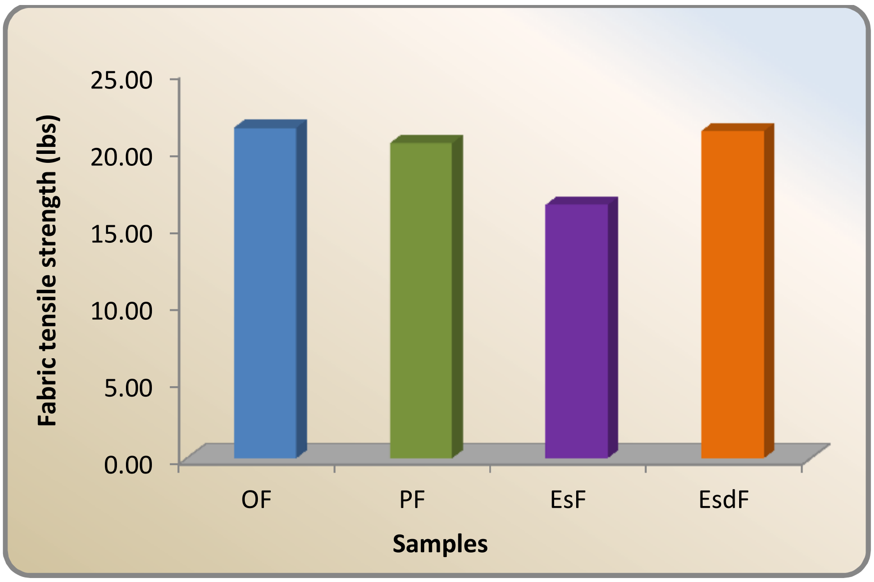

FIGURE – 7

FABRIC STRENGTH – WARP

Table XIII and Figure 7, show that there is a decrease in strength when treated with commercial enzymes. Among the samples, the strength was decrease in enzymatically softened dyed fabrics recorded 23.36 percent strength than the original fabric.

Statistical analysis of data pertaining to fabric strength (warp) proves that there was a significant difference at one percent level with F value of 11.40 between the processes such as original and treated fabrics.

Tensile Strength (weft)

The mean fabric strength in the weft direction is compared with original and treated fabrics and the results and values are presented in Table-XIV and Figure-8.

TABLE – XIV

FABRIC STRENGTH (WEFT)

S.No.	Sample	Mean fabric strength (lbs)	Loss/Gain over original	Percent Loss/Gain
1.	OF	22.8	-	-
2.	PF	18	-4.8	21.05
3.	EsF	19.6	-3.2	14.03
4.	EsdF	20.4	-2.4	10.52
		'F' value		**9.09****

** Significant at one percent level.

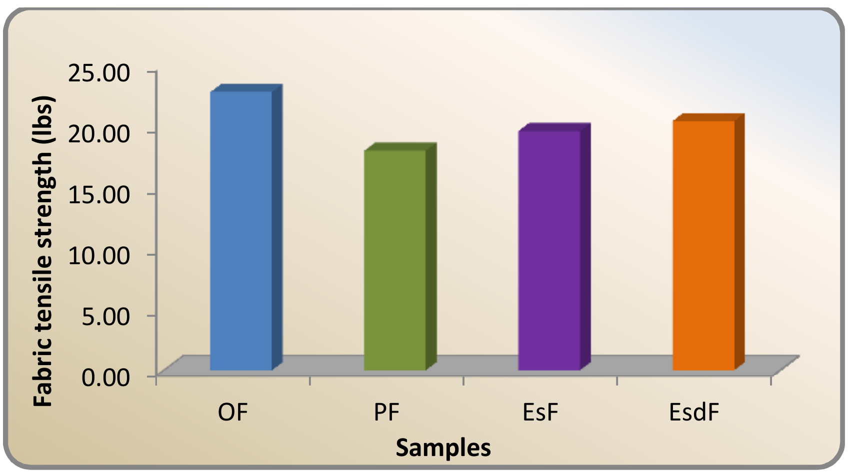

FIGURE – 8

FABRIC STRENGTH – WEFT

From the above Table XIV and Figure 8, it is evident that there is a decrease in strength when compared to original sample. Whereas strength was decreased in sample PF 21.05 percent.

Statistical analysis of data also proves that there was a significant difference at one percent level between the processes such as original and treated fabrics with ‘F’ value of 9.09.

Fabric Elongation (warp)

The mean difference between the original and treated fabrics were analysed and the results are shown in the Table-XV and Figure-9.

TABLE – XV

FABRIC ELONGATION (WARP)

S.No.	Sample	Mean fabric elongation (cm)	Loss/Gain over original	Percent Loss/Gain
1.	OF	1.98	-	-
2.	PF	3.06	1.08	54.54
3.	EsF	2.54	0.56	28.28
4.	EsdF	2.72	0.74	37.37
		‘F’ value		**47.96****

** Significant at one percent level.

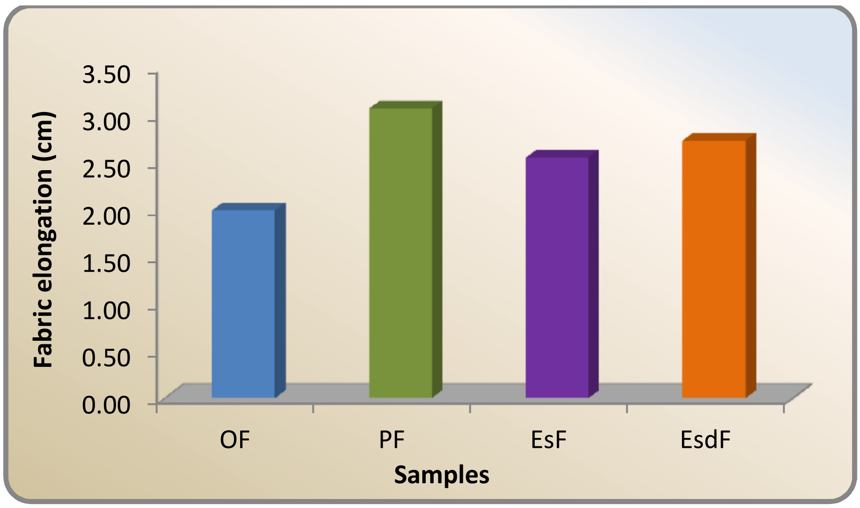

FIGURE – 9

FABRIC ELONGATION – WARP

From the Table XV and Figure 9, it is clear that the fabric elongation is higher than the original fabric. Percent gain over original for PF and EsdF is 54.54 percent and 37.37 percent respectively. However the weight loss of EsF is only 28.28 percent.

Statistical analysis of data also proves that there was a significant difference at one percent level between the processes such as original and treated fabrics with ‘F’ value of 47.96.

Fabric Elongation (weft)

The mean difference between the original and treated fabrics were analyzed and the results are shown in the Table-XVI and Figure-10.

TABLE-XVI

FABRIC ELONGATION (Weft)

S.No.	Sample	Mean fabric elongation (cm)	Loss/Gain over original	Percent Loss/Gain
1.	OF	1.72	-	-
2.	PF	2.82	1.1	63.95
3.	EsF	2.18	0.46	26.74
4.	EsdF	2.48	0.76	44.18
		‘F’ value		**75.12****

** Significant at one percent level.

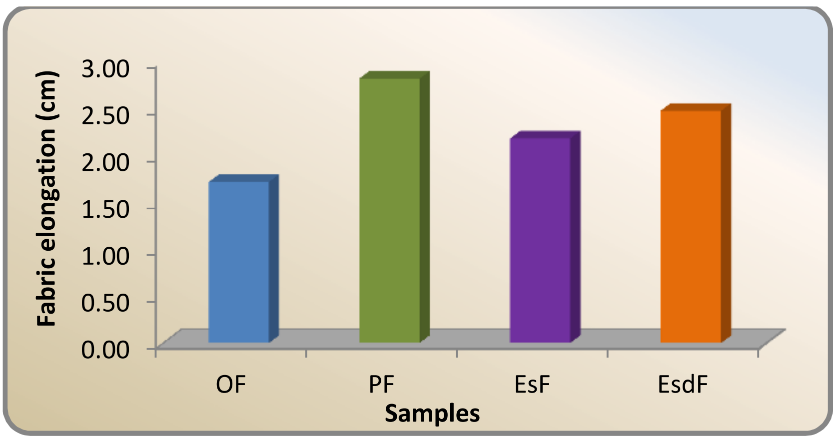

FIGURE – 10

FABRIC ELONGATION – WEFT

From the Table XVI and Figure 10, it is obvious that there is a difference in fabric elongation which has been increased when comparison is made between the original and treated fabrics. Elongation along weft direction of PF is recorded to be 63.95 percent. Enzymatically softened Aloevera-Cotton mixture fabric (EsF) exhibited 26.74 percent increase higher than the original and 44.18 percent of more elongation is noticed in sample EsdF when compared with OF.

Statistical and analysis of data pertaining to fabric elongation (weft) reveal that there was a significant difference at one percent level between the processes such as original and treated fabrics with 'F' value of 75.12.

Fabric Pilling

TABLE-XVII

FABRIC PILLING

S.No	Sample	Rating
1.	OF	4
2.	PF	4
3.	EsF	5
4.	EsdF	4

4- Slight pilling 5- No pilling

A slight pilling was observed in samples OF, PF and EsdF, whereas pilling is not observed in EsF. Hence it could be concluded that the cellulase enzyme followed by dyeing resisted pilling to a great extent.

Fabric Abrasion Resistance

Fabric abrasion resistance of the original and treated fabrics were compared and analysis of variance are shown in Table-XVIII and Figure-11.

TABLE – XVIII

FABRIC ABRASION RESISTANCE

S.No.	Sample	Mean fabric resistance (gms)	Loss/Gain over original	Percent Loss/Gain
1.	OF	0.22	-	-
2.	PF	0.19	-0.03	13.6
3.	EsF	0.16	-0.06	27.27
4.	EsdF	0.14	-0.08	36.36
'F' value				**32.39****

** Significant at one percent level.

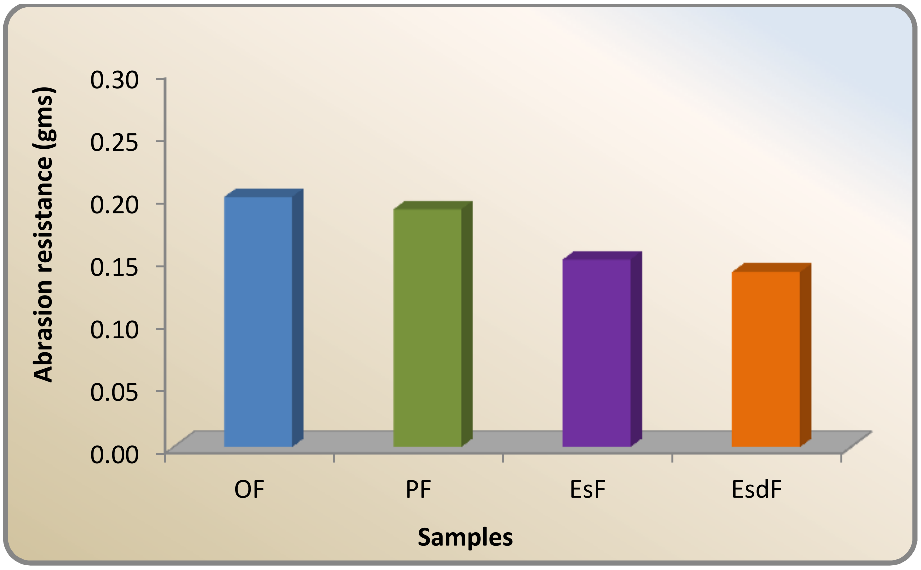

FIGURE – 11

FABRIC ABRASION RESISTANCE

From the Table XVIII and Figure 11, it is understood that the sample EsdF has shown a decreased abrasion resistance by 36.36 percent. The abrasion resistance of the fabric EsF is 27.27 percent followed by PF (13.6 percent) when compared to the original fabric.

Statistical analysis of data pertaining to fabric abrasion resistance proves that there was a significant difference at one percent level between the processes such as original and treated fabrics with 'F' value of 32.39.

4.2.2.3. Comfort Property Test

Fabric Stiffness

Fabric stiffness of the original and treated fabrics were compared and analysis of variance in warp and weft directions are given in Table-XIX, XX and Figure-12, 13.

TABLE – XIX

FABRIC STIFFNESS (WARP)

S.No.	Sample	Mean fabric stiffness (cm)	Loss/Gain over original	Percent Loss/Gain
1.	OF	3.06	-	-
2.	PF	2.18	-0.88	28.75
3.	EsF	2.66	-0.4	13.07
4.	EsdF	2.76	-0.3	9.80
'F' value				**43.74****

** Significant at one percent level.

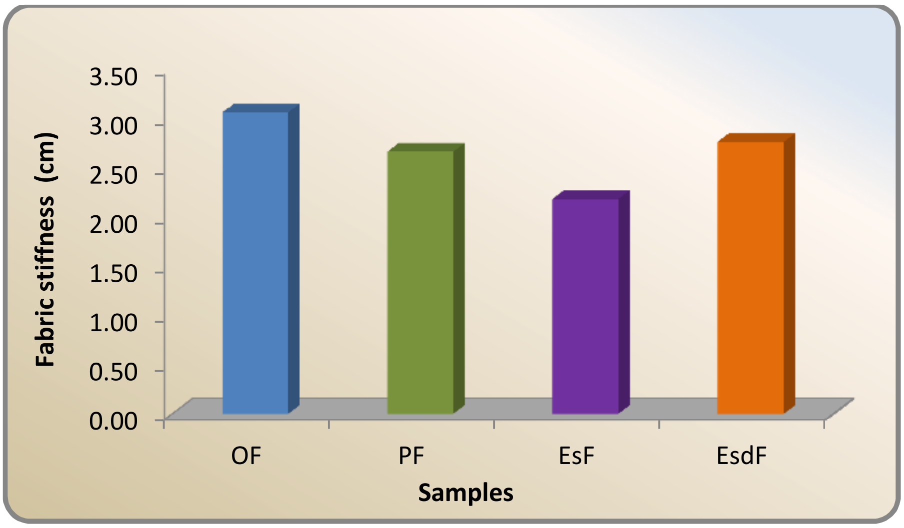

FIGURE – 12

FABRIC STIFFNESS – WARP

From Table XIX and Figure 12, it is evident that the fabric stiffness in warp direction of the treated fabric was decreased when compared with the original fabrics. The minimum stiffness reduction is noticed in EsdF as the recorded percent loss is 9.80 percent. Stiffness of EsF is decreased by 13.07 percent. The maximum stiffness reduction is seen in PF (28.75 percent).

Statistical analysis of data also proves that there was a significant difference at one percent level between the processes such as original and treated fabrics with 'F' value of 43.74.

TABLE-XX

FABRIC STIFFNESS (WEFT)

S.No.	Sample	Mean fabric stiffness (cm)	Loss/Gain over original	Percent Loss/Gain
1.	OF	2.84	-	-
2.	PF	2.34	-0.5	17.60
3.	EsF	1.78	-1.06	37.32
4.	EsdF	2.52	-0.32	11.26
'F' value				**75.12****

** Significant at one percent level.

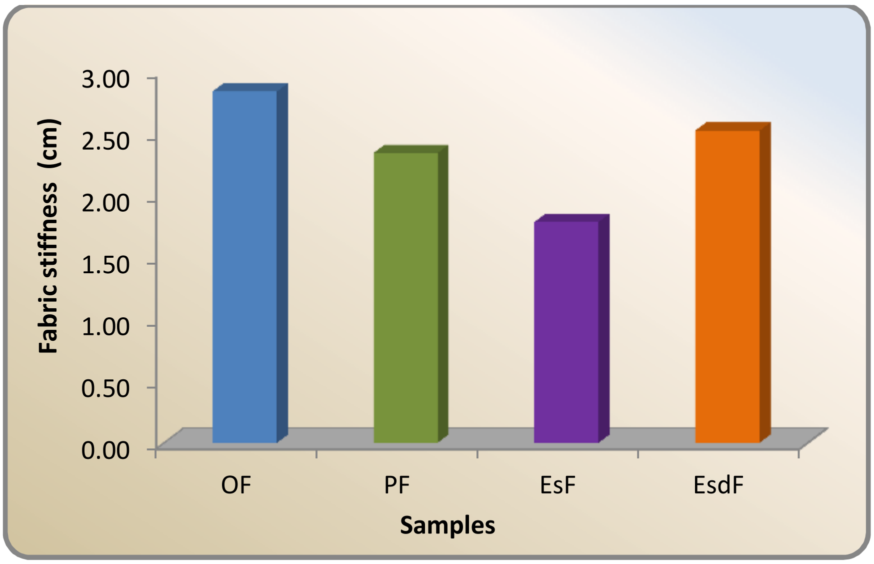

FIGURE – 13

FABRIC STIFFNESS – WEFT

From Table XX and Figure 13,it is evident that the stiffness of all the samples decreased after treatments along weft direction. After treatment, a maximum reduction is seen in EsF (37.32 percent) followed by the sample PF (17.60 percent). Hence it could be concluded that EsF had better flexibility along weft direction. Minimum fabric stiffness reduction is seen in the sample EsdF (11.26 percent).

Statistical analysis of data pertaining to fabric stiffness (weft) also proves that there was a significant difference at one percent level between the processes such as original and treated fabrics with 'F' value of 75.12.

Fabric Crease Recovery

Fabric crease recovery of the original and treated fabrics were compared and analysis of variance in warp and weft directions are given in Table-XXI, XXII and Figure-14, 15.

TABLE – XXI

FABRIC CREASE RECOVERY (WARP)

S.No.	Sample	Mean crease recovery (degrees)	Loss/Gain over original	Percent Loss/Gain
1.	OF	104.78	-	-
2.	PF	100.7	-4.08	3.89
3.	EsF	99.28	-5.5	5.24
4.	EsDF	97.2	-7.58	7.23
'F' value				**0.99 NS**

NS-Not significant.

From Table XXI and Figure 14, it is evident that the crease recovery angle is reduced in case of treated fabric and dyed fabric than the original fabric. The percent crease recovery angle in PF is 3.89 percent. In EsF and EsdF, the crease recovery angle is noted to be 5.24 and 7.23 percent respectively. Hence it could be concluded that enzymatic softened dyed fabric had lesser crease recovery along warp direction than the original.

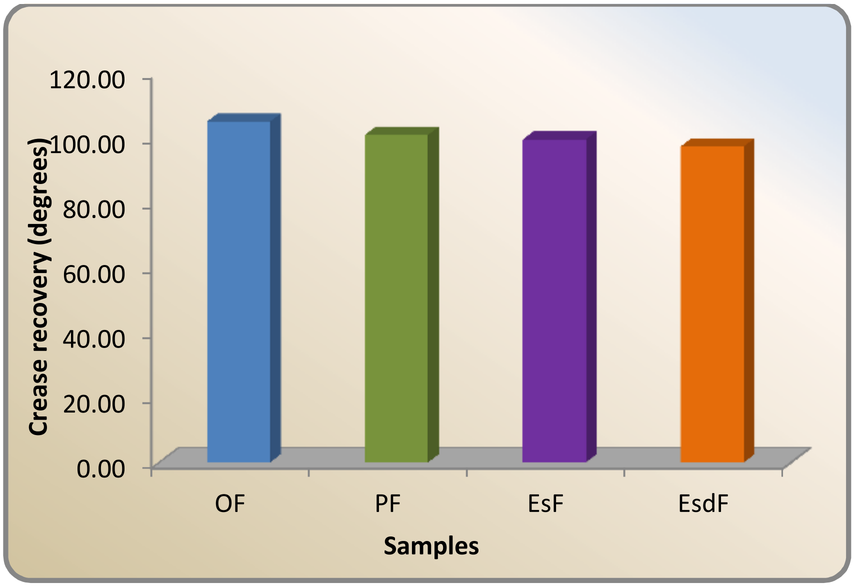

FIGURE – 14

FABRIC CREASE RECOVERY – WARP

However the statistical analysis of data pertaining to crease recovery (warp) proves that there was a no significant difference between the processes such as original and treated fabrics with 'F' value of 0.99.

TABLE – XXII

CREASE RECOVERY (WEFT)

S.No.	Sample	Mean crease recovery (degrees)	Loss/Gain over original	Percent Loss/Gain
1.	OF	101.26	-	-
2.	PF	98.1	-3.16	3.12
3.	EsF	95.12	-6.14	6.06
4.	EsdF	91.6	-9.66	9.53
		'F' value		**0.98 NS**

NS-Not significant.

From Table XXII and Figure 15, it is evident that the crease recovery angle is reduced in case of treated fabric and dyed fabric. The percent crease recovery angle in EsdF is 9.53 percent and in EsF,it is 6.06 percent. Hence it could be concluded that EsF and EsdF had better crease recovery along weft direction than the pretreated fabric.

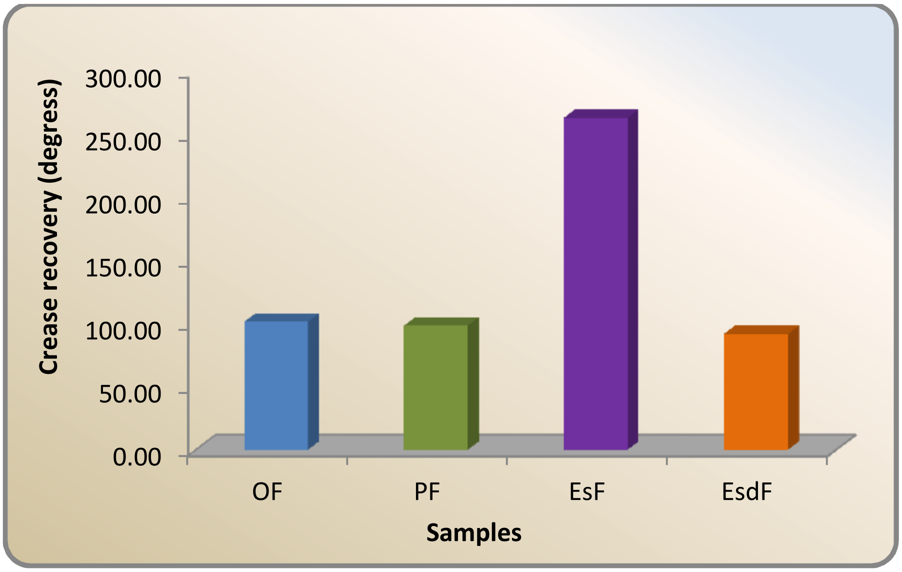

FIGURE – 15

FABRIC CREASE RECOVERY – WEFT

Statistical analysis of data pertaining to crease recovery (weft) also proves that there was a no significant difference between the processes such as original and treated fabrics with 'F' value of 0.98.

Fabric Drape

The fabric drapability of the original and treated fabrics were compared and analysis of variance are shown in Table-XXIII and Figure-16.

TABLE – XXIII

FABRIC DRAPE

S.No.	Sample	Mean drape co-efficient (%)	Loss/Gain Value	Loss/Gain percentage
1.	OF	0.69	-	-
2.	PF	0.71	0.02	2.89
3.	Es	0.59	-0.1	14.49
4.	EsdF	0.58	-0.11	15.94
		'F' value		**363.45****

** Significant at one percent level.

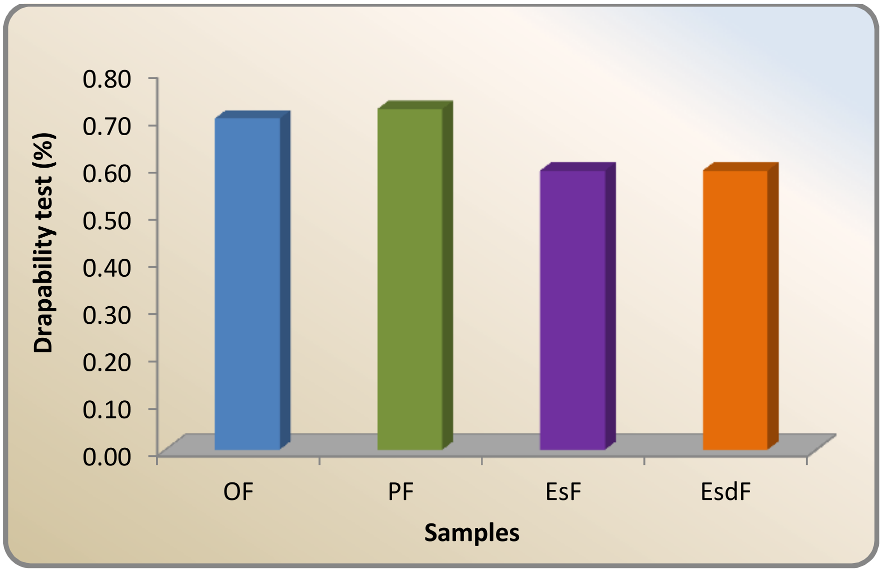

FIGURE – 16

FABRIC DRAPE

From Table XXIII and Figure 16, it is evident that the drapability of the samples increased after treatments. After treatment, the samples EsdF and EsF shown a better drape by 15.94 and 14.49 percent. As far as the sample PF is concerned drape co-efficient is decreased by 2.89 percent. Hence it could be concluded that that EsdF and EsF had better drapability.

Statistical analysis of data pertaining to drapability of fabric proves that there was a significant difference at one percent level between the processes such as original and treated fabrics with ‘F’ value of 363.45.

4.2.2.4. Absorbency Test

Drop Test

The results of drop test and analysis of variance of original and treated fabrics are shown in Table-XXIV and Figure-17.

TABLE-XXIV

DROP TEST

S.No.	Sample	Mean absorbency (seconds)	Loss/Gain over original	Percent Loss/Gain
1.	OF	41	-	-
2.	PF	2.26	-38.74	94.48
3.	EsF	1.88	-39.12	95.41
4.	EsdF	1.64	-39.36	96
'F' value				**1502.05****

** Significant at one percent level.

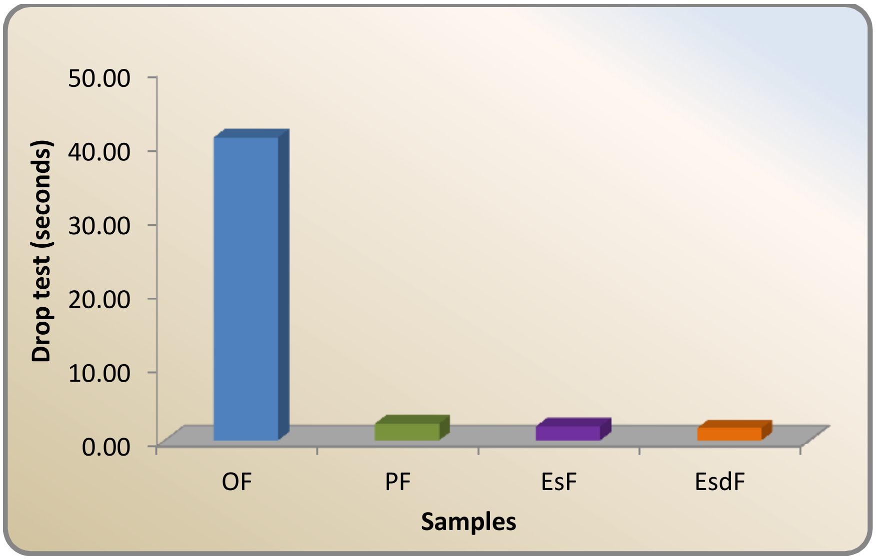

FIGURE – 17

DROP TEST

From the Table XXIV and Figure 17, it is clear that the time taken for the drop to penetrate into the sample OF was 41 seconds. This is reduced drastically in the sample PF which has taken only 2.26 seconds. The samples showed a reduction in time thereby expressing the increase in absorbency of the fabric. Among all the samples, the absorbency was the highest with least time consumption of 1.64 seconds in sample EsdF followed by the samples EsF (1.88 seconds) and PF (2.26 seconds).

Statistical analysis of data pertaining to drop test proves that there was a significant difference at one percent level between the processes such as original and treated fabrics with 'F' value of 1502.05.

Sinking test

The fabric sinking test and analysis of variance of original and treated fabrics are shown in Table-XXV and Figure-18.

TABLE – XXV

SINKING TEST

S.No.	Sample	Mean sinking time (seconds)	Loss/Gain over original	Percent Loss/Gain
1.	OF	46.2	-	-
2.	PF	2.86	-43.34	93.80
3.	EsF	2.24	-43.96	95.15
4.	EsdF	1.56	-44.64	96.62
		'F' value		**65.14****

** Significant at one percent level.

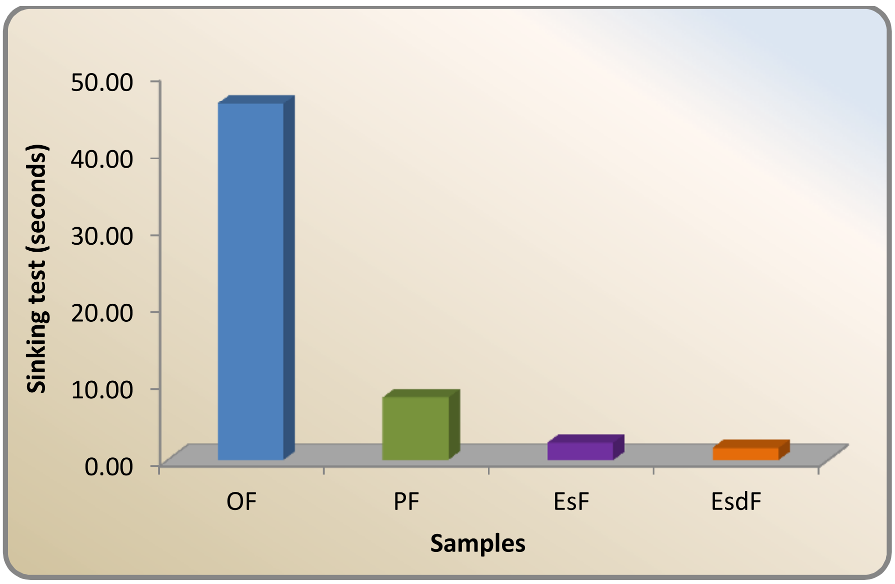

FIGURE – 18

SINKING TEST

The time taken for sinking was 46.2 seconds in sample OF which is reduced drastically in the sample PF (2.86 seconds). Further reduction in the time for sinking is noticed in the sample EsF (2.24 seconds) followed by the samples EsdF (1.56 seconds). Reduction in time for sinking among the treated sample prove that the samples are more absorbent due to softening with enzyme.

Statistical analysis of data pertaining to sinking test proves that there was a significant difference at one percent level between the processes such as original and treated fabrics with ‘F’ value of 65.14.

Capillary Rise Test

The fabric capillary rise test and analysis of variance of original and treated fabrics are presented in Table-XXVI and Figure-19.

TABLE – XXVI

CAPILLARY RISE TEST

S.No.	Sample	Mean capillary rise (cm)	Loss/Gain over original	Percent Loss/Gain
1.	OF	0.98	-	-
2.	PF	1.97	0.99	101.02
3.	EsF	2.4	1.42	144.89
4.	EsdF	2.9	1.92	195.91
‘F’ value				**356.28****

** Significant at one percent level

. The capillary rise in the original sample is 0.98 cm, whereas the increase in the sample PF is noted to be 1.97 cm. Among the treated samples, the time taken for increase in the capillary rise in the sample EsdF is 2.9 cm followed by the samples EsF 2.4 cm respectively. The capillary Rise is seemed to be lower among the treated samples when compared with original.

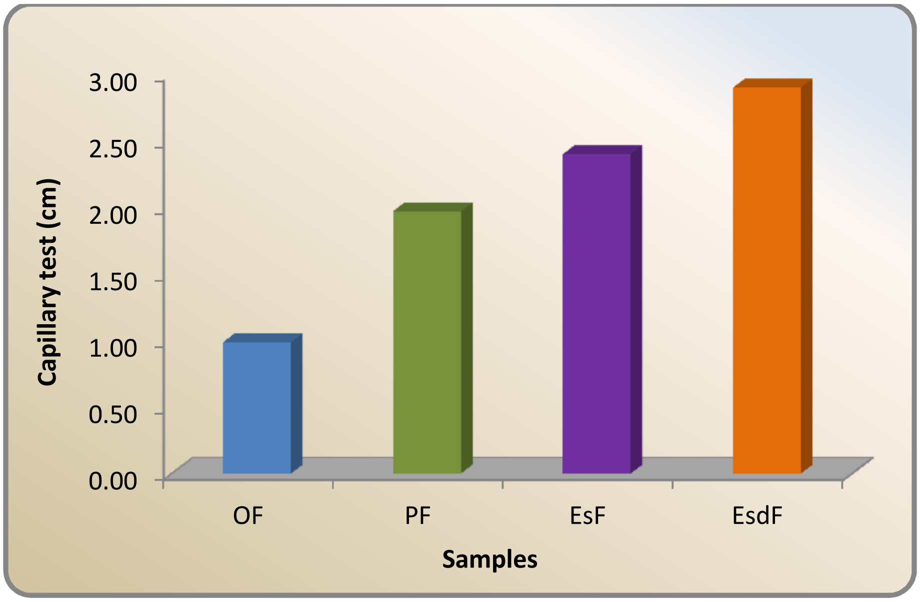

FIGURE – 19

CAPILLARY RISE TEST

Statistical analysis of data pertaining to capillary rise test proves that there was a significant difference at one percent level between the processes such as original and treated fabrics with ‘F’ value of 356.28.

4.2.2.5. Colour Fastness Test

The result of colour fastness tests are presented in Table XXVII.

TABLE-XXVII

COLOUR FASTNESS TEST

S.No.	Sample	Colour fastness to crocking		Colour fastness to pressing		Colour fastness to washing	Colour fastness to sunlight
		Dry	Wet	Dry	Wet		
1.	OF	4	4	4	4	4	4/5
2.	PF	4/5	4	4/5	4	4/5	4
3.	EsF	4/5	4/5	4/5	4	4/5	4/5
4.	EsdF	4/5	4/5	4/5	4/5	4	4/5

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

Crocking: All the dyed samples expressed good colour fastness to crocking with ratings of 4 in dry and wet condition.

Pressing: In both dry and wet conditions, the colour fastness was observed to be 4/5 and 4 (Very good) and (good) in all the dyed samples.

Washing: Colour fastness to washing was noted to be very good in the dyed samples.

Sunlight: Colour fastness to sunlight was 4/5 in the dyed samples.

Hence it could be concluded that the colour fastness was very good in the treated samples.

5. SUMMARY AND CONCLUSION

Textiles have played a very crucial role in the evolution of human culture by being at the front of both artistic and technological developments. Textile industries are facing a challenging condition due to the globalization of the world market. For many decades textile and clothing technology has centered on the comfort, primarily for economical and protection of human body but a greater concern is now emerging that of the survival of the environment itself. The textile industry, also focusing upon usage of eco-friendly products such as Natural fibres, Natural dyes and the most important Eco-friendly material like enzymes. Cotton fibre is a cellulosic fibre having properties like absorbency, high strength, non toxic, non allergic, softness, cool and so on, researchers are concentrating on some of the unconventional cellulosic fibres such as Aloevera fibres. Some of the demerits of Aloevera fibre such as poor weaveability, it is blended with cotton to improve the quality of the fabric and to improve the production process.

In recent years, Aloevera-Cotton mixture fabrics are in the growth of stage between the people for garments, upholstery etc. As both Aloevera and Cotton fibres has more natural impurities and the fabric having a rough surface So, it must undergo Desizing, Scouring and Bleaching and Softening.

Now-a-days, our lives are increasingly changed by the wide application of new technologies. Enzymatic processes have been increasingly incorporated in textiles over the last years. Focusing up this concept the present investigation is framed to softening by using selected Cellulase enzyme. This enzymatic process has been chosen mainly due to the enzymatic qualities such as eco-friendly, non-toxic, biodegradable and can be reused etc.

Hence the present study on **"The Effect of Enzymatic Softening on Aloe vera- Cotton Mixture Fabric"** has been presented with the following objectives to:

- study the effect of Enzymatic Softening on Aloevera-Cotton mixture fabric.
- optimize the parameters for enzymatic softening.
- evaluate the comfort properties of Aloevera-Cotton mixture fabric.

Experimental Procedure

The experimental procedure adopted for the present study includes,

Selection of Source

Cellulase enzymes are used for the present study. It is used for the softening of Aloevera-Cotton mixture fabric.

Optimization for Enzymatic Softening

- Optimization of different parameters is needed to improve the enzymatic softening process. Inorder to acquire the best results for the Aloevera-Cotton mixture fabric softening, various physical parameters like source concentration, incubation time, temperature were optimized. The optimized parameters are given as follows.

- Different concentration of the source like 3, 4, 5 grams were taken and the activity was analysed of source for enzyme concentration and among the various concentrations 4 grams yielded the best result and thus chosen as the optimum concentration.

- Enzymatic softening was carried at different incubation time such as 20, 25 and 30 minutes were selected. Based on the results the optimum incubation time for enzymatic softening of Aloevera-Cotton mixture fabric was chosen as 25 minutes.

- The temperature was varied as 35, 40 and 45°C for enzymatic softening and feel of the fabric under these temperatures were calculated.

- The optimum pH for enzymatic softening was found by calculating the weight loss of the Aloevera-Cotton mixture fabric at different pH such as 5, 6, 7. The optimum pH was found to be 7.

Findings of the study

- The evaluation of enzymatically softened fabric were evaluated to determine the softening effect on the properties.

- The visual evaluation proved that the softened fabric using enzymatic were rated as good in general appearance, luster and texture.
- As far as weight of the fabric is concerned, all the samples showed increased in weight. The sample EsdF showed more weight as 7.79 percent.
- Fabric thickness was found to be maximum in EsF and EsdF samples of 5.88 percent.
- Fabric tensile strength in warp was found to be decrease in EsdF when compared with original sample.
- Fabric tensile strength in weft was found to be decrease in PF as 21.05 percent.
- Fabric elongation in warp was found to be higher in PF.
- Fabric elongation in weft was found to be higherin EsdF when compared with original fabric.
- Fabric pilling was found to be minimum in all samples.
- Fabric abrasion resistance was found to be decrease in the sample EsdF by 36.36 percent.
- Fabric stiffness in warp and weft direction was found to be minimum reduction in the sample EsdF.
- The reduction in crease recovery in both warp and weft direction of EsdF was reduced by 7.23 and 9.53 percent.
- Fabric drape was found to be better in EsF and EsdF by 14.49 and 15.94 percent.
- The absorbency tests proved that all the EsdF samples were rated to be good when compared to EsF, PF and OF.
- The colour fastness test proved that all the treated samples was very good than the original fabric.

Conclusion

The results of this study have thrown light on the utilization of cellulose enzyme for softening of Aloevera-Cotton mixture fabrics. Since the aloevera has medicinal properties, it could be made as a mixture fabric with other natural fibers.

Enzymatically treated Aloe vera – cotton mixture fabric can be utilized for medical textiles.

Recommendations

- Enzymatic softening process can be used for other natural fibers.
- Aloe vera fiber utilization for apparels is worth attempting..

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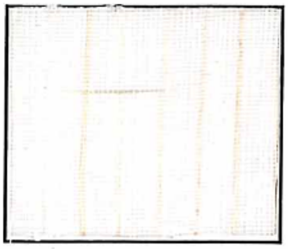
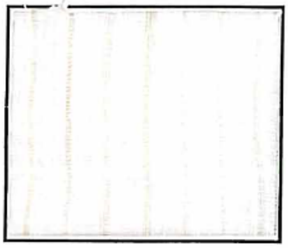
APPENDIX – i

Details of Selected Material

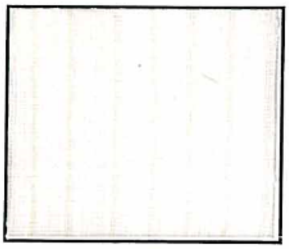
Original Fabric



PF



EsF



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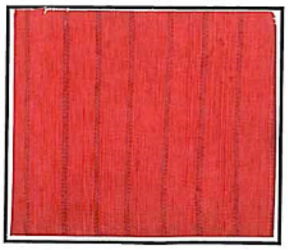

APPENDIX – ii

Performa for Visual Evaluation

Samples	General appearance			Texture			Luster		
	Excellent	Good	Fair	Coarse	Rough	Smooth	High	Medium	Low
OF									
PF									
EsF									
EsdF									