DESIGNING TEXTILE MADE-UPS FROM AHIMSA SILK

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By

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CERTIFICATE

This is to certify that the thesis entitled **"DESIGNING TEXTILE MADE-UPS FROM AHIMSA SILK"** *submitted by* **Ms. SANAPAPAMMA K.J.** *for the degree of* **DOCTOR OF PHILOSOPHY** *in* **TEXTILES AND CLOTHING** *to the University of Agricultural Sciences, Dharwad, is a record of research work carried out by her during the period of her study in this university, under my guidance and supervision and the thesis has not previously formed the basis of any award of any degree, diploma, associateship, fellowship or other similar titles.*

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April, 2004

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INTRODUCTION

I. INTRODUCTION

Silk is the most handsome of all textile fibres with a unique property of fineness, strength, sheen, hand and feel with great affinity for dyeing. No other textile fibres possess such a fine natural luster, softness and comfort wear properties. Silk all over the world is considered as anti-allergic eco-friendly fibre, the "queen" of textiles.

Historical evidences revealed that Korea was the country after China to learn the secret of sericulture. It is further learnt that, silk was discovered around 2640 BC, when a Chinese queen "Tsi-Ling-Chi", become intrigued by silk worms. She carefully observed the cocoons and then learned how to unwind the silk from the cocoon and make fabric from it. This industry later spread to Japan, India and Persia (Rao, 1990). Sericulture is deep rooted in the culture and tradition of Indian Society and is known for its excellence with its agriculture base, industrial super structure and labour intensive nature. It is remarkable for its low investments, quick and high returns that makes it an ideal industry or enterprise that fits well into the low socio-economic segment of India.

India continues to be second largest silk producing country in the world and has the distinction of producing all the four varieties of silk *viz.*, Eri, Muga, Tassar and Mulberry. Today, India produces 14.617 MT of mulberry silk. Among the Southern States, Karnataka and Andhra Pradesh produce bulk of mulberry silk. Major Tasar producing States are Andhra Pradesh, Uttaranchal, Jarkhand, Chattisgarh and West Bengal. On the other hand, Assam, Nagaland, Meghalaya, West Bengal and Manipur are the major Eri and Muga producing states.

However, Karnataka continues to maintain its pre-eminent place by sharing 73 per cent of the Indian mulberry raw silk production. Rearing silk worms, commercial production of cocoons and silk reeling in Karnataka dates back to 18th century when sericulture was patronized by then, the rules Tippu Sultan of the erstwhile Mysore state. Today Karnataka produces 9.000 MT of mulberry silk of the total 14.617 MT, produced in the country.

Sericulture industry comprises of 4-5 major activities from soil to fabric *viz*; mulberry cultivation, silk worm egg production, silk worm rearing, silk reeling and twisting, weaving, dyeing, printing and finishing. Each major activity results into marketable products, which forms the basic raw material to the next activity. At the end of each major activity, large amount of by-products are generated which are inevitable. Effective utilization of these by-products for value addition has enormous scope in the industry and these activities generate additional income and employment in this agro-based cottage industry.

In the state, 764 grainages situated in different parts cater to the seed requirement of the Sericulturist. During the grainage operations moths emerge out of cocoons by piercing through and rendered them unreelable. Such cocoons amount to about 240 MT (metric ton) per year and most of it were procured by Bihar and West Bengal for Matka Spinning.

Traditionally, the pierced cocoons were spun on a very simple rudimentary device known as *Takli*, a thin long spindle having a basal round plate placed slightly above from one end of the spindle whereas the other end formed into a hook. Silk is drawn on *takli* from softened cocoons by twisting between fingers and wound on the basal plate of the spindle. *Mataka* spinning is nothing but *takli* spinning well known in West Bengal wherein, Bengali *Mook* means mouth and *kata* means cut or pierced. Further, *mataka* spinning famous in Murshidabad and Malda district of West Bengal was the main occupation of the poorer families. Tracing back the history it is observed that *mataka* fabric was largely used by Hindu and Jain royal families as is produced in *Ahimsa* way. *Ahimsa* a Sanskrit word means 'non-violence', inturn means 'non-killing of pupae' for silk extraction. Thus the silk obtained from pierced cocoons is called as *Ahimsa* silk. Similar name implies to Eri silk also since Eri is open mouthed *i.e.*, the filament need to be discontinued and then can only be spun. This sentiment made the *Ahimsa* silk fabrics quiet popular among the Hindus and Jain communities, who strongly believed in non-violence.

The spinning process in practice for mulberry pierced cocoons are rather primitive and traditional ones like *takli*, which could spin 50g yarn/8 hours with 10s to 14s. Similarly, N.R. Das spinning machine which worked on the principle of 'Flyer system', could spin silk of about 80g /8 hours with 10s to 14s. The yarn found to be non uniform with irregular twist. Another charaka famous in North India, the 'Choudhary Charaka' worked on the principle of ring and traveler system of spinning. It helped to produce comparatively better quality yarn over the traditional devices, but lacked in yarn uniformity. On this charaka it was possible to produce 80-100g yarn/8 hours of 10s - 15s. The Central Silk Technological Research Institute (CSTRI) pedal operated spinning machine worked on the principle of ring and traveler and produced about 40 - 90g of yarn / 8 hours with a count of 15s - 25s. Another manually operated charaka famous in Northern Karnataka the 'Medleri Charaka' a new invention by India Development Service (IDS), an NGO at Dharwad, with the technical assistance form the TOOL of Netherlands for wool spinning, was later modified to spin pierced cocoons. However, the yarn did not produce regular twisted yarn though the spinnability was 15s - 25s. Hence it was a felt need to develop a most appropriate technology of spinning to suit the region wise production and promote quality spun silk production. This prompted CSTRI Bangalore to develop an improvised 'motorized spinning-cum-twisting machine' during 1998-99, a real break through. This machine was perfectly suitable to spin *Ahimsa* silk. It was possible to produce 80 - 120g of yarn /8 hours of about 25s - 35s, almost 2 ½ times greater production than *takli*.

The handloom sector is next to agriculture in terms of economic and employment impact particularly in rural areas. Over 30 lakh households and 124 lakh weavers are directly and indirectly dependent on handloom industry. The section contributes nearly 23 per cent of the cloth produced in the country and also contributes substantially to the export income of the country. Weaving silk on handloom is one of the traditional occupations of India, which speaks of ancient glory. Ahimsa silk is specially suited for handloom sector, because of its coarseness and unevenness. Thus, ahimsa silk having these unique properties may not go as warp ends but can definitely be used as weft to produce designer textile materials, to make designer garments. To achieve unique fashioned characteristics, to reduce the cost of production and to improve the tactile properties of the dress materials, shirting and furnishing material, an effort was made to inter weave Ahimsa silk with Cotton, Art silk, Polyester and Filature silk.

Hence, the present study on "Designing Textile made-ups from Ahimsa silk" is taken up with the following objectives.

- To explore the existing technology of cooking mulberry pierced cocoons.
- To find out the technique of spinning, degumming and dyeing of Ahimsa silk.
- To ascertain the possibilities of producing spun silk made-ups on simple and complex looms.
- To assess the physical characteristics of newly designed spun silk made-ups.
- To know the tactile properties of the newly designed spun silk made-ups.
- To enumerate the economic analysis of newly designed made-ups.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

The literature of the related researches conducted provides a suitable back ground for the study undertaken. The review of literature of relevance to the present study is arranged in this chapter under the following sub headings.

2.1 Cocoon cooking (Boiling)

2.2 Spinning method

2.3 Degumming of silk

2.4 Dyeing of silk

2.5 Utilization of by-products in Silk Industries

2.6 Blending of Silk

2.1 Cocoon cooking (Boiling)

This is an important process by which the quality of raw silk and the efficiency of the reeling/spinning machine are interdependent. The objective of cooking is to bring forceful penetration of water molecules into the sericin molecular network to increase swelling and softening, there by reducing the adhesive forces between the molecules and to dissolve sericin molecules under controlled conditions such that the agglutinating forces between the shell layers is reduced enabling easy unwinding of filament with minimum tension. This action has to be uniform in all the layers of the cocoon shell. If not, due to uneven swelling and softening of sericin, several problems arise during silk reeling or spinning affecting yield and quality of raw silk.

Nagaraj (1996) conducted a study on "Influence of cooking duration on reeling performance of some of the defective mulberry silk cocoons". The influence of normal and defective cocoons *viz.* Uji- pierced, melted stained and malformed cocoons was studied under three different cooking durations *i.e.* 5, 8 and 12 minutes. It was concluded that Uji- pierced and malformed cocoons cooked for five minutes and melted and stained cocoons for 12 minutes duration were found suitable for commercial reeling. The study indicates that these cocoons were physically defective but not defective for reeling.

Raju (1997) conducted a study on " the properties of Uji- pierced mulberry silk cocoons in relation to cooking and Reeling". The Uji- pierced cocoons of PM x NB_4D_2 were sorted from the cocoon lot and cooked at three temperature levels *i.e.* 98±2^{0}C, 92±2^{0}C and 86±2^{0}C for three durations of 3, 6 and 9 minutes. Finally reeled on electrically improved cottage basin. The results showed desired lowest renditta, longer filament length, higher raw silk yield and less number of breaks with Uji-infested cocoons when cooked at 98±2^{0}C for 3 minutes duration. All the four parameters were significantly inferior when Uji-infested cocoons cooked at 86±2^{0}C for 3 minutes duration. Uji-infested cocoons can be conveniently reeled by cooking at 98±2^{0}C for 3 minutes, 92±2^{0}C for 6 minutes and 86±2^{0}C for 9 minutes duration, as the difference observed among these was statistically non-significant. The study revealed that the Uji-infested cocoons need to be cooked at lower temperature for longer duration or at higher temperature for lesser duration.

Gulrajani *et al* (1997) Made on attempt "To optimize the cooking conditions of tasar silk cocoons with ethylene diamine using the Box and Behnken factorial design for three variables and three levels for each variable". It is observed that the duration and temperature of cooking as well as the concentration of ethylene diamime significantly influence the cocoon shell weight loss and silk filament recovery. Silk recovery improved with shell weight loss up to 11.5 percent of which no further improvement in silk recovery was observed. For better silk recovery the following cooking conditions were recommended *i.e.* ethylene diamine –(10%) on the weight of cocoon, temperature 80^0c, duration of treatment- 30 min and M:L:R-1:30. The hardness of water up to 1100 ppm did not have significant effect on the recovery of silk filament in ethylene diamine cooking system.

Selvakumar and Das (1998) in a studied on 'Improvement of muga silk realization in Assam using better cooking method under optimized cooking condition'. With a view to improve the muga silk realization using three stage cooking process in a suitable designed cooking vessel. The experiment was carried out at various conditions of cooking *viz;* concentration of Na_2CO_3 (0.5, 0.25 and 0.5 gpl) time (15, 20 And 25 minutes) and temperature of cooking (boiling) in order to optimize the cooking conditions. The reeling was done on Bhir and CSTRI reeling machines. The results showed maximum silk yield with good tenacity and breaking extension was obtained when cocoons cooked at 0.5 gpl Na_2Co_3 at boiling temperature for 20 minutes.

Bulbul *et al* (1999) in a write up on " Use of surface active agent in cooking and reeling of muga cocoon and its effect on properties of fibre and yarn", observed that, the use of surface active agent (tinopal-300) along with Na_2CO_3 in cooking and reeling of muga cocoon was highly satisfactory. Surface active agent along with Na_2CO_3 helped in easy removal of Sericin from silk fibre without damaging the fibre and there by easy tracing of it from the cocoon.

Anonymous (2000) in a report on "Influence of cooking temperature on reeling characteristics of normal and defective mulberry silk cocoons reeled on multi end Reeling machine". The influence of normal and defective cocoons *viz.,* Uji-pierced, melted and stained cocoons were studied under two different cooking temperatures (86±2^{0}C and 90±2^{0}C) for commercial characteristics. It is inferred that, normal and Uji-pierced cocoons cooked at a temperature of 86±2^{0}C whereas melted and stained cocoons cooked at 90±2^{0}C were found suitable for obtaining superior commercial characteristics.

Sengupta *et al* (1998) carried out study on " Improved cooking and reeling methods of Tasar cocoons A: MYLITTA D,- A break through", with a view to improve the cooking and reeling efficiency. The trial made with different types of cooking *i.e.,* traditional (soap + soda), enzymatic cooking (Biopril-50) and new method with Soap+ H_2O_2 were tried for cooking and same were reeled on Central Tasar Research and Training Institute (CTR and TI) reeling machine. The silk was observed for cooking efficiency, raw silk recovery, denier and tenacity. The data revealed maximum silk recovery, with finer denier and good tenacity was obtained when cocoons cooked in soap + H_2O_2 than that of traditional and enzymatic cooking.

2.2 Spinning Method

In addition to the spun silk mills, silk waste is also being consumed for the production of coarse counts of spun silk yarn in the decentralized hand-spinning sector dispersed over larger parts of central and Eastern states. Almost the entire production of tasar silk waste and also the bulk of the muga and eri silk waste are bring consumed by the hand-spinning sector. Besides the non-mulberry silk waste, the hand spinners also consume some quantity of mulberry silk waste, mainly pierced cocoons for the production of handspun yarns. The hand-spinning process when advocated for the use in cottage industry of India shall serve effective means of rural employment in addition to the utilization of waste cocoons.

The term spinning may be defined as the process of formation of yarn by a combination of drawing, twisting and winding operation applied to prepare fibre mass. These three basic operations in spinning are required sequentially.

Bhalerao (1997) conducted a study on " Eri silk yarn production", eri silk is the second largest variety in the total production of silk. As eri cocoons are unreelable, it is spun for getting yarn. Most of the eri cocoons were degummed and hand spun on "Takli", consisted of a spindle with disc- like base. The spinner holds the strand with right hand to the spindle. The spindle is frequently rotated by right hand to import twist after certain length of yarn is spun. The spinning is discontinued in order to wind the yarn on the spindle. Generally, eri handspun yarn is of 10s-20s, whose out put is quite low. Improved spinning equipments have been developed on the continuous spinning principle with simultaneous drafting, twisting and winding. The NR Das spinning wheel, Trivedi spinning wheel, and Chowdhury spinning wheels are also popular for eri spinning.

Sreenivasa *et al* (1999) conducted a study on" Improved spinning techniques of Tasar silk waste through Amber charaka". The main objective of the silk industry is to produce raw silk for the manufacture of silk fabrics. However, different kinds of silk wastes as byproducts are further used to make useful article. This study revealed that utilization of different tasar wastes for the preparation of diversified products towards product development and to attract consumers. Hand and pedal operated machines are in vogue for spun yarn preparation, which can give production up to 100g/day/ person. But on Ambar charaka a person can spin 450-500g/day/person. On Ambar charaka blended yarns could by spun to contribute special effects like comfort, feel and additional strength for preparation of diversified fabrics.

Maharaddi and Hakeem (2000) carried out a study on "Yaki Tsumugi fabrics from cut and pierced cocoons". Tsumugi is a high quality traditional handspun silk fabric produced in Yuki village of Japan. Tsumugi spinning is quite different from the regular one. Here the yarn is spun by pulling out the oiled (softened) Matawa or floss silk, which is mounted onto the spinning device called Tsumushi. It is a wooden stand having five to six well polished pegs around the top of the stand and is convenient to unravel the filaments are drawn, according to the fineness of the yarn required. Pseudo twist is inserted by fingers to bind the fibres and the spun yarn is collected on a soft bamboo or in a plastic basket. Average production of this yarn is just 18 to 30 g/day. It takes several years to master this technique of yarn preparation.

Mishra (2002) reported in " Sericulture Industry in Indonesia", that wild cocoons produced in Indonesia are unreelable and hence are subjected to spinning of handspun yarn from Attacus or Cricula cocoons. These shells are cut by scissors for removal of pupa, cleaned, degummed and spun into yarn on electrically operated wooden flyer type spindle with hand-spinning wheels. These wheels work with a mini motor of 0.05 HP and are regulated by leg operated speed regulator. The out put of this machine is around 160 g of 7s count yarn per 8 hours.

George (2003) mentioned that "Enterprise promotion of handspun silk through Medleri Charaka", with plenty of resources untapped in utilization of the spinning of pierced mulberry cocoons and with an objective to empower the women in rural area, India Development service (IDS) developed not only a suitable Medleri Charaka but also a complete package to help the situation. The Medleri Charaka an innovative tool that was developed with the technical assistance from TOOL of the Netherlands for wool spinning was used mostly for pierced cocoons. As these charakas are operated by the beneficiary women at their houses without affecting their household chores, thus production of yarn depended on the total time *i.e.*,an average of 4-5 hours per day helped to produce 70-80 g which is an additional income for women without neglecting their domestic route.

Somashekar (2003) worked on " Recent advances in Eri silk spinning, weaving and future prospects". The eri silk cocoons cannot be reeled as are made of entangled layers and hence spun into yarn. The cut cocoons form the raw material for mill spinning. The cocoons are degummed with 0.3 gpl of sodium carbonate, 3gpl of soap, MLR 1:40 for one hour. The degummed material after drying and conditioning was mechanically processed on the machines working on Japanese and Italian technologies. The Japanese sequence of machines consisted of opener, filling engine, dressing frame, spreader, gill rowing, drawing frame, rowing, spinning, winding, doubling, twisting followed by gassing of the yarn, winding and packing.

The Italian sequence of machines consisted of staple length cutter, hopper feeder, oiling, carding, gill rowing, combing, post combing, roving, spinning, winding, doubling, twisting followed by gassing, winding and packing. The Japanese technology maintained the length of the fibres, the Italian technology brought uniformity in length by cutting the fibres. Both the technologies use woolen system of machineries modified suitably for silk processing. The counts of eri spun silk ranged from 2/20s to 2/120s when spun on both type machines.

Rabindranath and Das (2003) studied on " Eri spinning on Ambar Charaka an experience TAGS (Tamulpur Anchalik Gramdar Sangh) in Assam have modified the Amber Charaka to suit eri spinning for better productivity and ease of operation. A complete unit of TAGS eri spinning device consisted of five parts *viz.*, cocoon opener, fine fillet drum machine, tape drawing machine, roving machine and fibre cutting machine as well as five additional Amber Charaka to make the entire process cost effective. The entire process is done manually and hence does not require power. The experienced spinners can earn an average of Rs. 15-20 a day. The quality of yarn produced on TAGS method exhibited better tensile strength compared to yarn produced with traditional method. It is possible to spin yarn with the required counts as TAGS.

2.3 Degumming of Silk

The raw silk is mainly composed of fibroin and sericin. Due to presence of sericin, silk losses its brightness, which are the praised qualities of silk. Real silk is white or creamy white, soft, lustrous and smooth. Hence for silk to exhibit its true characteristics, removal of sericin is practically essential before any subsequent wet processing *viz.*, bleaching, dyeing, printing and finishing. The cultivated silks contain 25-27% sericin while wild silk contains only 12-18% sericin. The process of removal of sericin is known as "Degumming".

Sinnur *et al.* (1988) carried out a study on "Degumming of silk waste". The silk reeling waste of multi-bivoltine variety was taken for the experiment and degummed with soap and soda of different concentrations. The samples were degummed at three different periods of boiling for each method (45, 60, and 75 minutes) using 1:30 MLR. The degummed samples were subjected for bundle strength. The author concluded that, the fibre bundle strength has reduced as the treatment time was increased. This is an indication that increasing the treatment time shall damage the fibres.

Gulrajani and Malik (1993) in their study on " Degumming of silk with methylamine" observed that effect of methylamine treatment at different concentrations, temperature and treatment time on the weight loss, strength loss, bending length, crease recovery and flexural rigidity of mulberry silk fabric using a Box and Behnken response surface statistical design and the condition for degumming were optimized. The best degumming was achieved when the silk fabric treated with 0.2 ml methylamine at 80^0c for 30 min using 3 gpl non-ionic wetting agents. The fabric degummed under the optimum condition showed better properties than the fabric degummed with Marscicelle's soap. Unlike soap, the degumming efficiency of methylamine was affected by the hardness of water up to 1000 ppm.

Mishra *et al.*(1993) conducted a study on 'Degumming of silk with acetic acid'. The yarn was treated with acetic acid at 80^0c and 90^0c for 30 to 120 minutes. The results showed weight loss from 16 to 25 percent depending upon the conditions. This weight loss increased with the increase in the concentration of acid, temperature and time of treatment. Further the dye uptake also increased in a similar manner.

Chopra and Gulrajani (1994) reported on " Comparative evaluation of the various methods of degumming silk". The study revealed that various degumming agents *viz.*,acid, (Tartaric acid 0.5), alkali (Na_2CO_3 + $NaHCO_3$), soap (Marscicelles soap) enzyme (Alcalase) and amine (ethylene diamine) have been compared in terms of the extent of gum removed and the changes in mechanical properties of the degummed silk using the silk yarns of Chinese, Bangalore and Murshidabad varieties. Complete degumming could be achieved for all the three varieties of silk in case of alkaline degumming agents. Among the groups, degumming with Ethylene Diamine (EDA) was very effective, the role of sericin removal was very fast and almost instantaneous. Degumming with Marscicelles soap also results in the complete removal of sericin but the greater quantity of soap was required, which may not be economical. Enzymatic degumming was suitable only in the case of Chinese silk. Complete degumming could not be achieved in acidic degumming. Considering all the properties together, degumming with amine seems to be the best option followed by alkaline degumming.

Gulrajani *et al.* (1996) in a review article on " Degumming of silk with different protease enzymes" concluded that silk was degummed with eight different commercially available enzymes *viz.*, Degummase 1000L, Protosal, Trypsin, Alcalase, Protease-A, Protease-N, Pepsin and Protease-

M. The degumming conditions with respect to concentration and time were optimised for each enzyme. Enzyme activity imparted intrinsic property and degumming efficiency were evaluated in terms of weight loss, tensile strength, handle and luster. A weight loss of 24 ± 3 per cent was observed for most of the enzymes at an optimum enzyme concentration of 15 per cent, except for degummase 1000L, which gave this result at 25 per cent concentration. Trypsin and pepsin gave extremely poor results. The increase in treatment time at the optimum enzyme concentration showed no further significant weight loss. There was no significant strength loss in any of the degummed silk but marked improvement in handle and luster was observed.

Pathak *et al* (1996) in a study on " Effect of hardness of water on degumming of silk" observed that degumming of silk was carried in hard water and distilled water using different concentration of an industrial grade detergent based alphaolefin sulphate. The optimum quantity of detergent was calculated and the same was used for carrying out degumming with water having different levels of hardness. Degumming action has been found to be better in soft water. The correlation co-efficient between degumming loss and hardness of water with selected detergent was found to be -0.989. The degummed samples were tested for degumming loss, tenacity and elongation. It was found that the optimum degumming loss was obtained with 1 gpl detergent in soft water. The tenacity increased with decrease in hardness of water, however no clear trend in the case of elongation was observed.

Hadimani *et al* (1996) carried out study on "Degumming: Role of water and soap". It was concluded that, water is an essential input in wet processing of textiles. In degumming of silk, water and soap play a crucial role and hence maintaining their quality is of utmost importance. The usual process of degumming employs soap and soda, soap is the best degumming agent, which supplies the required alkalies to react with sericin in controlled quantities. However, to reduce both processing time and consumption of soap, sodium carbonate is added in the bath to maintain the pH 10.0 -10.5.

Chakrabarthy *et al* (1997) performed a study on "Effect of degumming and bleaching". The study revealed that, degumming with soap is best indeed; strength, crease recovery and other properties are excellent. Feel of degummed sample is superior because a negligible part of soap retained by the fibre, which provides suppleness. However, to reduce cost, soap can be partially eliminated by introducing sodium carbonate (Na_2CO_3). Control over application of alkali should be positive, otherwise fibres may get damaged and become harsh. Degumming may be done using alkaline nonionic detergent solution for further reduction in the cost of degumming. In doing so, the extent of dosing should be modified and optimized before application. Bleaching if required can be carried out in hydrogen peroxide/ammonia (H_2O_2/NH_3) technique to improve whiteness as well as other post-degumming properties.

Gulrajani *et al* (1998) carried out a study on "Efficiency of proteases on degumming of Dupion silk". It was found that dupion silk degummed with seven different commercial proteases *viz.*, Alkaline proteases Degummase, Protosal, Alcalase, Protease-A, Protease-N, Acidic protease-M and Pepsin. Conditions with respect to concentration and time were optimized for each enzyme and degumming efficiency was calculated. The treated samples were tested for tensile strength, handle, lustre and microscopic structure. Alkaline proteases have shown good results and the efficiency of degumming varied with variety of dupion.

A study on "Degumming of silk with tannic acid" was carried out by Jeyakodi (1999). It was concluded that, when the raw mulberry silk yarn was treated in 5, 10, 15, 20 and 25 gpl tannic acid solution for different periods *viz.*, 10 min, and its multiples up to 120 min at 90 °C with MLR 1:30 showed good dye uptake, wash and light fastness. However, with 25gpl concentration treated for 120 minutes showed maximum removal of sericin.

The effect of degumming followed by sequential oxidative and reductive bleaching on physical properties *viz.*, tenacity, thickness, fabric weight, bending length, crease recovery, flexural rigidity and air permeability of mulberry and tasar silk were studied. It was observed that tenacity, fabric weight, bending length, crease recovery and flexural rigidity decreased with increase in air permeability after degumming and bleaching as revealed by Sharma *et al.*, (1999) in their study "Effect of degumming followed by sequential oxidative and reductive bleaching an mulberry and tasar silk fabrics.

Gulrajani *et al.*, (2000) studied on " Degumming of silk with fungal protease" and observed that degumming with 25 per cent Marscicelles soap for 90 minutes at boil gives a weight loss of 20.5 per cent, whereas degumming with enzyme (3 gpl of the fabric) at 37°C for 3 hours gives a weight loss of 19.80 per cent. Treatment with enzyme was carried out at much lower temperature and therefore it was much more economical than the conventional process. Processing of silk with enzyme under the above conditions was likely to retain the lustre and softness of silk. Thus, considering the weight loss and properties of silk, fungal protease can be used as an effective degumming agent.

2.4 Dyeing of silk with acid dyes

Silk has affinity for almost all types of synthetic dyes, hence may be dyed with acid dyes, metal complex dyes and reactive dyes, which are most commonly used. Basic, vat and mordant dyes are also used but to a smaller extent.

The acid dyes are the most widely used class of dyestuff on silk combining brilliancy of shade and good fastness properties with simplicity of application. The dyeing is carried at boil for about an hour for complete exhaustion of dye.

Shenai and Chavada (1990) conducted a study on "Low temperature dyeing of silk in presence of Redox system". It was found that degummed and bleached silk yarn could be dyed with acid dyes at as low temperature as 40 °C for one hour to get nearly complete exhaustion of the dye bath. When dyeing is carried out in presence of a new redox system comprising of a mixture of formaldehyde and hydrogen peroxide considerable increase in dye exhaustion values were observed compared to the dyeing in absence of redox system.

Gulrajani *et al.*(1991) conducted a study on “Effect of temperature and time on dyeing of silk with acid dyes”. In this study three acid dyes manufactured by Sandoz (India) Ltd., were used which corresponded to three primary colours *i.e.*,Sandolan Navy 5 RLI, Sandolan Rhodine E 2GL and Sandolan Yellow 4 GLI. It was concluded that Sandolan Navy 5 RLI showed an increase in colour value and wash fastness with increase in time, temperature, and dye concentration. Sandolan Rhodine E 2GL had extremely poor washfastness. The K/S value increased with increase in temperature and time but the dye did not diffuse into the fibre so that the OD values remained almost constant even with increase in temperature and time.

In case of Sandolan yellow 4 GLI it was possible to lower the temperature of 70 °C and achieve fairly good results by increasing the dye concentration, while for Sandolan Navy, the dye concentration as well as the dyeing time were to be increased for better results at 70 °C in terms of colour value. Sandolan Rhodine was not recommended if dyeing is to be carried out at a lower temperature.

Venkiduswamy and Ramaswamy (1994) carried out a study on “Dyeing of silk with acid dyes involving redox system”. The results of the study revealed that dyeing of silk with redox system (potassium peroxide disulphate glucose) lead to better dyeability. The improvement depends mainly on the concentration of the system and dyeing temperature.

Farouqui *et al* (1995) carried out a study on "Effect of acid and direct dyes on silk". It was found that, dye absorption by silk fibre decreased with an increase in dye concentration for direct dyes. However, with acid dyes, the dye absorption increased with increase in dye concentration but further it decreased with gradual increase in dye concentration. The dye concentration for acid dye was 0.5 to 3.0 per cent or 3.5 percent and for direct dye it was 2.5 to 3 per cent.

Muralidharan and Shanmugasundran (1998) performed a study on "Dyeing of silk with acid dye involving Ammonium persulphate /Thio-urea Redox system". The study revealed that better dye uptake results can be achieved by using ammonium persulphate /Thio-urea redox system during dyeing of silk with acid dye than without it. The concentration of the redox system influenced the dye uptake. Maximum dye uptake was observed at a concentration of 0.015 ml/litre redox system; beyond, which the dye uptake decreased with increase in redox system concentration.

Muralidharan and Shanmugasundharan (1999) conducted a study on "The redox system assisted dyeing of silk with Kemacid yellow 2G". In this study the dyeing behaviour of silk with acid dye in the presence and absence of ammonium persulphate / thio-urea redox system was carried with a view to bring down the dyeing temperature. The use of redox system improved the dye uptake and fastness properties of the dyed material. The improved dye uptake was achieved through formation of free radical and the fixation of the dye is through covalent bond formation apart from ionic bonds, hydrogen bonds /Van der Waals forces of attraction. Better dyeing results can be achieved even at low temperature of dyeing for shorter duration compared to conventional dyeing methods. Maximum dye uptake was observed at a concentration of 0.015 ml/redox system, beyond which the dye uptake decreases with increase in the concentration of redox systems.

Pavlon and Nedkova (2001) studied on "Influence of Acid dyes on the properties of silk", reveals that, some properties of silk depend on the type and concentration of the acid dyes. The analysis of these dependences showed that irrespective of the peculiarities of the chemical structure of the dyes, it was found that with the increase in the concentration of acid dyes, the properties of silk changes according to a complex dependence with a less or more pronounced two-stage character. The first was relaxation and increase in the looseness of the super molecular structure and the second being cross linking of the polymer molecules prevailing consecutively in the amorphous regions with increasing density *i.e.* in the inter-fibrillar and inner fibrillar spaces. In this case the cross-linking effect is accepted to be the result of the formation of cross-links of unspecified type between the dye and its adjacent polymer molecule. In this way the cross-linking was considered to be a property of any particle, included among the polymer molecules irrespective of its chemical structure.

2.5 Utilization of By-products In Silk Industries

"Waste is wealth in Silk Industry". Silk industry in India is an agro-based industry, producing all main varieties of silk. During processing, right from the cocoon production till fabric manufacture about 50 per - cent of silk waste is generated. This silk waste material constitutes a portion of the total cost of the final product. Hence, efforts are to be made to minimize generation of waste at each stage of transformation process. A great deal of attention is to be given since the waste generated during silk reeling, egg production and further subsequent processing is a means of value addition. The waste is highly priced byproduct and a source of income for the farmers as well as silk manufactures.

Subhas *et al* (1992) studied on "The silk waste: Raw materials for spun silk industry". It was narrated that two varieties of yarns manufactured from natural silk fibre were filament silk and spun silk, the silk being reeled from cocoons and latter from the silk waste. Silk waste generated at reeling units (Reeling waste, deflossing waste and basin waste) formed the raw materials in manufacture of spun silk yarn. Apart from silk waste, other byproduct the pierced or cut cocoons and defective cocoons available in small quantity unsuitable for economic reeling also generated. Spun silk has a great value for end uses like pure silk to its practical virtues and attractive appearance. The hand spun yarn is extensively used in the manufacture of wide range of products *viz.*, dress materials and furnishings having considerable export potentiality. Mill spun silk is widely used for carpets and for insulating electric wires and industrial beltings. Spun silk from cut cocoons is widely used in the weaving of shirting, suiting, sarees, ties, curtain cloth and sewing threads. It is found that the utilization of by-products of silk industry is quite extensive. Once the technology of utilization of by-products is established and diversified, production cost may be reduced to a greater extent and the growers, reelers and silk manufactures will be benefited by earning higher profits.

Uma *et al.*(1992) stated in the study on " Silk handicrafts: source of lucrative earning", that cut/pierced cocoons formed the main by-products generated during egg production activity. Various handicrafts prepared from such cocoons may be garlands, flower of different types and decorative pieces like cocoon door curtains, hangings, silk wall plates, thermocol drawings/paintings and pleasantries exchange items like greeting cards and so on. These decorative items are found to be beautiful, attractive and long lasting. The process of handicraft making has immense potential of developing remunerative employment particularly for the women as household activity, widely adoptable almost by anyone, any where /every where and any time. Besides pierced cocoons being helpful for the students to utilize their leisure time constructively and earn supportive income. These handicrafts were running in the markets with great demand and acceptability is becoming a part of fashion that earns lucrative returns for the producer.

Rao (1996) studied on " The sale to an art conscious society". In India, manifestation of art and skill in the by-products and waste of different varieties of silk is not rare. In the post cocoon sector, defective cocoons *i.e.* cut/pierced cocoons and waste silk are the major by-products. Their use in the preparation of attractive handicraft items like lace table mats, wall hangings and carpets is not only the source of effective utilization of waste but a means of value addition and generating family income.

Moon and Naik (1998) conducted a study on "Utilization of Tasar silk waste for non-woven decorative". The waste fibre of Tasar silk generated during silk reeling was taken as the basic raw materials in the present study and polypropylene fibres were used in different proportion as bonding material. The silk waste fibres and polypropylene fibres were hand opened and mixed in different proportions of (Silk: polypropylene) 90:10, 70:30 and 60:40 and made into non-woven by thermal bonding. These non-woven fabrics were used as furnishings, wall decoratives, floor coverings and other decorative household textiles. However the author stated that the non-wovens with 30 to 40 percent binding materials (Poly propylene) are suitable as decoratives and furnishing fabrics, where as non-woven with less than 30 per cent polypropylene as wall decoratives.

Raje *et al* (1998) conducted a study on "Regeneration of silk fibroin from silk waste and its applications". The study revealed that it is possible to regenerate silk fibroin powder from silk waste by dissolution and reprecipitation method. The fibroin powder was regenerated by two solvent systems, firstly by formic acid or $CaCl_2$ and secondly by lithium bromide. The regenerated fibroin powder was then applied on polyester fabric (100% polyester fabric) and then assessed for its properties *i.e.* moisture regain, viscosity, X-ray diffraction, percentage add-on and bending length. Authors reported that, the regenerated fibroin powder was used to finish polyester from the point of view to imparting better moisture absorbing properties without significantly affecting the inherent properties of polyester.

Shivakumar *et al* (1999) conducted a study on" Eco-friendly silk quilts from unreelable cocoons". In the recent years, with the increasing demand for eco-friendly hand made novelties there were ample potential to diversify the utility of unreelable silk cocoons *i.e.* cut/pierced for the production of "Silk Quilts", a value added product for export. The unreelable silk cocoons, on cooking freed from the gum through which fibres gained better lustre and softness. Individual wet cocoon was slightly opened and then stretched with help of bell shaped web maker, till the base to form a bell shaped thin layer of web. The same process was continued placing three to four layers one above the other as per the required thickness. The web was later removed and dried under shade. Several webs were placed one above the other as per the thickness, length and width of the quilt required *i.e.*,7′ x 7.7′ x 4′. This non-woven sheet was stitched at different places and wrapped with the gauze/bandage type cloth. Finally to enhance the appearance of the quilt beautiful covers of dupion silk, printed silk and embroidered fabrics were used. The high cost of the silk quilts was compensated by its long life in comparison to wool and cotton and also its aesthetic appeal, beauty, elegance and feather touch.

"Yuki Tsumugi fabrics from cut and pierced cocoons". Tsumugi is a high quality traditional hand spun-silk fabric produced in Yuki village of Japan. Yuki Tsumugi fabrics were made from strong and durable handspun yarn with fast colours and fine and delicate texture. Its manufacturing process involves following steps *viz.*, cut/ pierced cocoon, degumming, floss making, kasuti tie-dye and weaving. These fabrics were woven on small back strap loom called Izaribata, that resembled throw shuttle loom. Tsumugi fabrics were of 12″ width with special design and motif woven in conjunction with tie-dye effect of the warp and weft yarns. Production of these fabrics is tedious and it takes about 50 days to several months to finish about 12.5 yards length. The cost of production of these traditional hand-made fabrics is very high yet have potential demand as reported by Maharaddi and Hakeem (2000).

2.6 Blending of Silk

Today fashion conscious customers demand variety in textile products. The traditional varieties are giving way for blended and mixed fabrics like silk blended with natural and man-made filaments. The main objective of silk industry is to produce silk from cocoons by rearing silkworm and to manufacture silk fabrics. To achieve this objective it is inevitable to undergo different stages of processing *viz.*, rearing, cooking, reeling, spinning, twisting and weaving. While undergoing different stages a lot of unwanted byproducts are obtained along with the main products. Among these, defective cocoons constitute a major portion of the byproducts, which are not suitable for reeling. These by-products or waste silk can be blended with other natural and man-made fibres, to produce further useful products and to bring end products at competitive level by lowering the cost of production as well as products price.

2.6.1 Physical properties of Blended silk

Hadimani *et al* (1986) conducted a study on "Prospects for polyester-silk blended fabric". Polyester fibre of 2d with silk waste of 1d mixed in the proportions of 85:15, 70:30 and 50:50 polyester/silk, respectively, yarns of 53s count were spun on regular worsted spinning machines. Plain fabrics were woven on Dobcross loom, from all the three blended 2/53s yarns, with 50s reed and 48s pick. The physical properties of yarns and fabrics were assessed. It was reported that tenacity and elongation decreased with an increase in the proportion of silk. Among these three blended 70:30 and 50:50 blended fabrics possessed most desirable properties. The cost of blended fabrics was found to be inexpensive than the pure silk fabric.

Linganur *et al* (1988) conducted a study on "Feasibility of blending cotton with silk", reported that cotton and silk were mixed in the proportion of 80:20, 60:40, 40:60 and 20:80 silk/cotton, respectively. On assessing the bundle strength and yarn tenacity of blends, it was found that the values decreased with the decrease in the silk component. The breaking elongation of yarns decreased gradually as the percent of cotton in the blend increased, since the breaking elongation of cotton was lower compared to that of silk. From the economic point of view processing silk, silk/cotton blends on the cotton system worked out to be inexpensive without making modification on existing machinery set up.

Krishnan and Halliyal (1989) studied the "Feasibility of blending merino wool with silk" in the proportion of 80:20, 60:40, 50:50, 40:60 and 20:80, respectively. The results revealed that the bundle strength of blends increased with increase in silk component may be due to higher content of the stronger fibre. The authors mentioned that the yarns can be used for the production of coarser varieties of fabrics. From the economic point of view processing silk wool blends on the cotton system works out to be economically feasible without making any change in the prevailing machinery set up.

Praveena and Vatsala (1992) carried out a study on "Blending of mulberry silk waste". Polyester, viscose rayon and acrylic fibres were blended with silk waste in the proportion of 50:50 and the fabrics were made. The results revealed that blended fabric of mulberry silk waste with polyester was found to be the best because of its durability, appearance and general properties. The said fabric possessed desirable combination of aesthetic characteristics and serviceability though exhibited poor crease recovery, which could be further improved by proper finishing techniques. The second preference was given for the viscose, mulberry silk fabric followed by cent percent silk waste fabric. The least preferred was the acrylic-mulberry silk blended fabric, which showed poor serviceability. It was also mentioned that polyester mulberry silk fabric provided economical as well as functional advantages over other test fabrics.

A study conducted by Kalita *et al* (1993) on "Silk blending for yarns and fabrics", explained that muga and eri wastes of 5.30d and 6d, respectively were blended with polyester of 3d in the proportion of 40:60 and 50:50 of polyester: silk, respectively. The fabrics were woven in plain on flyshuttle loom, from blended yarns. Considering the overall characteristics of yarns and fabrics, all blends possessed good performance. Among these two blend proportions 40:60 blended fabrics exhibited most of the desirable properties. It was finally concluded that muga and eri silks could be effectively blended with polyester and such blends can be used as shirting's, dress materials and suitings most suitable for both winter and summer seasons.

Moon (1999) studied on "Tasar silk wall coverings and hangings". Tasar silk waste fibres and polypropylene fibres were mixed in different proportion *viz.* 90:10, 70:30, and 60:40 respectively and made into non woven by thermal bonding and assessed for physical properties. The results reported that among the three blend proportion 70:30 and 60:40 combination non-wovens could be used as wall hangings and furnishings. The natural glamour of tasar silk and dyed silk shall reserve the place for aesthetic beauty and non-woven from these raw materials is well suited for the same.

Sreenivasa *et al.* (2001) studied that "Development of core spun tasar yarn utilizing tasar silk waste", revealed that core spun yarn could be effectively prepared by using pierced cocoons through pedal spinning wheel, which has dual benefit *viz.*, reduction of cost per kg of yarn production with diversified product. Core spun tasar yarn will be inexpensive with the use of low cost core material, *viz.*, cotton, viscose and wool. A fabric produced from core spun tasar yarn showed better qualities with respect to tensile strength and elongation.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The present investigation on "Designing textile made ups from Ahimsa silk" was carried out at the Department of Textiles and Clothing, UAS, Dharwad in collaboration with Central Silk Board, Rayapura (Dharwad District), during the years 2000-2004. The techniques involved and the materials used in the study are described under the following sub headings

3.1 Selection of sample

3.2 Cooking of cocoons

3.2.1 Selection of different cooking media

3.2.2 Cooking procedure

3.3 Ahimsa silk spinning

3.3.1 Spinning machine description

3.3.2 Operation procedure

3.3.3 Re-winding machine and procedure

3.4 Physical testing of Ahimsa silk

3.4.1 Yarn count (Ne)

3.4.2 Yarn twist (TPM)

3.4.3 Yarn tenacity (Kgf)

3.5 Degumming of Ahimsa silk

3.6 Dyeing of Ahimsa silk with acid dyes

3.7 Utilization of Ahimsa silk in handloom sector

3.7.1 Selection of weaving centers

3.1 Selection of Sample

The bivoltine and multivoltine pierced cocoons were procured from the state Department of Sericulture seed grainage at Rayapura (Dharwad District), for the production of Ahimsa silk yarn (Plate 1).

3.2 Cooking of cocoons

This is an important process by which the quality of raw silk and the efficiency of the spinning machine are dependent. Before spinning the cocoon must be degummed to ensure removal of the serecine to facilitate easy spinning.

3.2.1 Selection of different cooking media

Four types of cooking media were selected for cooking the pierced cocoons.

Sl. No.	Cooking media	Ingredients	MLR
1.	Plain water	Soft water	1:30
2.	Soap + soda	Soap (501) – 3 g/lt; Soda – 1.5g/lt	1:30
3.	Oxyphon oil	Oxyphon oil – ½ tsp/lt	1:30
4.	Ezee detergent	Ezee – ½ tsp/lt	1:30

Criteria for selection for cooking media

All the four cooking media i.e. plain water, soap + soda, oxyphon oil and ezee detergent are the prevailing practices in silk (cottage) industries to soften cut/pierced mulberry cocoons.

3.2.2 Cooking procedure

In order to standardize the cooking time for each media, four replications were carried out. On the basis of the texture and softness of

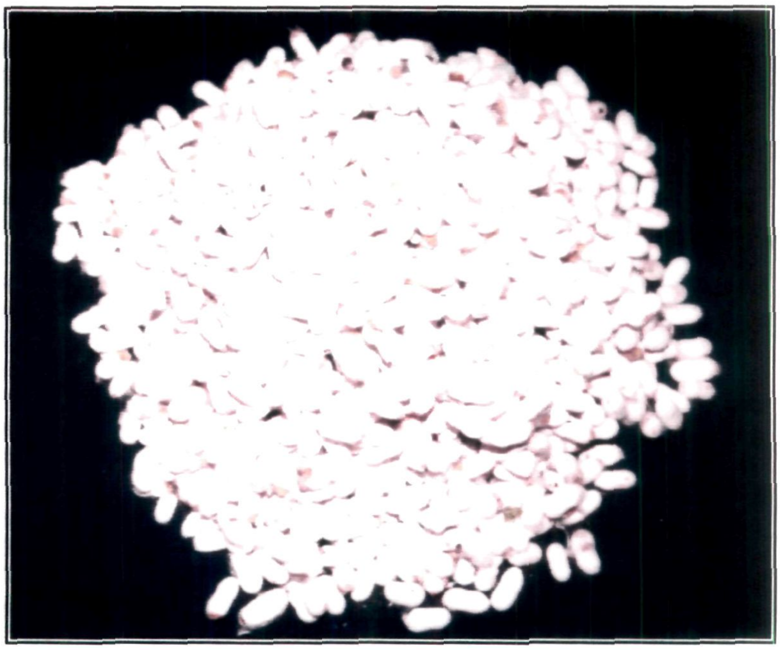


Plate 1: Mulberry pierced cocoons

Plate 2: Cocoons tied in a perforated cloth

cocoons, the duration for cooking was finalized and adopted for the present study.

Cocoons were tied in a piece of perforated cloth and dipped into the vessel containing the above recipe and boiled for different durations (Plate 2 & 3). Subsequently, the tied cocoons were taken and thoroughly washed in cold water without disturbing the material and finally squeezed by hand. After chemical boiling the material was boiled in plain water to wash off the traces of alkaline content. Finally the material was removed from the boiling water and squeezed out to remove excess water. The cocoons, thus prepared were spun in wet condition on spinning machine. Spinning in semi-wet condition gives better performance. For dry cocoons, it is advisable to sprinkle water frequently so as to keep the material damp.

3.3 Ahimsa silk spinning

The term spinning may be defined as the process of formation of yarn by a combination of drawing, twisting and winding operation, applied to prepare fibre mass. These three basic operations were carried out sequentially in spinning. Ahimsa silk was spun on "CSTRI twisting cum spinning machine", at Uppin Betageri, Dharwad District.

3.3.1 Spinning machine description

The new machine is an improved version over the five devices existing in the field. It is a tabletop model, made of cast iron frame with a dimension of 25"x14"x25". It consists of one horizontal spindle and gets

Plate 3: Cooking of cocoons

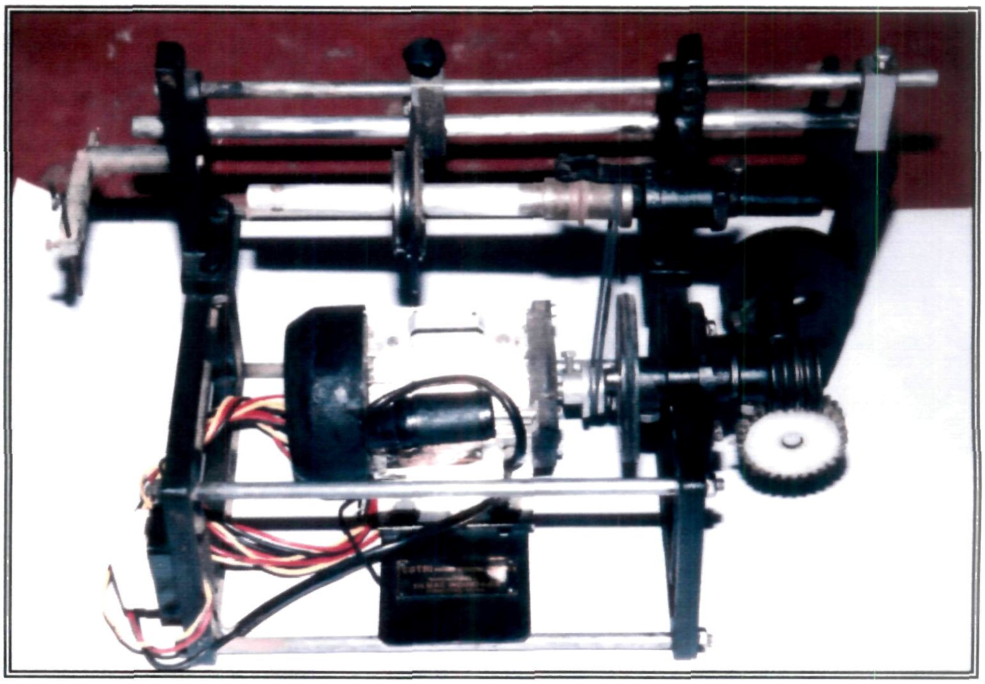


Plate 4: CSTRI motorized twisting-cum-spinning machine

drive from motor step pulley through urethane belts. Spindle runs at a speed of 850-2800 rpm. The speed can be regulated by changing pulley steps. The motor was run by a frictional current of 1/8 HP single phase. A ring is fitted exactly on the axis of the spindle, which moves to and fro, by means of cam lever arrangement. To and fro movement of ring and traveler is responsible for uniform built up bobbin. The twist is imparted to wet cocoons by means of ring and traveler. Spinning was done by drawing the wet cocoons by both hands, twisting of yarn by means of rotation of spindle and travelers and winding on to the bobbin. Drawing of cocoons by hand produces spun yarn with uniform twist. The desired count can be produced by means of drawing the cocoons by a skilled hand. This equipment is universal for all kinds of silk wastes, both mulberry and non-mulberry (Plate 4).

3.3.2 Operation procedure

The spinner sits on the operating table before the machine. Once the machine starts, spindle and travelers start rotating and the ring moves to and fro, continuously. Spinner holds the degummed and opened cocoon waste in the left hand and draws the filaments from the right hand fingers out of the bunch of the cocoon waste. Some false twist is given and wound on to the bobbin, which was fitted on the spindle through pigtail yarn guide and traveler. The spinner goes on drawing the filament to suit the twisting and winding on to the bobbin until the cocoon waste gets exhausted. In continuation the spinner takes fresh cocoon in left hand, while rotating the spindle she/he puts the last end of the yarn on to the next cocoon and this yarn automatically draws the filament from the fresh cocoon. Meantime, the spinner starts drawing and feeding of the filament. The uniformity of yarn depends on feeding of the filament. Once the spinning starts, it fills the yarn at 18 cm length of the bobbin, to fill up the entire bobbin of 18 cm, ring holders should move twice. After certain time the filled bobbin was taken out from the machine and transferred on to the rewinding machine for making silk hanks (Plate 5 & 6).

3.3.3 Re-winding machine and procedure

Re-winding machine

This device is comprised of a large wheel (1.5 meter circumference) made of wooden batten, a handle attached to the main shaft of the reel for its revolution, a transverse mechanism and an iron frame with horizontal rod to keep reeled bobbins for unwinding. Four-ends were operated at a time (Plate 7).

Procedure of Re-winding

Silk yarn was transacted in skein form and subsequently used in winding to prepare different size packages to suit weaving. Thus main aim of silk re-winding was to produce quality skeins that facilitate smooth and efficient operations in winding (Plate 8 & 9).

3.4 Physical testing of Ahimsa silk

After the spinning is performed the raw silk yarn is tested to determine the physical quality of the yarn. The physical testing of the raw

Plate 5: Spinning Ahimsa silk on motorized machine

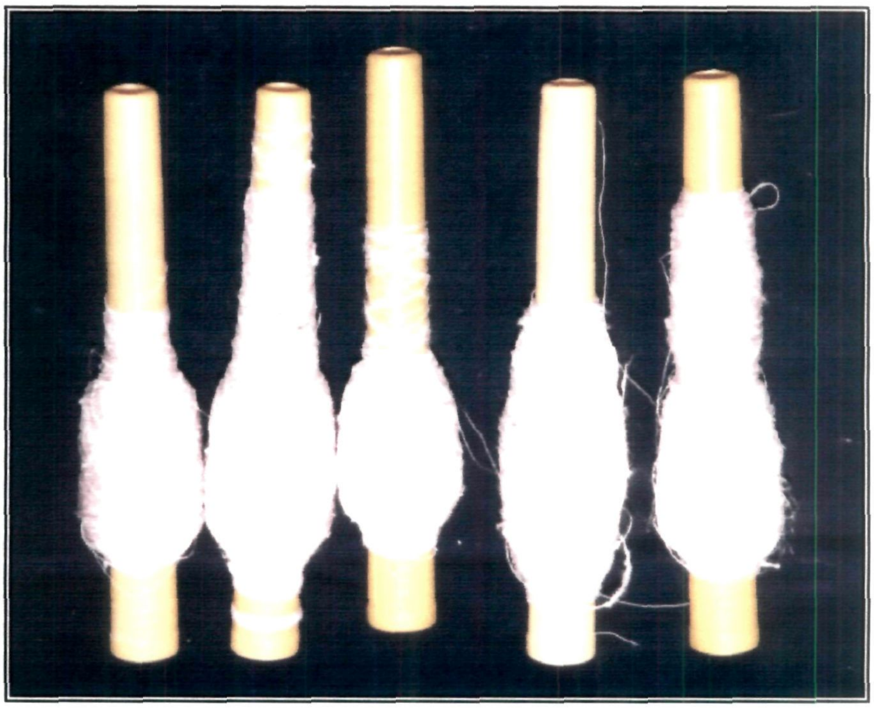


Plate 6: Filled bobbins

Plate 7: CSTRI rewinding machine

Plate 8: Rewinding operation

Plate 9: Ahimsa silk hanks

silk was carried out in testing laboratory at Demonstration Cum Training Center (DCTC), Central Silk Board, Rayapura (Dharwad District).

3.4.1 Yarn count (Ne)

The count of a yarn is a numerical expression, which defines its fineness. Yarn count or yarn linear density is expressed in metric system (Nm). It is the indirect system of yarn count and count is the number of "unit of length" per "unit of weight". The unit for length is one kilometer and unit for weight is one kilogram.

The specimens were tested as directed in BS-2060, 1963

$$\text{Count (Ne)} = \frac{\text{Length in meters}}{\text{Weight in grams}}$$

Length of the specimen : 1 meter
Number of specimen tested : 20
Name of the Instrument : Electronic Balance

3.4.2 Yarn twist (TPI/TPM)

Twist is the measure of spiral turns given to a yarn in order to hold the constituent fibers or threads together. The strength, the dyeing, finishing properties and feel of the manufactured product are dependent on twist in the yarn. With increase in twist, the yarn strength increases at first, reaches a maximum and then decreases. Yarn twist is expressed in twist per inch or twist per meter.

The specimens were tested as directed in BS-2085, 1973

Length of the specimen : 1 meter

Number of specimen tested : 20

Name of Instrument : Twist tester.

3.4.3 Yarn tenacity (kgf)

The maximum load (force) supported by specimen in a tensile test carried out to rapture is the breaking load or the tensile strength of a yarn. The breaking strength of a yarn determined under certain specific condition is usually taken as an index of yarn quality and is expressed in grams or pounds.

The specimens were tested as directed in IS-12673, 1989

Length of the specimen	: 32.5 cm
Load Range	: 0.900 kgs
Extension range	: 500.0 mm
Speed	: 250.0 mm/min
Gauge length	: 500.0 mm
Approach speed	:500.0 mm/min
No. of specimen tested	: 20
Name of instrument	: Hounsfield universal testing machine.

The reading for elongation at break was recorded simultaneously and expressed in terms of percentage.

3.5 Degumming of Ahimsa silk

The natural silk is to be purified before it takes any colour. The silk needs to be softened by removal of sericin gum and other impurities, by degumming process. The process also imparts lustre to the yarn.

The process was carried out using the following ingredients.

Soap (501)	= 3 gpl
Soda	= 1 gpl
M:L:R	= 1:30
Temperature	= 60-70 °C

Duration = 45 minutes – 1hr

After treating the sample in the degumming bath it was dipped in cold water successively four times and squeezed it thoroughly. About 6-12 per cent of weight loss would occur during degumming process of silk (Plate 10).

Percentage of weight loss was calculated by using the following formula.

$$\text{Weight loss (\%)} = [(W_1 - W_2)/W_1] \times 100$$

Where as,

W_1= Initial weight of the silk hanks.

W_2 = Final weight of the silk hanks.

3.6 Dyeing of Ahimsa silk with acid dyes

The acid dyes are the most widely used class of dyestuffs on silk combining brilliancy of shade and good fastness properties with simplicity of application.

Acid dyeing recipe

Sl. No.	Acid dye recipe
1.	Dye stuff (1.5% - 5.0%)
2.	Glauber salt (10.0%)
3.	Acetic acid (2.0%)
4.	MLR (1:30)
5.	Temperature (60 - 75°C
6.	Time (60 to 90 minutes)

Plate 10: Degumming of Ahimsa silk

Plate 11: Dyeing of Ahimsa silk

3.7 Utilization of Ahimsa silk in hand loom sector

The handloom industry infact is the largest economic activity next to agriculture provides employment to about 10 million people in Indian either directly or indirectly. Ahimsa silk is specially suited for handloom sector because of its coarseness and unevenness.

3.7.1 Selection of weaving centers

The handloom weaving centers of Karnataka state selected for the present study were Khadi Gramodyoga Kendra (KGK)-Bengeri (Dharwad district) Karnataka Handloom Development Corporation Ltd.- (KHDC)-Ilkal and Guledgudda (Bagolkot district), KHDC- Kallur (Tumkur district) and KHDC-Gadag (Gadag district) (Figs.1a, 1b, 1c & 2).

3.7.2 Fabric information of newly designed made-ups

The material information for each made-up under the category of dress materials, shirting's and finishing's is given separately. It includes the general information like fibre content, colour composition, and dye composition and specific information about the constructional parameters of yarns and fabrics encompassing yarn type, twist direction, threads per inch, cloth cover, cover factor and type of weave (Table 1a to 1c and Plates 12-21).

3.8 LABROTARY TESTS

Tests include assessment of mechanical and functional properties of newly designed made-ups.

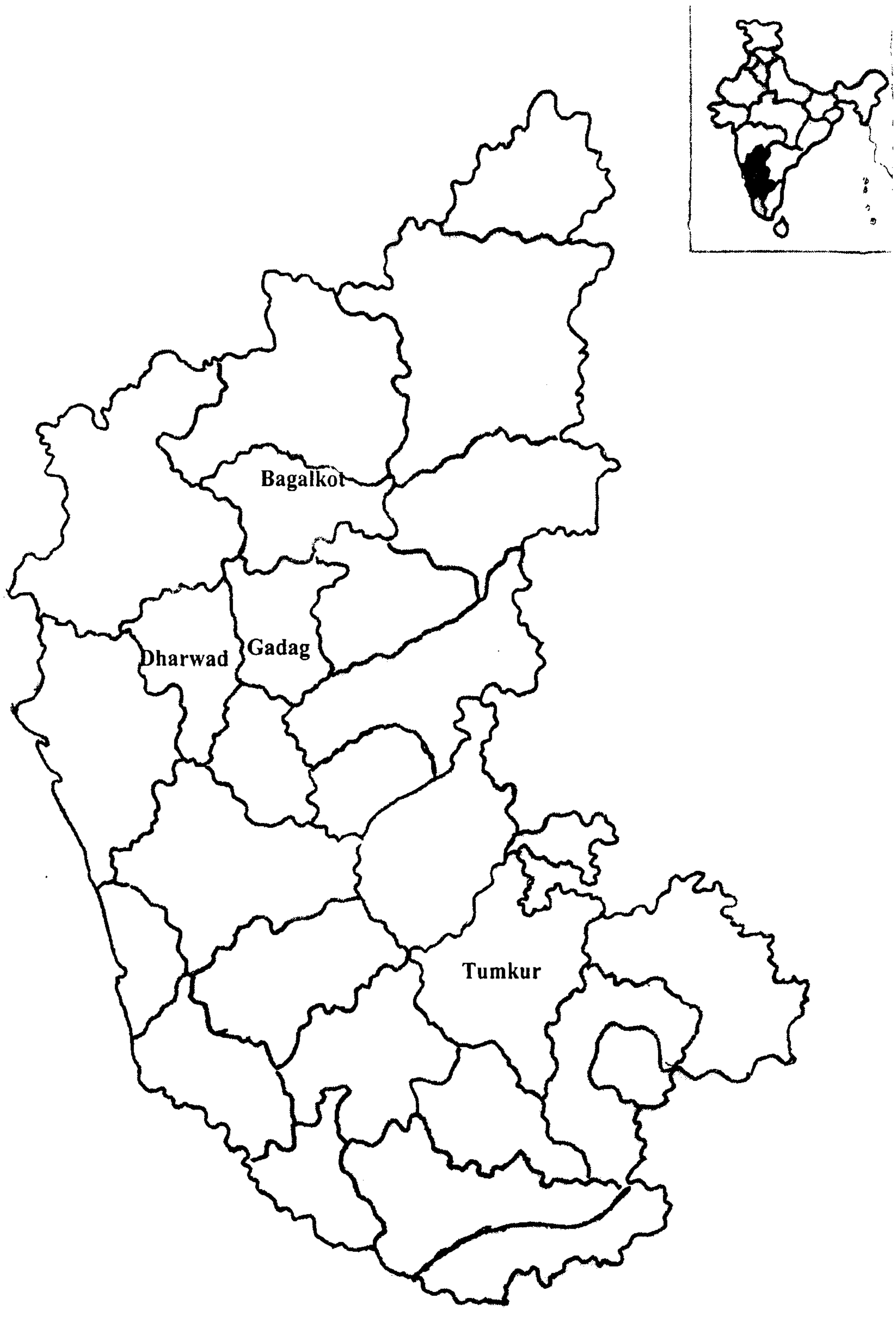
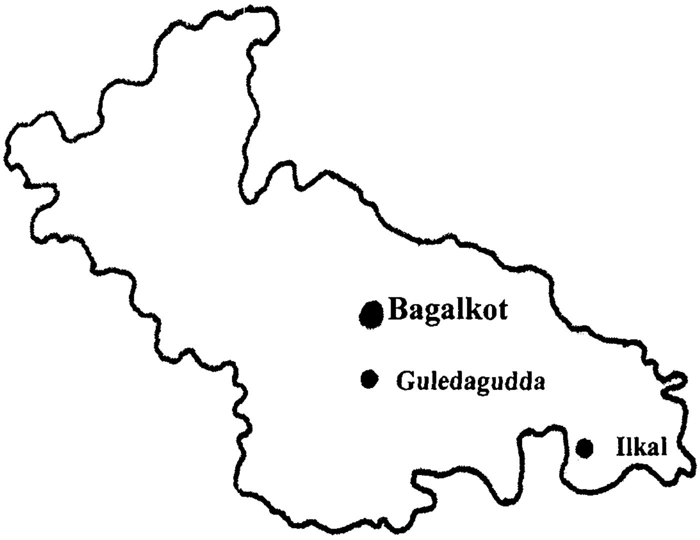
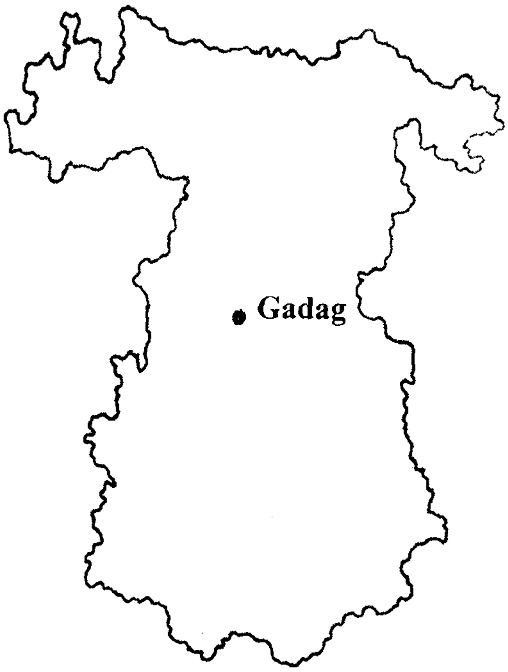


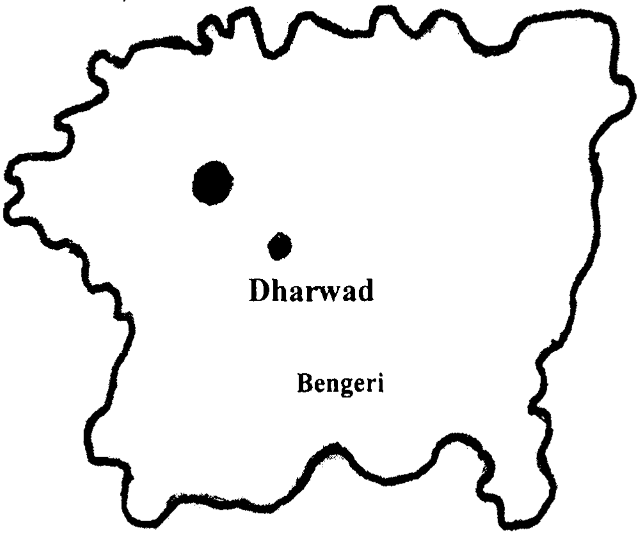
Fig. 1a: Locale of the study: Bagalkot, Gadag, Dharwad and Tumkur districts of Karnataka state



Ilkal and guledagudda of Bagalkot district



Gadag of Gadag district



Bengeri of Dharwad district

Fig. 1b: Locale of the study

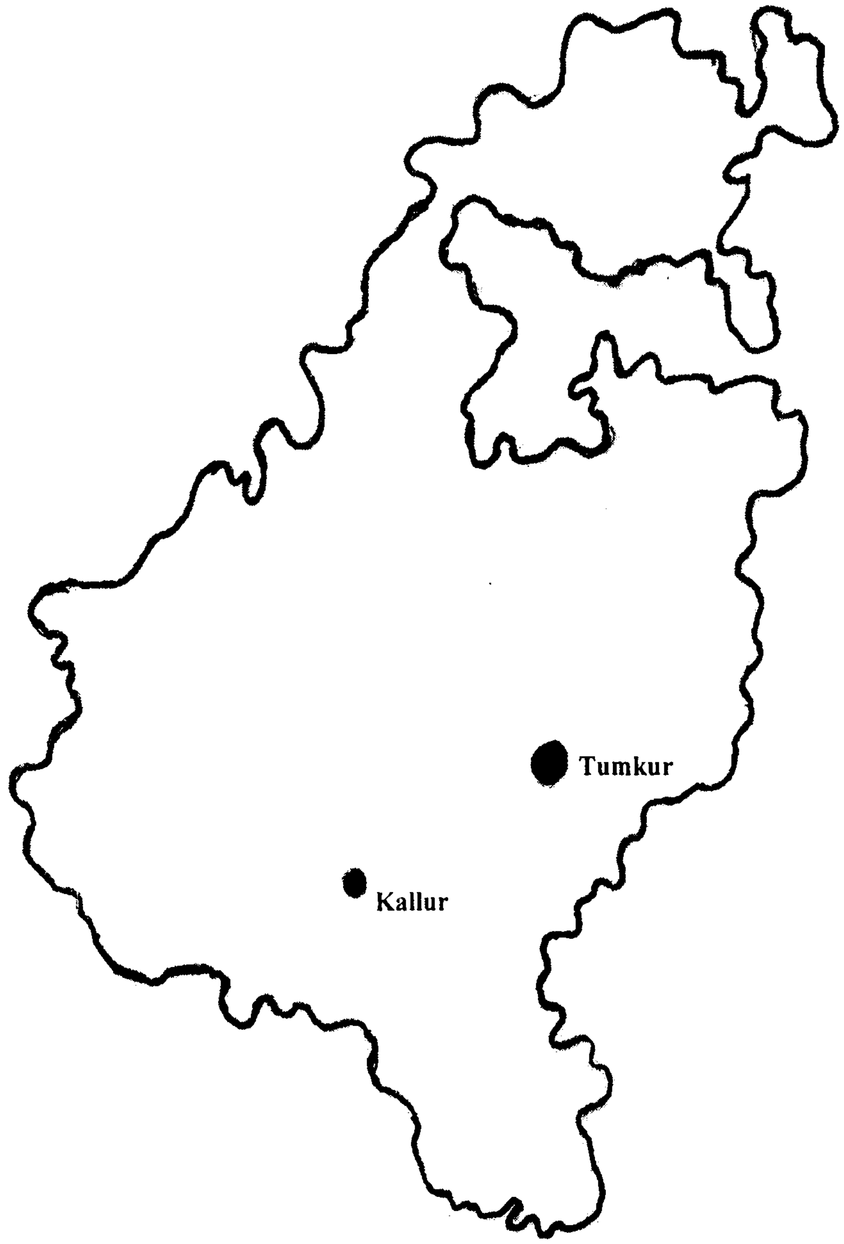


Fig. 1c: Locale of the study: Kallur (Tumkur District)

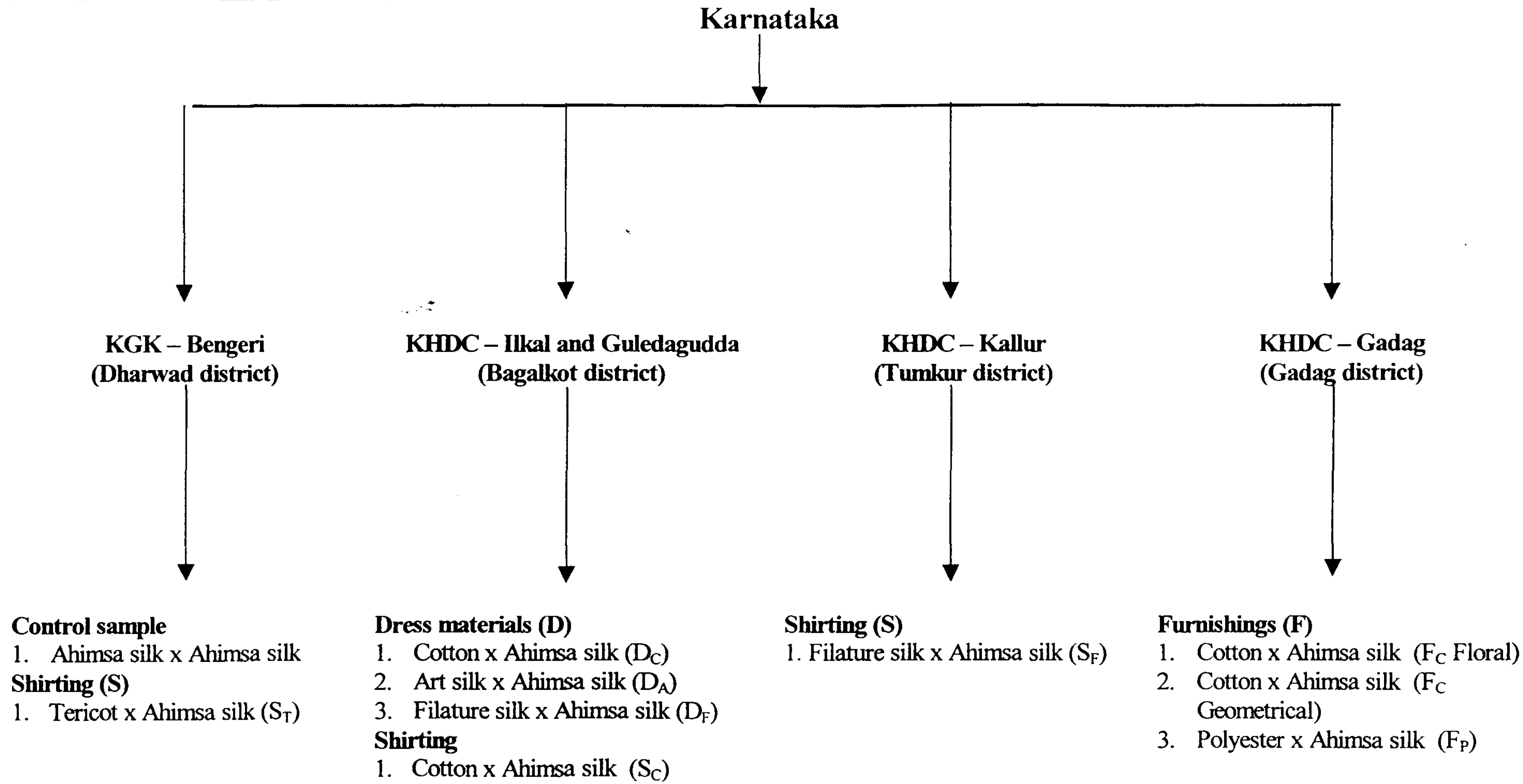


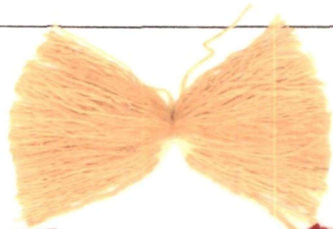
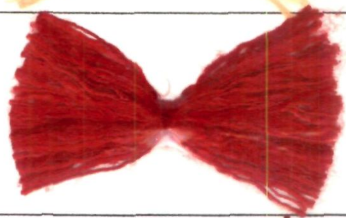
Figure 2. Selection of handloom weaving centres

Table 1a. Fabric information of newly designed dress materials

Sl. No.	Dress materials	Direction	Fibre Content	Colour Composition	Dye Composition	Yarn type	Twist Direction	Yarn Count (Ne/d)	Threads/ inch	Cover factor	Cloth cover	Weave type
1.	Control Ahimsa silk x Ahimsa silk	Warp	Ahimsa silk	White	--	Single	Z	35 s	24	4.06	6.29	Basket
		Weft	Ahimsa silk	White	--	Single	Z	35 s	20	3.38		
2.	Cotton x Ahimsa silk dress material (D_C)	Warp	Cotton	Blue	Vat dye	Single	Z	60 s	72	9.30	16.05	Plain
		Weft	Ahimsa silk	Black	Acid dye	Single	Z	33 s	58	10.10		
3.	Art silk x Ahimsa silk dress material (D_A)	Warp	Art silk	Golden yellow	Vat dye	Single	S	44 s (120 d)	72	10.85	16.84	Plain with dobby
		Weft	Ahimsa silk	Black	Acid dye	Single	Z	34 s	57	9.77		
4.	Filature silk x Ahimsa silk dress material (D_F)	Warp	Filature silk	White	--	2 ply	S	241s (20/22d)	74	4.76	13.45	Plain
		Weft	Ahimsa silk	Maroon	Acid dye	Single	Z	35 s	62	10.49		

Dyeing procedure:

The dye bath was set with required quantity of water, 2 per cent of glacial acetic acid and 10 per cent glauber salt. The dissolved dye paste was then added to the dye bath and the temperature was raised. The degummed silk were made into hanks and were suspended on smooth steel rods and immersed in dye bath. The temperature was gradually raised to 60 °C to 75 °C and dyeing was carried out at this temperature for 30 minutes. If the dye was not exhausted within the stipulated period of dyeing time, 1 to 2% of acetic acid was added and the sample was treated for another 10-15 minutes. After dyeing the sample was rinsed thoroughly in cold water, squeezed and shade dried (Plate 11).

Colours	% Shade number	Dyed samples
Yellow	1.5 % yellow GL	
Red	4.0 % Red G	
Dark Brown	2.4 % Dark brown SR	
Black	5.0 % Black RBL Suprol	

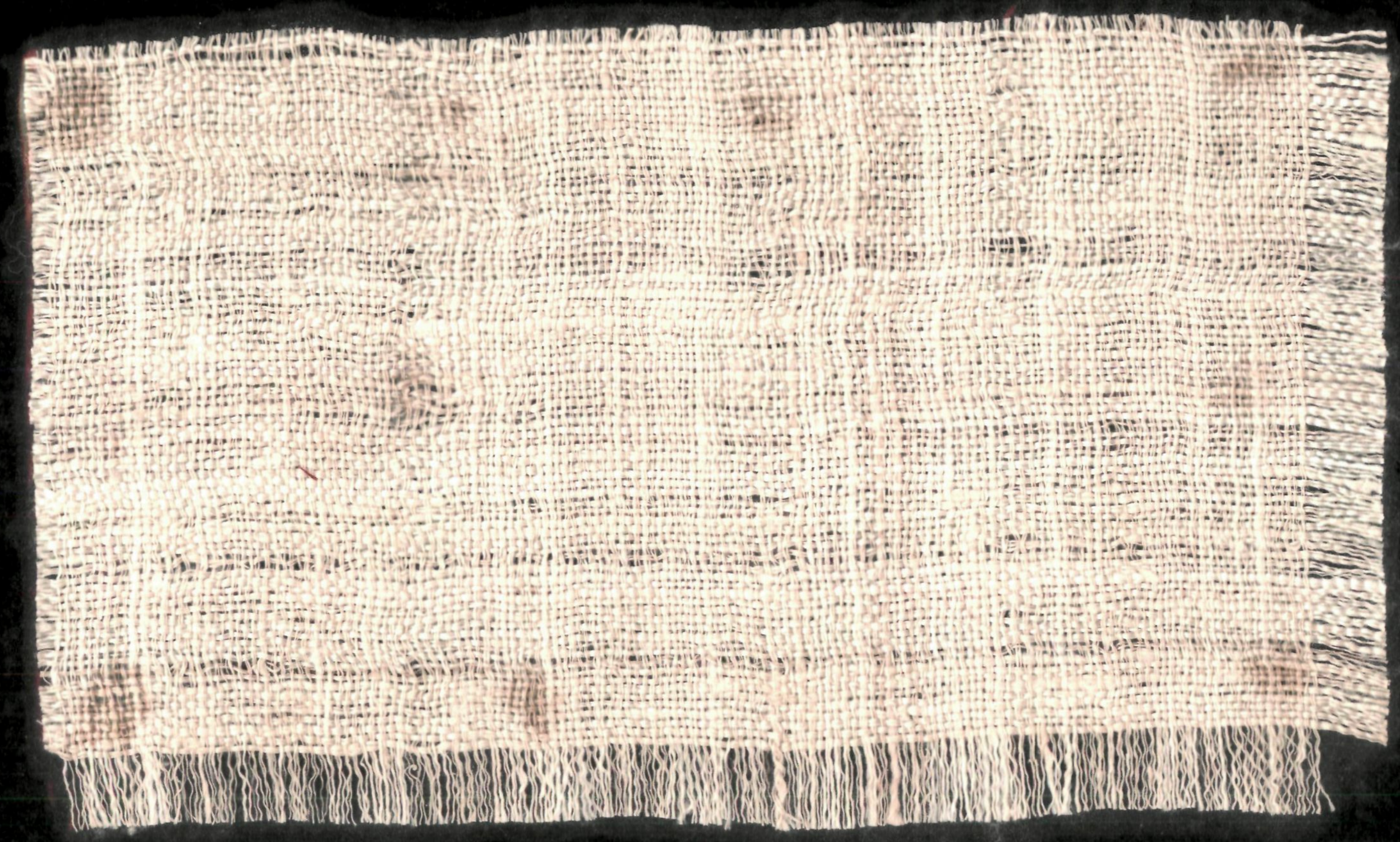


Plate 12: Control sample (Ahimsa Silk x Ahimsa silk)

Plate 13: Cotton x Ahimsa silk dress material

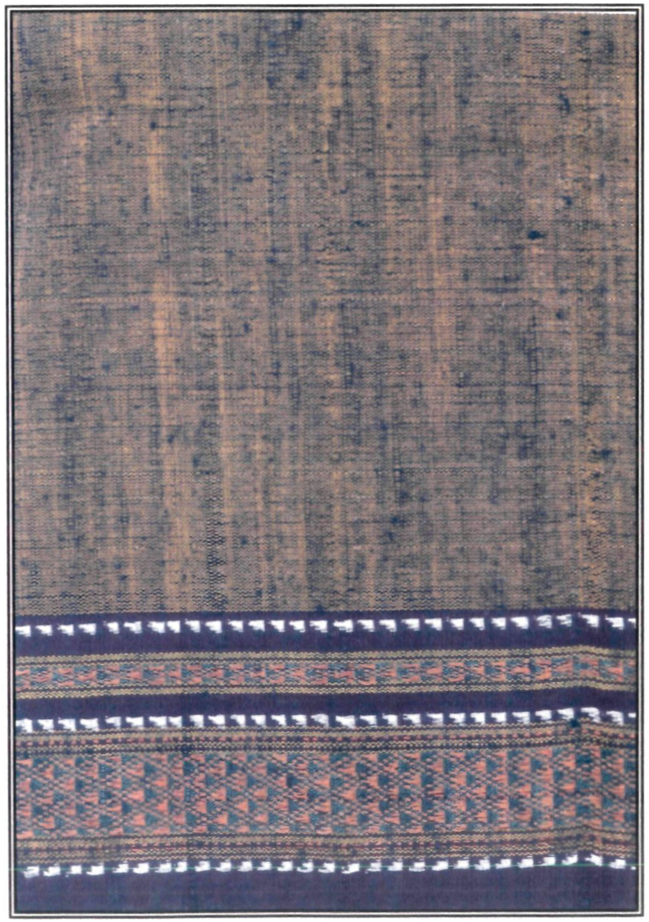


Plate 14: Art silk x Ahimsa silk dress material (D_A)


Plate 15: Filature silk x Ahimsa silk dress material (D_F)

Table 1b. Fabric information of newly designed shirting materials

Sl. No.	Shirting materials	Direction	Fibre Content	Colour Composition	Dye Composition	Yarn type	Twist Direction	Yarn Count (Ne/d)	Threads/ inch	Cover factor	Cloth cover	Weave type
1.	Cotton x Ahimsa silk shirting (S_C)	Warp	Cotton	White	--	2 ply	Z	40 s	52	8.22	13.87	Plain
		Weft	Ahimsa silk	White	--	Single	Z	36 s	48	8.00		
2.	Tericot x Ahimsa silk shirting (S_T)	Warp	Tericot	White	--	Single	S	60 s	54	6.97	12.64	Plain
		Weft	Ahimsa silk	White	--	Single	Z	34 s	44	7.54		
3.	Filature silk x Ahimsa silk shirting (S_F)	Warp	Filature silk	White	--	2 ply	S	241 s (20/22 d)	120	7.72	17.02	Plain
		Weft	Ahimsa silk	White	--	Single	Z	35 s	76	12.85		

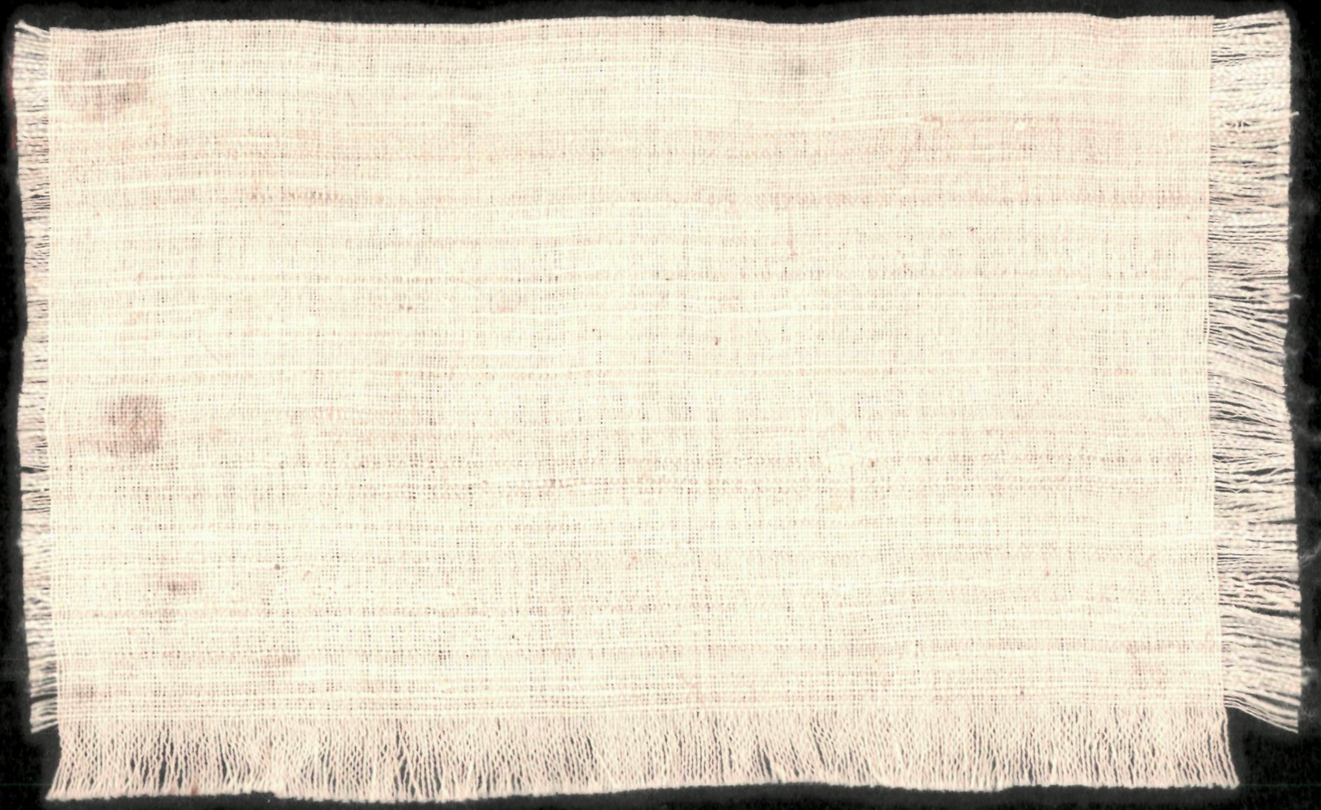


Plate 16: Cotton x Ahimsa silk Shirting material (Sc)

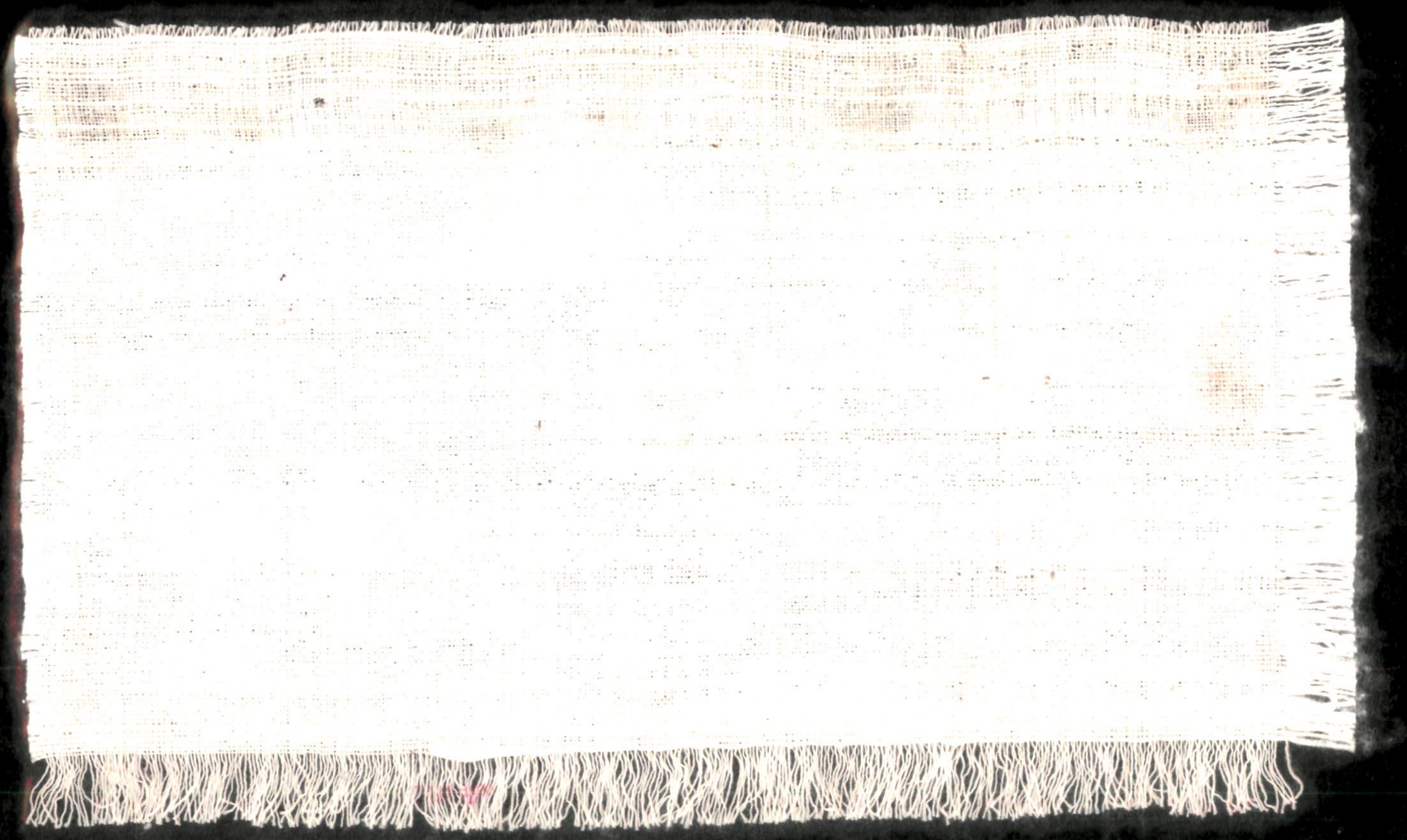


Plate 17: Tericot x Ahimsa silk Shirting material (S_T)

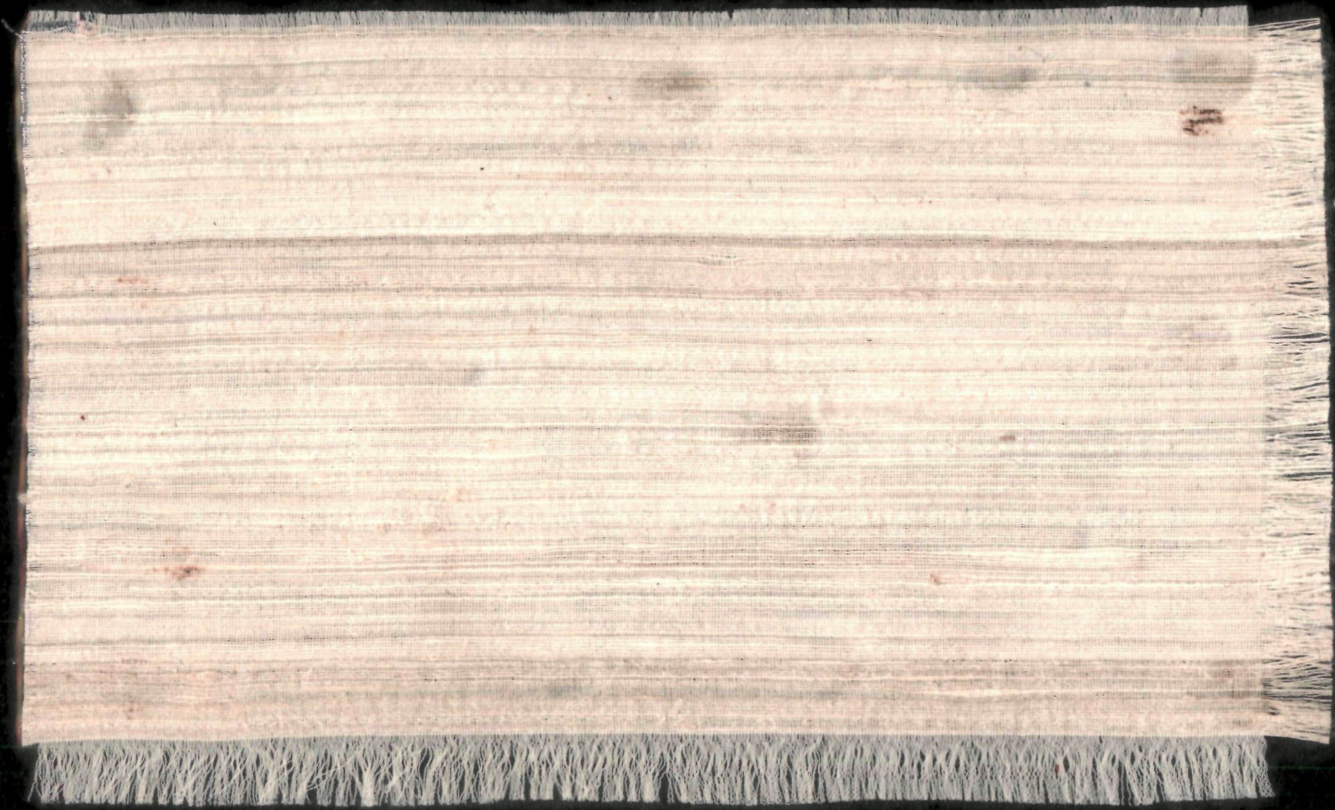


Plate 18: Filature silk x Ahimsa silk Shirting material (S_F)

Table 1c. Fabric information of newly designed furnishing materials

Sl. No.	Furnishing materials	Direction	Fibre Content	Colour Composition	Dye Composition	Yarn type	Twist Direction	Yarn Count (Ne/d)	Threads /inch	Cover factor	Cloth cover	Weave type
1.	Cotton x Ahimsa silk furnishing (F_C - Floral)	Warp	Cotton	White	--	2 ply	Z	40 s	60	9.67	12.98	Fancy
		Weft	Ahimsa silk	Red	Acid	Single	Z	33 s	30	5.21		
2.	Cotton x Ahimsa silk furnishing (F_C - Geometrical)	Warp	Cotton	White	--	Single	S	40 s	60	9.67	14.16	Fancy
		Weft	Ahimsa silk	White	--	Single	Z	34 s	40	6.86		
3.	Polyester x Ahimsa silk furnishing (F_P)	Warp	Polyester	Brown	Vat	2 ply	S	34 s 155 d	48	8.23	16.35	Fancy
		Weft	Ahimsa silk	Dark brown	Acid	Single	Z	35 s	68	11.50		

Plate 19: Cotton x Ahimsa silk Furnishing material (F_C - Floral)

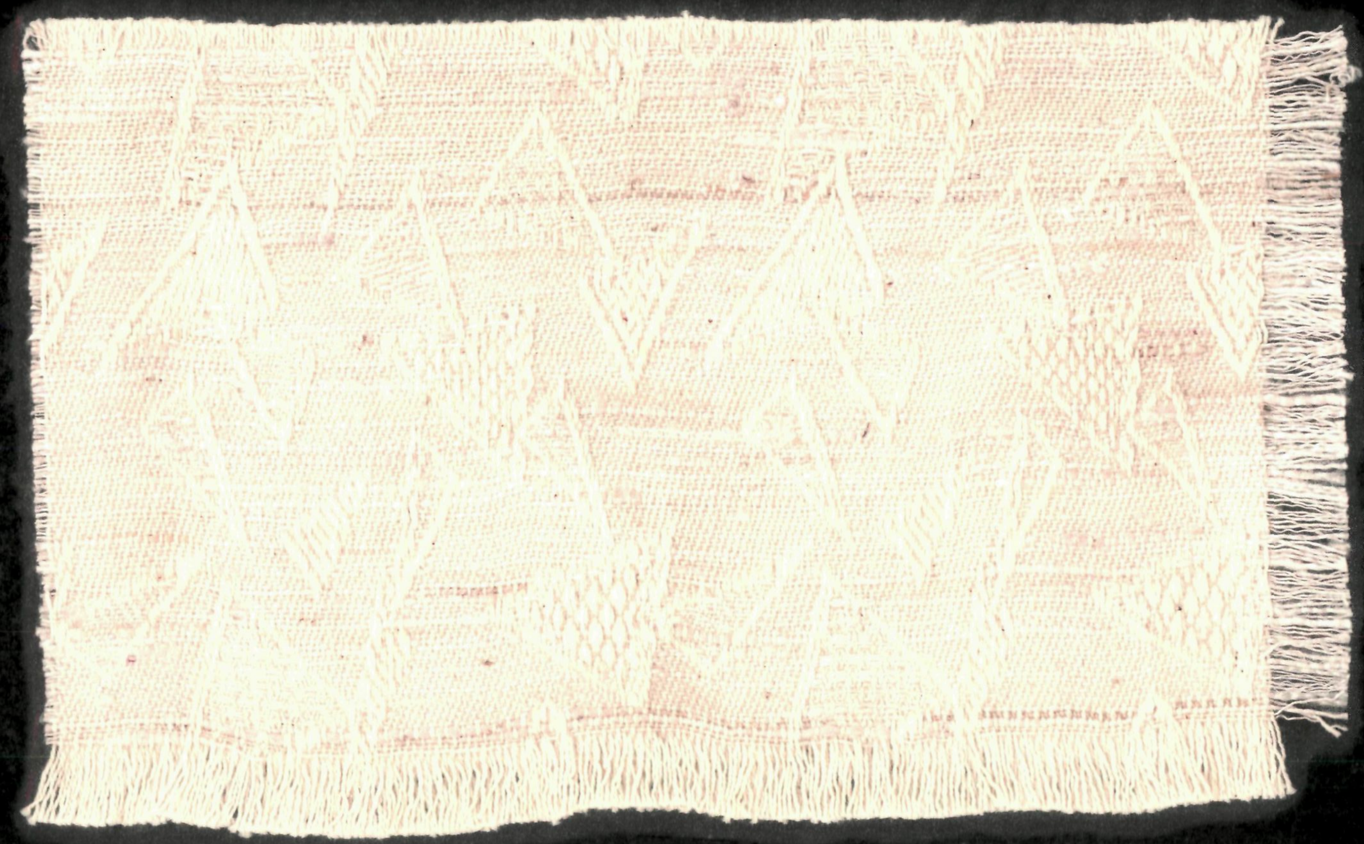


Plate 20: Cotton x Ahimsa silk Furnishing material (Fc - Geometrical)

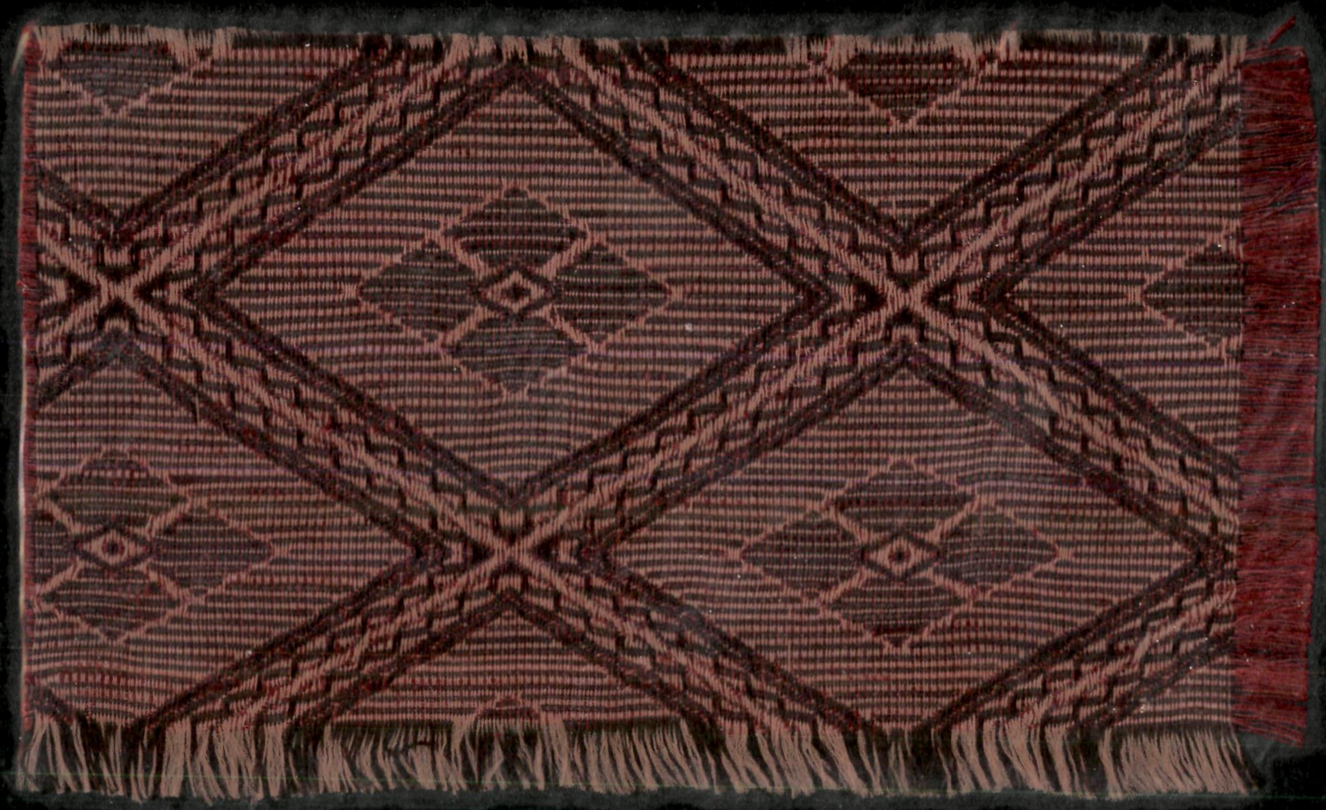


Plate 21: Polyester x Ahimsa silk Furnishing material (Fp)

3.8.1 Assessment of mechanical properties of newly designed made-ups

The fabric is woven either manually or mechanically on handloom or power loom respectively. Weaving may be simple or complex but ultimately it is the manipulation in interlacement order of ends and picks that depended on type of yarn, weave, loom and shedding mechanism. Thus mechanical properties of any woven fabric is the complex of all these features that provide basic texture, hand and feel and dimensions of the fabric and inturn affect the functional properties. Following are the mechanical properties assessed in the present study.

3.8.1.1 Yarn Count (Ne)

The information on yarn count of Cotton, Tericot, Art silk, Polyester and Filature silk was obtained from the respective weaving centres.

3.8.1.2 Cloth count (numerical expression)

Cloth count, in woven textiles is the number of warp yarns (ends) and filling yarns (Picks) per unit area, while the fabric is held under zero tension and is free from folds and winkles.

The number of warp and weft yarns per unit area are determined by using a suitable magnifying pick glass.

The number of warp yarns in one inch of fabric width is counted at ten randomly designed places across the width of the fabric sample, so that a different set of yarn is counted each time. Successively filling yarns count was also taken at ten different randomly designated points along the length of the fabric.

Number of specimen tested	: 10 each warp and weft
Method	: Direct counting the treads per unit area, 1 inch.
Name of the instrument	: Magnifying counting device, pick glass

Further the mean values of ends and picks per inch are calculated.

3.8.1.3 Cloth Weight (g/sq. mt)

Cloth weight is expressed either as mass per unit area or g/sq mt. a sample of 5X5 cm is cut and weighted on electronic weighing balance to determine the weight per square meter (g). Further warp and weft threads are separated and weighed to calculate the per cent of warp and weft. The percentage composition of warp and weft is calculated as follows.

Weight of 5 X 5 cm sample	= a gm
Weight of warp yarns	= b gm
Weight of weft yarns	=c gm

Therefore,

$$\text{Per cent of warp} = \frac{100 \text{ x b}}{\text{a}}$$

$$\text{Per cent of weft} = \frac{100 \text{ x c}}{\text{A}}$$

Number of specimen tested : 5

Name of the instrument : Electronic weighting balance

3.8.1.4 Cloth thickness (mm)

Thickness is the distance between one surface its opposite in textile, the distance between the upper and lower surface of the material, measured under a specified pressure.

The specimens were tested as directed in ASTM test method D. 1777-1975.

The average thickness of the material is determined by observing the linear distance that a movable plane is displaced from a parallel surface by the textile material while under a specified pressure.

The specimen taken were free from folds, crushing or distortions abnormal to the material.

Place the specimen on the anvil of the apparatus and bring the pressure foot into contact with the opposite side of the material and record the thickness in mm.

Shape of the anvil : Round

Area of the anvil : 1 cm diameter

Shape of the presser foot : Round

Number of specimen tested : 15

Name if the instrument : Shirley's thickness tester

3.8.1.5 Cloth stiffness (cm)

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. It equals half the length of rectangular strip of fabric that bends under its own weight to an angle of 41.5^0. It is also equal to the length of a rectangular strip of material that bends under its own weight to an angle 7.1^0. Bending length is expressed in centimeter.

This quantity is one of the factors that determines the manner in which fabric drapes i.e., the cloth having high bending length tends to drape stiffly.

The specimens were tested as directed in BS test methods: 3356-1961.

Place the test specimen on the platform with the scale on the top of it lengthwise and the zero of scale coinciding with the leading edge of the specimen. Start pushing the specimen along with the scale slowly and steadily when the leading edges project beyond the edges of the platform. An increasing part of the specimen overhangs and starts bending on its own weight. When two inclined lines (Of the inclined plane making an angle 41.5^0 with the horizontal) of the tester coincide, record the length of the over-handing portion from the scale.

Four readings from each specimen with each side up were taken.

Size of the specimen : 25 X 2.5 cm

Number of specimen tested : 1 with 4 readings

Name of the instrument : Shirley's stiffness tester

Further the bending length is calculated by using the formula

$$\text{Bending length} = \frac{L}{2} \text{ cm}$$

Where L, is mean length of the overhanging portion in cm.

3.8.1.6 Cloth crease recovery (degree)

This method cover the determination of wrinkle recovery of selected khadi fabrics.

The specimens were tested as directed in AATCC test method 66-1975.

The test specimen is creased for a definite period of time at a known load and then allowed to recover or to regain its crease. The recovery was measured in terms of the extent of angle to which it has been recovered.

Size of the specimen : 5 X 2.5 cm

Weight/load applied : 2 Kg

Creasing period : 5 min

Recovery period : 5 min

Number of specimen tested : 5 each warp and weft

Name of the instrument : Crease recovery tester

Further, cloth crease recovery is determined by using the formula

Cloth crease recovery = √Warp way angle X √weft way angle

3.8.2 Assessment of functional properties of newly designed made-ups

Any fabric produced on handloom, powers loom or in mill sector need to perform the intended functions satisfactorily. In other words money spent on clothes should serves the purpose and gives maximum satisfaction to the consumer. Of the several functional properties, durability or serviceability is the most important one that depends on the most important functional parameters assessed for durability of the selected fabrics.

3.8.2.1 Cloth tensile strength (kgf) and Elongation (%)

Tensile strength is the ability of the material to resist strain or rupture induced by external force. It is expressed as force/unit cross sectional area of the specimen at the time of maximum load.

The specimens were tested as directed in IS test method: 12676-1989.

The method employed to determine the breaking load of the materials is by using the 'raveled strip test'. The specimen was 5 cm wide piece of fabric prepared by initially cutting the material to a width of about 7 cm and raveling the threads from both until the width has attained 5 cm. The test length is 20 cm in between the jaws, so extra length was taken for gripping in the jaws. The reading for elongation at break was recorded simultaneously and expressed in terms of per cent.

Size of the specimen	: 20 X 5 cm
Number of specimen tested	: 10
Test method	: Raveled strip test
Load range	: 200 kg force
Extension range	: 300 mm/min
Gauge length	: 203.00 mm
Approach speed	: 500 mm/min
Name of the instrument	: Hounsfield universal testing machine

3.8.2.2 Cloth tear strength (g)

Cloth tearing strength is the force required to tear the fabric it is the average force required to continue a tear previously initiated in a fabric by twice the length of tear.

The specimen was tested as directed in IS test method: 6489-1971.

This method covers the procedure for the determination of average force required to propagate a single-rip tounge type tear, stating from a cut in a woven fabric by means of Elemendorf tear tester.

The average force required to continue a tongue type in a fabric was determined by measuring the work done in tearing it through a fixed distance. The tester consisted of a sector-shaped pendulum is in the raised staring position with maximum potential energy. The specimen was mounted in the clamps and the tear was initiated by a slit in the specimen between the clamps. The pendulum is than released and the specimen was torn as the moving jaw swing away from the fixed one. The scale attached to the pendulum is so graduated as to read directly the tearing force in grams.

The selected capacity of apparatus is such that the specimen shall tear between 20 and 60 per cent of the scale value.

The falling pendulum (Elemendorf) type has three capacities ranging from 0 to 1600 g, 0 to 3200 g and 0 to 6400 g and a scale reading directly in hectograms (100 g unit) for each capacity so as to provide for a wide range of fabrics and convenience in reading results.

The cutting provided the basic rectangular test specimen 100±2 mm long by 63±0.15 mm wide along with additional fabric at the top edge of the specimen to ensure the last yarns being torn during the test by preventing or minimizing their raveling. The critical dimension of the test specimen is distance of 43±0.15mm, which is torn during the test.

The improved die modal has two new features namely a cut out for the bottom of the specimen to aid in centering it in the clamps and provision for cutting the 20.0 mm slit (the initial cut) prior to inserting the specimen in the tester.

Size of the specimen	= 10 cm long X 7.5 wide
Critical dimension of the test specimen	= 4.5 cm
Number of specimen tested	= 5 each warp and weft
Tearing force	= 3200 g
Name of the instrument	= Elemendorf tear tester

Further, tear strength (g) is calculated by using the formula.

Mean tearing strength (g) = K X mean value of scale reading

Where the value of K is

16 = without any augmenting weight

32 = with augmenting weight for 3200 g

64 = with both augmenting weights

3.8.2.3 Cloth abrasion resistance (cycles)

Cloth abrasion is the wearing away of any part of material by rubbing against another surface. The specimen is abraded by rubbing multidirectionally against an abradant having specified surface characteristics held in a fixed position without any creases. The pills of matted fibres interfering with proper contact between the specimen and abradant during the test were removed as they would cause a marked vibration of the abradant plate.

The specimen was abraded until a hole was formed and the number of cycles were noted. Further, the estimation of degree of wear is determined by loss in mass and thickness of the fabric.

Size of the specimen	= 13.5 cm (diameter)
Number of specimen tested	= 4
Type of abradant	= Silicon carbide water proof paper, 180 F
Type of abrasion	= Multidirectional
Determination of end point	= Formation of hole
Name of the instrument	= Martindale's abrasion tester

Further, loss in thickness and loss in mass calculated by using these formulas.

$$\text{Loss in thickness (\%)} = \frac{\text{Initial thickness} - \text{Final thickness}}{\text{Initial thickness}} \times 100$$

$$\text{Loss in mass (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

3.8.2.4 Cloth drapability (%)

Drape is the one of the subjective characteristic of fabric that contributes to aesthetic appear. Fabric drape is the extent to which a fabric deform when it is allowed to hang under its own weight.

Drape coefficient is the area covered by the shadow of the draped specimen expressed as percentage of the area of the annular ring of fabric.

The specimens were tested as directed in IS:8357-77

A specimen was cut by means of a circular template, which is sandwiched between two horizontal discs of smaller diameter and the unsupported annual ring of fabric is allowed to hang down. On switching the lamp, it gives a circular parallel beam of light and falls on the cloth. A known dimension of ammonia sheet (printing paper) was placed on the base plate with sensitive side up, laying flat. The line of vision was kept along the baseboard and the height of the lower fringe of specimen was adjusted so that it was about 2 inches above the paper. The time setting knob was adjusted to 4 min, the green pilot lamp lit up, hen the buzzer alarm was switched on. At the end of exposure time, when the buzzer alarm rang and the ammonia paper removed, rolled and placed in the developing box where strong ammonia solution was kept. The lid was shut air tight, after four minutes, the drape pattern was ready.

Further, drape coefficient is calculated by

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

Where,

AD = Area of specimen

Ad = Area of supporting disc

As = Actual projected area of specimen

Size of the specimen = 25 cm diameter

Size of the printing paper= 29 X 29 cm

Name of the instrument = BTRA drape meter

3.8.2.5 Cloth pilling (Rating)

Pills are the balls or bunches of tangled fibres are held to the surface of a fabric by one or more fibres. Pilling resistance is the resistance to form pills on a textile fabric. This method covers the determination of resistance to the formation of pills and other related surface changes on textile fabrics.

The specimen were tested as directed in IS test method: 10971-1984.

The fabric piece measuring 5 X 5 sq. inch was sewn so as to be firm fit when placed around a rubber tube of 5 inch, 1¼ inch outside diameter and 1/8 inch thick, which is then rotated at 60 rev/min for 5 hours to complete 18,000 revolutions.

After tumbling the extent of pilling was assessed visually by comparing with the arbitrary standards-1, 2, 3, 4, and 5.

Rating scale

1 – No pilling

2 – Slight but tolerable pilling

3 – Moderate pilling

4 – Severe pilling

5 – Extremely high pilling

Size of the specimen	= 12.5 X 12.5 sq. inch
Number of specimen tested	= 4
Name of the instrument	= Heal's pilling tester

3.9 Subjective evaluation of newly designed made-ups

A panel of 25 textile experts comprising of faculty members and PG student of Department of Textile and Clothing, College of Rural Home Science, UAS, Dharwad and faculty of Central Silk Board (CSB) Rayapura, Dharwad carried out the visual assessment of newly woven fabrics using pre tested questionnaires.

Appearance, handle and texture were the three tactile properties assessed by ranking method. Further the results were expressed in terms of percentages and weighted average ranking wherever appropriate.

3.10 Variables included for the study

3.10.1 Independent variables

1. Age of the respondents
2. Education of the respondents
3. Occupation of the respondents
4. Yarn count (Ne)
5. Cloth count (Numerical expression)
6. Cloth weight (g/sq. mt)
7. Cloth thickness (mm)
8. Cloth crease recovery (degree)
9. Cloth stiffness (cm)

3.10.2 Dependent variables

1. Cloth tensile strength (kgf) and elongation (%)
2. Cloth abrasion resistance (cycles)
3. Cloth drapability (%)

3.10.3 Classification of independent variables

3.10.3.1 Age of the respondents

Based on the age, the judges were classified into three groups using the statistical formula $\overline{X} \pm 0.425$ S.D

3.10.3.2 Education of the respondents

The respondents were grouped based on their education as stated by them *i.e.* degree, post graduation and Ph.D

3.10.3.3 Occupation of the respondents

The respondents were classified broadly into two categories *viz.*, employed and unemployed.

3.11 Economics of newly designed made-ups

The fixed cost and variable cost of the newly designed made-ups were calculated for cost comparison. Depreciation was worked out at the rate of 10 per cent per annum on the fixed costs and thus apportioned for the weaving of different materials taking into account the time required for weaving per meter of cloth.

Interest on working capital was calculated at the rate of 9 per cent per annum and then apportioned to different materials considering the period of capital lacking in the form of raw material and finished products.

3.12 Statistical Analysis

The data were analyzed by using frequency tables. Percentages were calculated for subjective evaluation. The result obtained was subjected to statistical analysis by using completely randomized design.

Coefficient of determination (R^2) was calculated to know the effect of mechanical properties on functional properties using the formula,

$$R^2 = \frac{\text{Sum of squares due to multiple regression}}{\text{Total sum of squares.}}$$

To know the individual effect of all the independent variables on the dependent variable multiple regression was carried out using the formula

$Y= a+b_1x_1+b_2x_2+$-------------------------b_nx_n

$x_1.x_2.$-----------------x_n= Independent variables

$b_1.b_2.$-----------------b_n= Dependent variables, (Regression coefficients)

Weighted rank average was calculated by using the following formula

$$\text{Weighted rank average} = \frac{\text{E Rank x No. of Respondents}}{\text{Total number of Respondents}}$$

Ranking was given in an ascending order *i.e.*, first rank with less value and last rank with highest value was given and is presented at the end of frequency and percentage tables.

3.13 Hypothesis set for the study.

- There is no effect of cooking media on physical properties of Ahimsa silk.
- Mechanical properties does not influence the functional properties of newly designed made-ups.

RESULTS

IV. RESULTS

The results pertaining to the study entitled "Designing textile made-ups from Ahimsa silk" are presented under the following headings.

4.1 Cooking and spinning of mulberry pierced cocoons

4.2 Physical testing of Ahimsa silk yarn

4.3 Weaving of newly designed made-ups

4.4 Physical testing of newly designed made-ups

4.4.1 Mechanical properties of newly designed dress materials

4.4.2 Functional properties of newly designed dress materials

4.4.3 Mechanical properties of newly designed shirtings

4.4.4 Functional properties of newly designed shirtings

4.4.5 Mechanical properties of newly designed furnishings

4.4.6 Functional properties of newly designed furnishings

4.5 Subjective evaluation of newly designed made-ups

4.6 Economic analysis of newly designed made-ups

4.1 Cooking and spinning of mulberry pierced cocoons

The objective of the cocoon cooking is to soften and swell the sericin present on the silk filament and remain in the softened form until spinning is completed. During cocoon formation the viscous fluid of the fibroin is hardened on exposure to atmospheric air. The liquid sericin covering the fibroin does harden and adheres to the portion of the filament laid by the silk worm. As the sericin dries, the cocoon shell becomes hard and compact. The hardened sericin was softened by treating the cocoons with hot water, a routine practice or by chemicals *viz.*, soap + soda, Ezee detergent and oxyphon oil that loosens the cocoon structure to facilitate unwinding of the filament with minimum tension during spinning.

It is clear from Table 2 that in the media of soap + soda cooking the cocoons were remarkably softened when worked at a shorter period of 1.15 hours compared to Ezee detergent (2.15 hours). Relatively greater time to soften the cocoons was taken by boiling in oxyphon oil (3.30 hours) and plain water (4 hours). Further it was possible to extract greater length of silk yarn (130 g) when boiled in soap + soda followed by Ezee detergent (105 g) and oxyphon oil (90 g). On the other hand minimum length was obtained when cooked in plain water (80 g). Hence the cocoons cooked with soap + soda media was used for the study.

4.2 Physical testing of Ahimsa silk yarn

Table 3 depicts that cocoons cooked in soap + soda and Ezee detergent recorded finer yarn count and higher TPM (Turns Per Meter) of 232 and 254. Further the silk with coarser count and lesser TPM was observed when cooked in oxyphon oil (29.75 and 155) and plain water (28.65 and 176).

Greater tensile strength (1.87) with elongation (7.34) was registered for cocoons cooked in Ezee detergent followed by plain water (1.82 and 6.95). A

Table 2. Cooking and spinning performance of pierced (pc) cocoons cooked under different media

Name of cooking media	Cooking time (hr)	Yarn obtained /8 hrs. (g)
Plain water	4	80
Soap + soda	1.15	130
Ezee detergent	2.15	105
Oxyphon oil	3.30	90

trend of decrease in tensile strength and elongation was noticed in soap + soda (1.67 and 6.75) and oxyphon oil (1.45 and 6.90).

Analysis of variance for four cooking media and four physical parameters is presented in Table 3. ANOVA indicated that there was significant difference in physical parameters of silk yarn when cooked in different cooking media.

Degumming of silk yarn

The removal of sericin, the silk gum from the raw silk material is one of the most important steps in processing of silk material. The process of eliminating the gum from raw silk or silk waste is known as degumming and is generally carried out by treating with soap + soda. Degumming with soap and soda helps to maintain the softness and is the most widely utilized degumming process in both organized and decentralized factories. The effectiveness of degumming treatment is assessed by the extent of removal of sericin. Since the residual sericin on the material cannot be estimated by any direct method of analysis, in most cases the progress of degumming is assessed in terms of percentage loss of weight.

Table 4 depicts the degumming loss when cooked in selected cooking media. It was found that greater amount of weight loss was noticed when cooked in plain water *i.e.*, 12.11 per cent followed by Ezee detergent (10.25%) and oxyphon oil (8.85 %) cooking medias. On the other hand minimum weight loss was observed when cooked with soap + soda *i.e.*, 6.27 per cent only.

Table 3. Effect of different cooking media on physical properties of Ahimsa silk yarn

Sl. No.	Physical properties	Cooking media			
		Plain water	Soap + soda	Ezee detergent	Oxyphon oil
1.	Average size (NM)	28.65	35.4	32.5	29.75
2.	Average twist (TPM)	176	232	254	155
3.	Average tenacity (kgf)	1.82	1.67	1.87	1.45
4.	Elongation (%)	6.95	6.75	7.34	6.90

Source	F value	Probability	Sem±	CD	CV (%)
Average size (NM)	6292.5806**	0.0000	0.0426	1.778	0.27
Average twist (TPM)	4312.5000**	0.0000	0.7906	3.450	0.77
Average tenacity (kgf)	528.3734**	0.0000	0.0091	0.039	1.07
Elongation (%)	1185.6240**	0.0000	0.0082	0.358	0.23

** = Significant at 1 per cent

Table 4. Effect of different cooking media on degumming loss of Ahimsa silk yarn

Cooking media	Degumming loss (%)
Plain water	12.11
Soap + soda	6.27
Ezee detergent	10.25
Oxyphon oil	8.85

Source	F value	Probability	Sem±	CD	CV (%)
Degumming loss (%)	36.5315**	0.0003	0.3524	1.538	4.52

** = **Significant at 1 per cent**

Analysis of variance for four cooking medias and degumming loss (%) is presented in Table 4. ANOVA indicated that there was significant difference in degumming loss (%) when silk yarn was cooked in different media.

4.3 Weaving of newly designed made-ups

The technique of weaving fundamentally means the interlacment of lengthwise threads, the warp with crosswise threads, the fillings. In weaving it is possible to interlace the warp and filling threads at right angles to each other according to a pre-arranged plan or design. For the present study cotton, art silk (Rayon), polyester and filature silk yarns as warp were interwoven with Ahimsa silk as weft. Production of newly designed made-ups involved various process like pre loom, loom process and particulars, post loom, which are dealt separately in this chapter.

4.3.1 Weaving of Ahimsa silk x Ahimsa silk material (Control sample)
Pre loom processes

The control sample was woven with Ahimsa silk as both warp and weft to compare the properties of which with that of newly designed made-ups. The control sample underwent various pre loom processes like bobbin winding, warping, beaming and pirn winding.

- **Bobbin winding**

The Ahimsa silk hank was transferred on to plastic bobbins with the aid of winding wheel to obtain a continuous thread for greater length. Simultaneously minor spinning defects in the yarn was corrected (Plate 22).

Plate 22: Bobbin winding

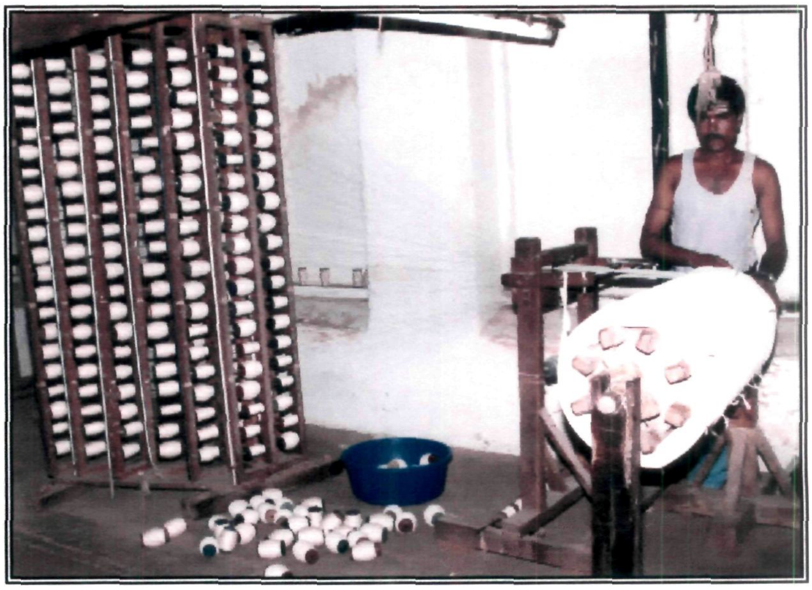


Plate 23: Combined warping and beaming

- **Warping**

The yarn was then converted into warp where sufficient number of threads was laid in parallel form under uniform tension to make the required width of the cloth. 'Sectional warping' was the technique adopted in warping.

- **Beaming**

The process of winding the previously prepared warp in the form of a sheet, on to a beam is known as beaming. The beam is often provided with disc or flanges on both the ends to maintain the required width of warp to keep in control the selvedge ends. While winding the warp on to the beam the individual threads are laid parallel to each other and are kept under uniform tension (Plate 23).

- **Pirn winder or winding wheel**

As the right hand side of the plat form a large wheel or metal bicycle wheel was fixed with a small wooden or metal handle in the center of the wheel, to rotate it in clockwise direction. On the left hand side of the wheel, a metal spindle in the platform, having pulleys in its center was carefully fitted. A strong and fine leather conveyor or cord or a cycle chain or even strong twine was used to connect the large wheel to the pulley. When the wheel rotates the spindle also revolves automatically at a much greater speed. The tapered and elongated projected spindle, the pirn or spool is fixed and filing yarn is wound on it.

➢ Pirn winding

Pirn winding, a process of transferring the weft yarn from hand reel onto the pirn and was manually performed. In the present study the Ahimsa silk yarn always formed the weft, which shot across the width of the cloth. Most of the times pirn winding is carried out by children, young and older women (a skill oriented task). Pirn winder is an important adjunct to the loom since successful weaving depends a good winding. Hand charaka or winding wheel was used to fill the pirn (Plate 24).

Loom process

➢ Loom particulars and weaving of control sample

Loom was set with all necessary parts before weaving. Control sample was woven on pit loom with reed count of 24, 2 threads/ dent, reed width of 28 inch and cloth width of 36 inch (Table 5 and Plate 25).

➢ Cutting and doffing of the control sample

After weaving a known length of material an extra length of approximately an inch was woven and separated from the cloth beam with the help of knife. This however, helped to prevent the slippage of yarns through the dents.

Post loom processes

The woven control sample was examined for flaws, folded and packed neatly.

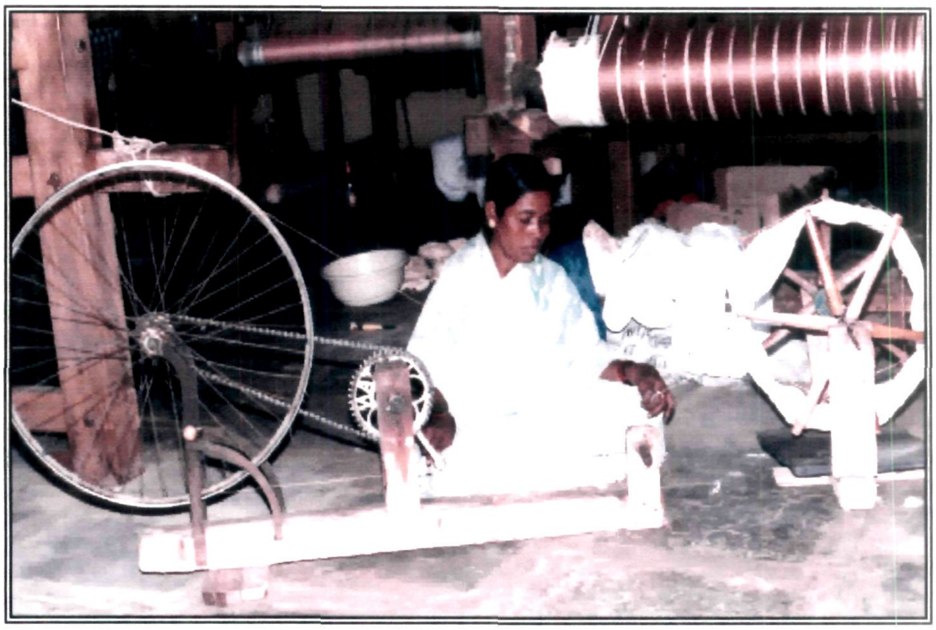


Plate 24: Pirn winding

Plate 25: Weaving of control sample

4.3.2 Weaving of newly designed dress materials

Weaving technique for all the three dress materials i.e. Cotton x Ahimsa silk (D_C), Art silk X Ahimsa silk (D_A) and Filature silk x Ahimsa silk (D_F) were woven at Karnataka Handloom Development Corporation Ltd. (KHDC), Ilkal and Guledgudda which are dealt here under in detail.

4.3.2.1 Weaving of Cotton x Ahimsa silk Dress material (D_C)

Pre loom process

KHDC centre, Ilkal procures the ready cotton warp in the form of dyed balls from Chirala and Vijayawada (Andhra Pradesh), which has already undergone various preparatory processes like scouring, bleaching and dyeing. This ball warp of known length is sufficient to weave the cloth of recommended length and breadth. This dyed warp in a package of ball was then subjected to sizing.

- **Sizing cotton dyed ball**

The dyed warp is unsuitable for weaving hence, is sized to withstand the strain and friction caused during weaving. The local weavers follow the primitive technique of sizing where appropriate quantity of starch powered is dissolved in cold water, sufficient to soak ball warp for about 15 mins.

- **Twisting and Joining (Piece work)**

Twisting and joining was the technique employed to join the warp ends together, i.e. two strands of new warp are joined to each end of previous warp. This job work is exclusively handled by skilled and experienced women, since any little error or fault in joining the warp ends may not only ruin the basic pattern of the weave but also creates lots of problems while weaving because of the faulty weave and entanglement of warps. This new warp was later gaited also known as 'dressing the loom'. A certain length of surplus warp was extended behind the loom according to the desired length and conveniently divided into four or six sections and were tied securely to the bamboo stave at the back of the loom to facilitate weaving (Plate 26).

- **Pirn winding**

The procedure of pirn winding is similar to that of control sample (4.3.1).

Loom process

- **Loom particulars and weaving of Cotton x Ahimsa silk dress material**

The salwar suit was woven on pit loom with reed count of 72, 2 threads /dent, reed width of 42 inch and cloth width of 40 inch. The made-ups for kameez, salwar and veil were woven on three separate pit looms to achieve different colour combinations (Table 5 and Plate 27 & 28).

- **Cutting and doffing of the dress material**

After completion of known length of dress material an extra length of approximately an inch was woven and separated from the cloth beam with the help of knife. This however, helped to prevent the slippage of yarns through the dents.

Table 5. Loom particulars for newly designed dress materials

Sl. No.	Particulars	Control	Dress material		
			D_C	D_A	D_F
1.	Type of loom	Fly shuttle pit loom	Fly shuttle pit loom	Fly shuttle Pit loom with dobby	Fly shuttle pit loom
2.	Reed count				
	Body	24s	72s	72s	74s
	Border	24s	72s	100s	74s
3.	Reed width	28″	42″	42″	42″
4.	Cloth width	36″	40″	40″	40″
5.	Denting order	2/dent	2/dent	2/dent	2/dent

Plate 26: Twisting and joining (piece work)

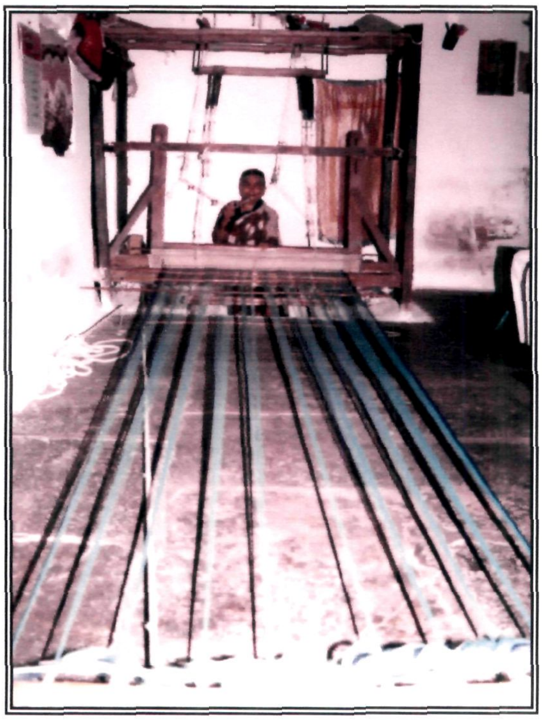


Plate 27: Fly shuttle pitloom

Plate 28: Weaving Cotton x Ahimsa silk dress material (D_C)

Post loom processes

The woven dress material for kameez, salwar and veil were examined for flaws, folded and packed neatly.

4.3.2.2 Weaving of Art silk x Ahimsa silk Dress material (D_A)

Pre loom processes

Art silk of bright colours were purchased by KHDC centre from Vadodhara (Gujarat) and Mumbai (Maharastra) and was subjected to various pre loom processes, mentioned below:

- **Warping frame / board**

To weave any great length of material on a loom, it is necessary to have longer warp threads than the required for a single small article, achieved by warping on a warping board. Warping board is a square framework of wood with pegs arranged in such positions that a definite number of yards may be measured off between them while winding. The purpose of the warping board is to make it possible to lay in perfect order of the required number of warp threads for the width of the cloth, to keep them in regular succession without entanglement and to make them the desired length. The method of warping focuses on the length of one thread and then to make rest of the threads of same length. The warping is accomplished on a framework by winding the yarn back and forth between the pegs arranged on the framework.

- **Warping**

Art silk yarns supplied in the form of cones were fed through each feeder, the 'bangle' knitted on a wooden stave in a row, before taken over to the warping board. This wooden stave is permanently tied to the ceiling. Now the yarns were collected in the left hand of the worker from the feeder and warping was done with right hand. Threads traveled from the feeder were tied to the first peg using slipknot and later were carried to the second peg. The process was continued until all the pegs were completed and reversed the circuit direction till it reached first peg.

In order to maintain the length of all the yarns, the threads were handled at even tension. To get the required number of warp threads forming a desired width of web, a definite number of circuits were completed during warping (Plate 29).

- **Dyeing**

Yarns were taken from warping board, were vat dyed in brilliant yellow colour shade.

- **Twisting and Joining (Piece work)**

The method of twisting was similar to that adopted for Cotton x Ahimsa silk dress material (Dc, 4.3.2.1).

- **Pirn winding**

The procedure of pirn winding is similar to that of control sample (4.3.1).

Plate 29: Warping

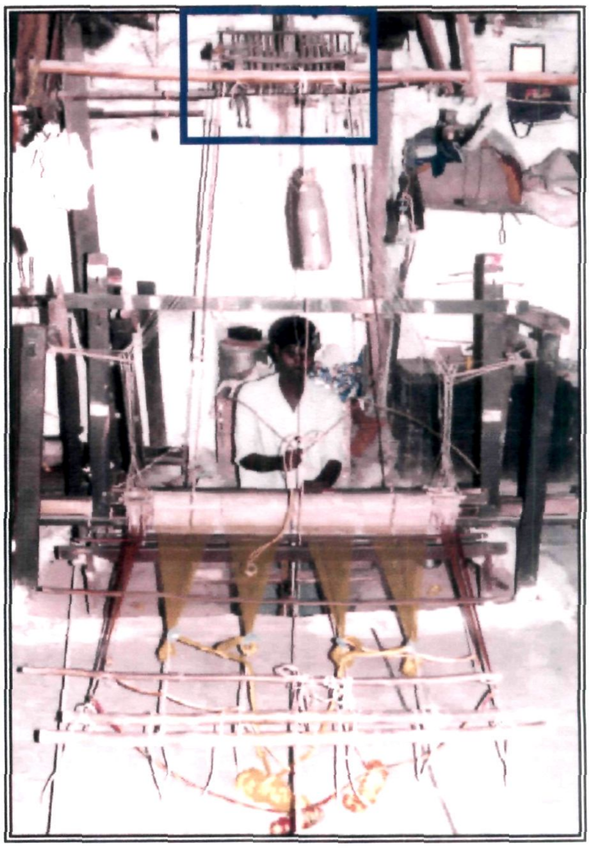


Plate 30: Fly shuttle pitloom with dobby attachment

Loom process

- **Loom particulars and weaving of Art silk x Ahimsa silk dress material**

Table 5 indicates that, the salwar suit of Art silk x Ahimsa silk was woven on pit loom with dobby attachment with reed count of 72 for body and 100 for border and reed width 42 inch. The cloth width of the suit was 40 inch and denting order was 2 threads/dent. Dobby mechanism assisted to construct extra warp designs, that could not be produced by plain, twill, and stain weaves. The designs were simple, limited in size and mostly in geometrical form. Though dobby generally control the extra warp threads in the present study, dobby mechanism assisted to produce figured motifs on either sides of the border (Plate 30 & 31).

- **Cutting and doffing of the Dress material**

The procedure is similar to that mentioned under 4.3.2.1 (D_C).

Post loom processes

The woven dress materials for kameez, salwar and veil were examined for flaws and finally folded and packed neatly to transport.

4.3.2.3 Weaving of Filature silk x Ahimsa silk Dress material (D_F)

Pre loom processes

The KHDC centre procures filature silk yarn from Karnataka Silk Marketing Board (KSMB) Bangalore, which usually under goes the following preliminary processes.

Plate 31: Weaving Art silk x Ahimsa silk dress material

- **Warp preparation**

Silk yarn in the form of 'hank' was transferred to creel section of the reeling machine, which were wound onto the wooden or plastic bobbins.

- **Doubling**

The ready bobbins were then placed on the creel section of the doubling machine according to the type of ply required for the weaving. The yarn was usually plied into two or more. During this operation a small amount of twist was inserted by traverse and finally wound on to the cones. These cones were taken to creel section of the warping machine (Plate 32).

- **Warping**

The individual yarn from each cone was taken through the tensioner and leasing section and was wound on a warping wheel having diameter of one yard with six sides each measuring one yard. The machine is manually operated and single person can operate the machine. The purpose of the warping machine is to make it possible to lay in perfect order the required number of warp threads for the width of the cloth, to keep them in regular succession, avoid entanglement and ultimately make the desired length. These yarns later slipped off from the warp wheel and made into a hank form. The ready hanks were then taken for degumming process (Plate 33).

- **Degumming**

The natural silk need to be purified before colouring. The silk need to be softened by removal of sericin and other impurities by degumming,

Plate 32: Doubling

Plate 33: Filature silk warping

which inturn imparts lustre too. The recipe of degumming solution is given below:

Soap (501 bar soap)	: 20g /kg
Soda	: 50 to100g /kg silk
MLR	: 1:30
Temperature	: boiling
Time	: 30 - 40 minutes

After treating the sample in degumming bath it was dipped in cold water successively four times, followed by squeezing out extra water and shade drying. About 25 per cent of weight was lost in degumming. The degummed silk was taken for twisting and joining process.

- **Twisting and Joining (Piece work)**

The procedure was same as that of Cotton x Ahimsa silk Dress material (D_C, 4.3.2.1).

- **Pirn Winding**

The technique of pirn winding was same as that of control sample (4.3.1)

Loom Processes

- **Loom particulars and weaving of Filature silk x Ahimsa silk Dress material**

Pit loom was employed for weaving salwar suit of Filature silk x Ahimsa silk (D_F) with reed count of 74 for both body and border and reed width of 42 inch (Table 5). However, width of the suit was 40 inch and the denting was two threads per dent. The weaving procedure followed is similar to that of Cotton x Ahimsa silk Dress material (D_C, 4.3.2.1) (Plate 34 & 35).

- **Post loom process**

The woven dress material for kameez, salwar and veil were examined for flaws, folded and packed neatly.

4.3.3 Weaving of newly designed Shirting materials

The three varieties of shirting materials *viz.*, Cotton x Ahimsa silk (S_C), Tericot x Ahimsa silk (S_T) and Filature silk x Ahimsa silk (S_F), are woven at KHDC Guledegdda, Khadhi Gromodyoga Khendra Bengeri, (Dharwad dist) and KHDC, Kallur are explained separately.

4.3.3.1 Weaving of Cotton x Ahimsa silk Shirting material (S_C)

Pre loom processes

KHDC centre procured the unbleached cotton warp from Chirala and Vijayawada (Andhra Pradesh), which was subjected for various pre loom process like sizing, twisting & joining and pirn winding, the procedure of which is similar to that explained under Cotton x Ahimsa silk Dress material (D_C, 4.3.2.1).

Loom process

- **Loom particulars and weaving of Cotton x Ahimsa silk Shirting material**

The Cotton x Ahimsa silk Shirting material (S_C) was woven on fly shuttle pit loom with reed count of 52 reed width of 42 inch, cloth width of

Plate34: Weaving Filature silk x Ahimsa silk dress material

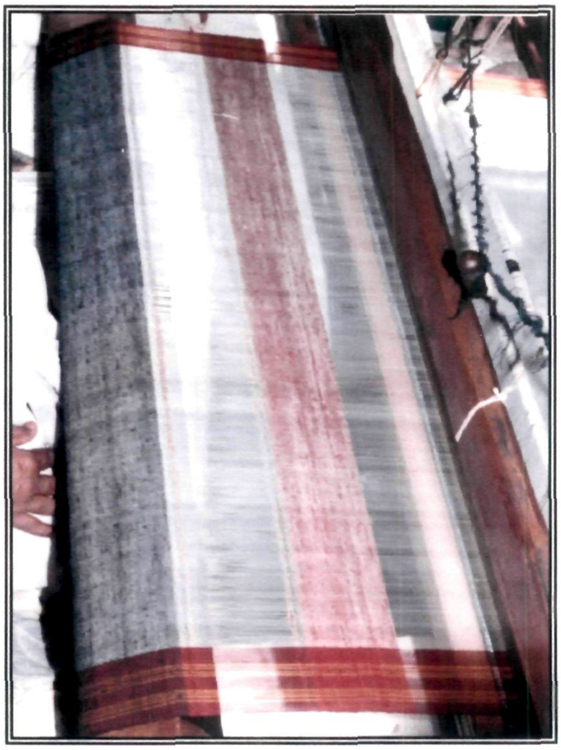


Plate 35: Close up profile of Filature silk x Ahimsa silk dress material

the material was 40 inch and denting order of 2 threads/dent (Table 6). The weaving technique employed was similar to that of Cotton x Ahimsa silk Dress material (D_C, 4.3.2.1) (Plate 36 & 37).

Post loom processes

The woven sample was examined for flaws, folded and packed neatly.

4.3.3.2 Weaving of Tericot x Ahimsa silk Shirting material (S_T)

Pre loom processes

Khadi Gramodyoga Kendra, Bengeri (Dharwad district) procured 65:35 PC blended yarn from Century Mill, Mumbai (Maharashtra), which passes through various pre loom processes like bobbin winding, warping, beaming and pirn winding, and were similar to that mentioned under 4.3.1 for control sample.

Loom process

- **Loom particulars and weaving of Tericot x Ahimsa silk Shirting material**

It is apparent from the Table-6 that Tericot x Ahimsa silk shirting material was woven on fly shuttle pit loom with reed count of 54, reed width of 40 inch, cloth width of 38 inch and denting order of passing 2 threads/dent. The weaving procedure followed is similar to that of control sample (4.3.1).

Post loom processes

The technique adopted is similar to that of Control sample explained under 4.3.1.

Table 6. Loom particulars for newly designed shirting materials

Sl. No.	Particulars	Shirting material		
		S_C	S_T	S_F
1.	Type of loom	Fly shuttle pit loom	Fly shuttle pit loom	Fly shuttle pit loom
2.	Reed count	52	54	120
3.	Reed width	42″	40″	48″
4.	Cloth width	40″	38″	46″
5.	Denting order	2/dent	2/dent	2/dent

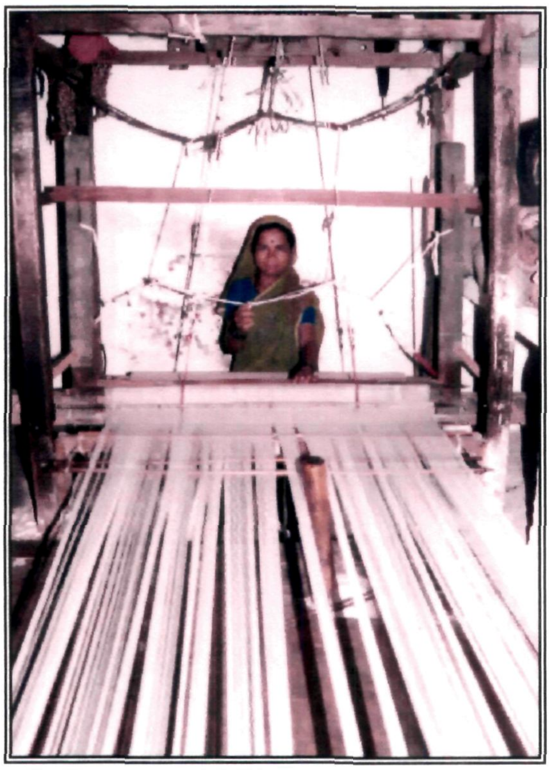


Plate 36: Weaving shirting materials

Plate 37: Side profile of weaving shirting materials

4.3.3.3 Weaving Filature silk x Ahimsa silk Shirting material (S_F)

The pre loom and post loom processes adopted for weaving Filature silk x Ahimsa silk Shirting material was similar to that of Filature silk x Ahimsa silk Dress material (D_F, 4 .3.2.3).

Loom Process

- **Loom particulars and weaving of Filature silk x Ahimsa silk Shirting material**

Pit loom was employed to weave Filature x Ahimsa silk Shirting material with reed count of 120, reed width of 48 inch, cloth width of 46 inch and denting order of 2 threads/dent (Table 6).

4.3.4 Weaving of newly designed Furnishing material

The newly designed furnishing materials of Cotton x Ahimsa silk and Polyester x Ahimsa silk were woven at Export Oriented Cotton Project (KHDC) at Gadag are explained here under:

4.3.4.1 Weaving of Cotton x Ahimsa silk Furnishing materials (F_C – Floral and Geometrical)

Pre loom process

The KHDC centre procured cotton yarns from Cotton Mill Co-operative Society at Hulkoti (Gadag District), which were subjected to various pre loom processes mentioned below:

- **Bobbin winding (Cone winding)**

Yarn in the hank form was wound with the aid of winding wheel onto a plastic bobbins to obtain a continuous thread of greater length. At the same time minor spinning defects in the yarn were rectified.

- **Warping**

Sectional warping was the method adopted to prepare the warp. Required number of bobbins were arranged on the automatic creel machine. From each bobbin thread was drawn through a small reed and finally wound onto a warp beam. The small reed acts as a guide to check the broken yarns. Approximately 200 mts of yarn is wound in each section and in total eight sections were wound to make the required width of the cloth.

- **Beaming and pirn winding**

The procedure of beaming and pirn winding is similar to that of control sample (4.3.1).

Loom processes

- **Loom particulars and weaving of Cotton x Ahimsa silk furnishing materials**

A glance at Table 7 revealed that the furnishing materials of Cotton x Ahimsa silk were woven on Hardekar Jacquared loom with reed count of 60 and reed width of 50 inch for both the varieties. However dimensions of furnishing material were of 48 inch with 4 threads/dent. Two types of Cotton x Ahimsa silk Furnishing materials were woven one with floral design

Table 7. Loom particulars for newly designed furnishing materials

Sl. No.	Particulars	Furnishing material		
		F_C Floral	F_C Geometrical	F_P
1.	Type of loom	Hardekar jacquard	Hardekar jacquard	Hardekar jacquard
2.	Reed count	60s	60s	48s
3.	Reed width	50″	50″	50″
4.	Cloth width	48″	48″	48″
5.	Denting order	4/ dent	4/dent	4/dent

and other in geometrical figure with different colour combination. The designs were produced with jacquard shedding mechanism having a capacity of 150 to 400 hooks. The KHDC procured the ready punched cards from Channamalai of Erode (Tamilnadu) (Plate 38, 39 & 40).

- **Cutting and doffing of the Furnishing materials**

After completion of required length of material an extra length of approximately an inch was woven and separated from the cloth beam with the help of knife. This however, helped to prevent the slippage of yarns through the dents.

Post loom processes

The woven materials were examined for fabric defects and flaws, finally folded and packed systematically.

4.3.4.2 Weaving of Polyester x Ahimsa silk Furnishing material (F_P)

Pre loom processes

The dyed polyester yarn was purchased in the form of cone by KHDC centre from Century Mills Bombay (Maharashtra), which was subjected to various preparatory processes like warping, beaming and pirn winding which were similar to that of Cotton x Ahimsa silk Furnishing materials (F_C, 4.3.4.1).

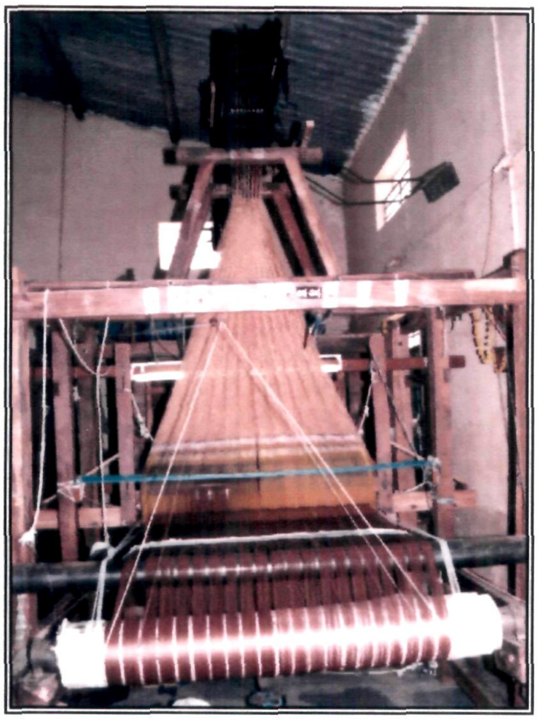


Plate 38: Hardekar jacquard loom

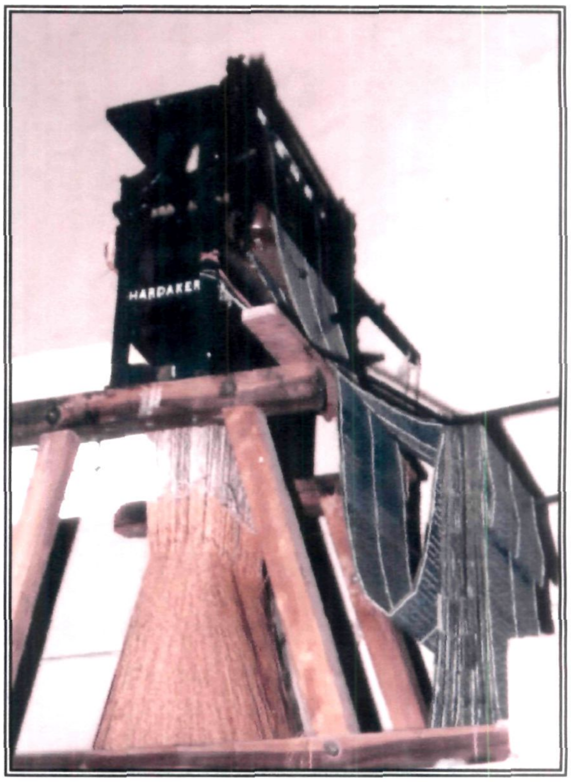


Plate 39: Close up view of jacquard mechanism

Plate 40: Weaving Jacquard furnishing materials

- **Loom particulars and weaving of Polyester x Ahimsa silk Furnishing material**

Table 7 records that, Hardekar Jacquard loom was employed to weave Polyester x Ahimsa silk Furnishing material with reed count of 48 and reed width of 50 inch, cloth width of 48 inch with 4 threads per dent.

Post Loom Process

The method employed is similar to that of Cotton x Ahimsa silk Furnishing materials (F_C, 4.3.4.1).

4.4 Physical testing of newly designed made-ups

4.4.1 Mechanical properties of newly designed Dress materials

4.4.1.1 Yarn count (Ne)

The count of yarn is a numerical expression, which defines its fineness. The two methods of determining count are Direct and Indirect systems. The spun yarns were measured in indirect system *i.e.*,cotton count (Ne) where in higher count expresses finer yarns, whereas the filaments measured in direct system expressed in terms of denier (D), higher the denier coarser the filament. The count of both warp and weft were determined separately.

It is viewed from Table 8 that, Filature silk x Ahimsa silk (D_F) dress material was woven with finer warp (241s or 20/22d) and weft (35s) compared to Cotton x Ahimsa silk (D_C) and Art silk x Ahimsa silk (D_A) *i.e.*,

Table 8: Yarn count of newly designed dress materials (Ne)

Dress materials	Direction		Yarn count	
	Warp	Weft	Warp	Weft
Control (Ahimsa silk x Ahimsa silk)	Ahimsa silk	Ahimsa silk	35s	35s
Cotton x Ahimsa silk (D_C)	Cotton	Ahimsa silk	60s	33
Art silk x Ahimsa silk (D_A)	Art silk	Ahimsa silk	44s (120 d)	34s
Filature silk x Ahimsa silk (D_F)	Filature silk	Ahimsa silk	241s (20/22 d)	35s

Source	F value	Probability	Sem±	CD	CV (%)
Warp	114968.00**	0.000	0.2887	1.51	0.53
Weft	12468.00**	0.002	0.3660	1.91	4.38

** = Significant at 1 per cent
* = Denier counted to Ne for calculation of conversion factor

60s & 33s and 44s (120d) & 34s, respectively. On the other hand control sample *i.e.* Ahimsa silk x Ahimsa silk was woven with relatively coarser warp and weft (each 35s).

Further, the simple CRD tests indicated that the yarn count of both warp and weft of newly designed dress materials is higher when compared to control, which means the yarns are significantly finer.

4.4.1.2 Cloth count (Numerical expression)

The cloth count in woven textile is the number of ends and picks per unit length as counted, while the fabric is under zero tension and free from folds and wrinkles. Cloth count which is nothing but the density of yarn *i.e.*, alignment of single, ply, cable or doubled yarns which not only influence the yarn count but also the mechanical and functional properties of the ultimate cloth.

From Table 9 it is learnt that, among all the newly designed salwar suit materials the ends per inch were greater than the picks per inch. It is clear from this table that the Filature silk x Ahimsa silk Dress materials (D_F) showed higher cloth density (74 x 62) compared to Cotton x Ahimsa silk (D_C, 72 x 58) and Art silk x Ahimsa silk (D_A, 72 x 57). However, control sample exhibited relatively low cloth density (24 x 20).

Further, the statistical results showed that the cloth count of newly designed dress materials was significantly higher compared to the control sample.

Table 9. Cloth count of newly designed dress materials (Numerical expression)

Dress material	Cloth count	
	Warp way	Weft way
Control (Ahimsa x Ahimsa silk)	24	20
Cotton x Ahimsa silk (D_C)	72	58
Art silk x Ahimsa silk (D_A)	72	57
Filature silk x Ahimsa silk (D_F)	74	62

Source	F value	Probability	Sem±	CD	CV (%)
Warp	1423.20**	0.000	0.645	3.43	1.85
Weft	2657.57**	0.000	0.382	2.00	1.34

** = Significant at 1 per cent

* = Significant at 5 per cent

4.4.1.3 Cloth weight (g/sq. mt)

The weight of the fabric depends on the type of fibre, yarn, threads per unit area and method of construction employed. Table 10 depicts about cloth weight of newly designed dress materials. Both control sample and Cotton x Ahimsa silk Dress material (D_C) showed heavier weight/ sq. meter *i.e.*, 132g and 130g respectively, whereas Art silk x Ahimsa silk (D_A, 109g) and Filature silk x Ahimsa silk (D_F, 100g) exhibited lighter weight. It is true that in a woven cloth the percentage of warp and weft many times is not equal which is evident from Table 9. The percentage weft is significantly higher than its corresponding warp in all the newly designed dress materials except control.

Moreover, statistical results exhibited significant decrease in cloth weight of newly designed dress materials as compared to control.

4.4.1.4 Cloth thickness (mm)

As might be expected thicker the fabric, longer it takes to wear. Thick fabrics however, are not always convenient because of their bulkiness and stiffness. Table 11 illustrates the cloth thickness of newly designed dress materials.

It is observed that of the four test samples *i.e.*, control and three types of dress materials the cloth thickness was noticeably high with control sample (0.50mm) compared to Cotton x Ahimsa silk dress material (D_C, 0.46mm). On the other hand Art silk x Ahimsa silk (D_A) and Filature silk x

Table 10. Cloth weight of newly designed dress materials (g/sq. mt)

Dress material	Total weight (g/sq. mt)	Percent warp	Percent weft
Control (Ahimsa x Ahimsa silk)	132	51.81	45.66
Cotton x Ahimsa silk (D_C)	130	30.61	69.23
Art silk x Ahimsa silk (D_A)	109	36.36	60.36
Filature silk x Ahimsa silk (D_F)	100	17.45	90.18

Source	F value	Probability	Sem±	CD	CV (%)
Total weight (g/sq. mt)	388.291**	0.000	0.779	4.08	1.14

** = Significant at 1 per cent

Table 11. Cloth thickness of newly designed dress materials (mm)

Dress material	Cloth thickness (mm)
Control (Ahimsa x Ahimsa silk)	0.50
Cotton x Ahimsa silk (D_C)	0.46
Art silk x Ahimsa silk (D_A)	0.36
Filature silk x Ahimsa silk (D_F)	0.31

Source	F value	Probability	Sem±	CD	CV (%)
Cloth thickness	230.75**	0.000	0.006	0.030	2.45

** = Significant at 1 per cent

Ahimsa silk (D_F) dress materials were found to be relatively less thicker *i.e.* 0.36 mm and 0.31 mm respectively.

However statistical results indicated that the cloth thickness of the newly designed dress materials were significantly low when compared to control.

4.4.1.5 Cloth stiffness (cm)

The textile materials used as apparels are expected to have some desired aesthetic qualities in terms of smoothness, resiliency, draping qualities and overall appearance along with properties of sufficient strength, durability, water absorbency, resistance to abrasion and so on. Quantitatively, stiffness is the key factor that determines handle and drape and is measured in terms of bending length. The bending length is characteristic of a fabric and is dependent upon the energy required to produce a given bending deformation under its own weight. The constructional feature affecting the stiffness of a cloth is mainly its nature of the fibre, yarn type, compactness of weave, cloth weight and thickness.

Table 12 depicts the bending length of test samples. In general weft-way bending length was greater than warp-way, observed among all the four samples. Of the newly designed dress materials, Cotton x Ahimsa silk (D_C) showed longer bending path both in warp-way and weft-way *i.e.* 1.22cm and 1.20cm respectively followed by Art silk x Ahimsa silk dress material (D_A, 1cm and 1.10cm) and control sample (0.99cm and 1.00cm). On the

Table 12. Cloth stiffness of newly designed dress materials (cm)

Dress material	Bending Length (cm)	
	Warp	Weft
Control (Ahimsa x Ahimsa silk)	0.99	1.00
Cotton x Ahimsa silk (D_C)	1.22	1.20
Art silk x Ahimsa silk (D_A)	1.00	1.10
Filature silk x Ahimsa silk (D_F)	0.68	1.00

Factors	F value	Probability	Sem±	CD	CV (%)
Warp	1.468*	0.015	0.2419	1.26	4.43
Weft	290.999**	0.000	0.0144	0.08	1.38

* = Significant at 5 per cent
** = Significant at 1 per cent

other hand the least bending length was observed with Filature silk x Ahimsa silk (D_F) (warp-way 0.68cm and weft-way 1cm).

The statistical results showed that warp-way cloth stiffness of dress material D_C and D_A was significantly greater than control and lower than D_F, whereas weft-way cloth stiffness of newly designed dress materials was significantly higher than control.

4.4.1.6 Cloth crease recovery (degree)

Creasing is the phenomenon of development of folds or deformations not removable or recoverable completely. The crease resistance is that property of the fabric, which causes it to recover from folding deformations that normally occur during its use. The recovery or resistance towards creasing largely depends on the resilience and elastic property of the material. The recovery depends on time, varying for different fabrics from an instantaneous recovery to a slow disappearance of the crease. All textiles to be used in clothing must be flexible and capable of being creased and folded to confirm to the figure and to be comfortable to the wearer.

Crease and its resistance can be explained on molecular theory. The cross links may break within the molecules and reform a new position, on removal of the load, where there will be no recovery. Alternately, the cross links may be strained without breaking and show a recovery on deloading. Cellulosic materials are notoriously susceptible for creasing (Nemailal and Prabir, 1999).

The feature more accepted in a fabric is, it can be deformed but rapidly recovers from the deformation. There must be resilience, which

Table 13. Cloth crease recovery of newly designed dress materials (degree)

Dress material	Warp	Weft	Cloth recovery
Control (Ahimsa x Ahimsa silk)	111.00	111.00	111.00
Cotton x Ahimsa silk (D_C)	75.30	105.00	88.91
Art silk x Ahimsa silk (D_A)	91.30	108.00	99.42
Filature silk x Ahimsa silk (D_F)	117.33	107.00	112.33

Source	F value	Probability	Sem±	CD	CV (%)
Cloth recovery	989.348**	0.000	0.573	3.003	0.94

** = Significant at 1 per cent

of the yarn cannot be greater than the sum of the maximum strength of its component fibers, which determines the strength of the fabric.

Table 14 depicts the tensile strength of newly woven dress materials. In general the weft-way strength was higher than warp-way. Highest tensile strength was observed in control sample both warp-way and weft-way *i.e.* 40.99 and 46.48 kgf respectively. Among the dress materials, Art silk x Ahimsa silk (D_A) showed higher strength both warp-way and weft-way (22.53 and 63.23 kgf) followed by Cotton x Ahimsa silk (D_C, 16.24 and 61.12 kgf) and Filature silk x Ahimsa silk (D_F, 10.50 and 52.75 kgf) dress materials both warp-way and weft-way. The least value of tensile strength was noticed with Filature silk x Ahimsa silk in warp-way (10.50 kgf).

However statistical results indicated that the warp-way cloth tensile strength in newly designed dress material was significantly lower than control and the results were vice-versa in weft-way direction.

Influence of yarn count and cloth count on cloth tensile strength of newly designed dress materials

The influence of yarn count and cloth count on cloth tensile strength presented in Table 15 clearly indicated that there existed strong relationship between independent and dependent variables of the test samples since, the values are highly significant, except in weft direction. Further the influence of yarn count and cloth count on cloth tensile strength was found to be negatively related in warp direction *i.e.* increase in yarn count and cloth count resulted into decrease in tensile strength. On the other hand though

Table 14. Cloth tensile strength of newly designed dress materials (kgf)

Dress material	Tensile strength (kgf)	
	Warp way	Weft way
Control (Ahimsa x Ahimsa silk)	40.99	46.48
Cotton x Ahimsa silk (D_C)	16.24	61.12
Art silk x Ahimsa silk (D_A)	22.53	63.23
Filature silk x Ahimsa silk (D_F)	10.50	52.75

Source	F value	Probability	Sem±	CD	CV (%)
Warp	266.53.23**	0.007	0.090	0.472	1.73
Weft	180.2657**	0.000	0.577	3.026	1.79

** = Significant at 1 per cent

include some resistance to creasing but also a powerful and rapid recovery there from. Among the common textile materials the order of diminishing crease resistance is wool, silk, viscose rayon, cotton and flax.

Table 13 narrates on crease recovery angle of the newly designed dress materials. In general weft-way recovery was found to be higher than warp-way. Among the test samples, Filature silk x Ahimsa silk dress materials (D_F) showed highest recovery angle both warp-way and weft-way (117.33° and 107°) followed by control sample (111°) and Art silk x Ahimsa silk (D_A, 91.30° and 108°). On the other hand least recovery was found in Cotton x Ahimsa silk dress material (D_C, 75.30° and 105°). Irrespective of weft-way and warp-way recovery, the ultimate cloth recovery was higher with Filature silk x Ahimsa silk dress material, control sample, Art silk x Ahimsa silk and Cotton x Ahimsa silk dress material.

The crease recovery in dress materials D_A and D_C was significantly lower than control but slightly better in D_F dress material.

4.4.2 Functional properties of newly designed dress materials

4.4.2.1 Cloth tensile strength (kgf) and elongation (%)

The tensile strength is the fundamental ability to resist strain or rapture induced by tension. The tensile strength properties of the fabric depends upon the fibre content and its inherent properties *i.e.* yarn type (single, ply, filament and soon), yarn number, yarn crimp, yarn twist, threads per unit area, cloth cover and weave density. However, the strength

Table 15. Influence of yarn count and cloth count on cloth tensile strength of newly designed dress materials

Source	Warp				Weft			
	Coefficient	Standard error	t value	p value	Coefficient	Standard error	t value	p value
X_1	-4.4590	9.6049	-4.642**	0.001	-1.6348	8.1970	-1.994 NS	0.071
X_2	-4.3018	3.8579	-11.150**	0.000	2.8455	6.5351	4.354**	0.001
R^2	0.96				0.78			

** = Significant at 1 per cent
NS = Non significant

X_1 – Yarn count
X_2 – Cloth count
R^2 – Coefficient of determination

there was no influence of yarn count on tensile strength in weft direction, but the cloth count showed highly significant and positive relation on tensile strength in weft directions *i.e.* increase in the cloth count enhanced the tensile strength. Further the influence of yarn count and cloth count on cloth tensile strength is explained by R^2 value *i.e.*, 96 per cent and 78 per cent respectively.

Table 16 reveals about elongation percentage of the samples. In general the warp-way elongation was higher than weft-way elongation. Among the samples Art silk x Ahimsa silk dress materials (D_A) showed highest elongation in warp-way (25.23 %) followed by Cotton x Ahimsa silk (D_C, 19.63 %) and control sample (14.87 %). On the contrary the warp-way elongation was found to be least in Filature silk x Ahimsa silk dress material (D_F, 11.98 %). A similar trend in weft-way elongation was observed among all the test samples, which ranged from 13.26 per cent to 13.81 per cent.

The statistical results revealed that the warp-way cloth elongation in dress material D_A and D_C was significantly greater but was relatively low in D_F. However, the control sample exhibited least elongation (%). On the other hand, the weft-way elongation among the newly designed dress materials, was slightly lower than the control.

Influence of yarn count and cloth count on cloth elongation of newly designed dress materials

It is apparent from Table 17 that yarn count and elongation are negatively related and highly significant in warp direction, *i.e.* increase in

Table 16. Cloth elongation of newly designed dress materials (%)

Dress material	Elongation (%)	
	Warp way	Weft way
Control (Ahimsa x Ahimsa silk)	14.87	13.81
Cotton x Ahimsa silk (D_C)	19.63	13.52
Art silk x Ahimsa silk (D_A)	25.23	13.26
Filature silk x Ahimsa silk (D_F)	11.98	13.70

Source	F value	Probability	Sem±	CD	CV (%)
Warp way	90.9417**	0.000	6.5774	3.026	4.53
Weft way	16.8443**	0.002	0.2887	1.513	3.73

** = Significant at 1 per cent

Table 17. Influence of yarn count and cloth count on cloth elongation of newly designed dress materials

Source	Warp				Weft			
	Coefficient	Standard error	t value	p value	Coefficient	Standard error	t value	p value
X_1	-4.9914	8.3440	-5.982**	0.000	-2.2404	2.6412	-0.848 NS	0.414
X_2	1.9893	3.5515	5.935**	0.000	-5.1308	2.1507	-2.437*	0.033
R^2	0.84				0.39			

* = Significant at 5 per cent
** = Significant at 1 per cent
NS = Non significant

X_1 – Yarn count
X_2 – Cloth count
R^2 – Coefficient of determination

the yarn count resulted into decrease in elongation. However, the relationship in weft direction was found to be statistically non significant. On the other hand, cloth count and warp-way elongation were positively related as well as highly significant, *i.e.* increase in cloth count enhanced the elongation. But in weft-way cloth count and elongation though negatively related the values were significant at 5 per cent level *i.e.* increase in cloth count resulted into decrease in elongation. Further the influence of yarn count and cloth count on cloth elongation is explained by R^2 value *i.e.*, 84 per cent and 34 per cent, respectively.

4.4.2.2 Cloth tear strength (g)

Tear strength is the work done in the tearing the test sample through a fixed distance. Tear strength is much lesser than tensile strength, when a large number of threads are to be broken together. While tearing, if threads slip, shall bunch-up together to some extent to support each other. Hence, the more easily the yarn slips, the greater is the tear strength. Maximum number of thread intersection in plain weave shall restrict the yarn slippage compared to other basic weaves with longer floats. A very closely woven fabric may restrict such movement and is because of this reason that, completely woven fabric as in plain weave may have low tear strength values. In warp-way samples the set of thread torn are weft and in weft-way samples it is warp.

From Table 18 it is evident that, all the test samples in warp direction did not tear, on the other hand Filature silk x Ahimsa silk dress material (D_F) showed low tear strength of 1194.56 g in weft direction followed by

Table 18. Cloth tear strength of newly designed dress materials (g)

Sl. No.	Dress material	Tear strength (g)	
		Warp	Weft
1.	Control (Ahimsa x Ahimsa silk)	*	*
2.	Cotton x Ahimsa silk (D_C)	*	1216.00
3.	Art silk x Ahimsa silk (D_A)	*	1296.00
4.	Filature silk x Ahimsa silk (D_F)	*	1194.56

* - Warp way tear strength was beyond the capacity of the instruments

moderate strength of 1216 g in Cotton x Ahimsa silk (D_C) and higher strength of 1296 g in Art silk x Ahimsa silk (D_A) in weft direction *i.e.* the ascending order of warp tear strength was cotton, filature silk and art silk yarns were torn, respectively.

4.4.2.3 Cloth abrasion resistance (cycles)

Abrasion, an aspect of wear is the rubbing away of the component fibres and yarns of the fabric. The abrasive wear of the material depends to a considerable extent on the construction of the yarn or fabric. In general, fibre breakage has been reported to be the most important mechanism causing abrasion damage in fabrics and abrasion resistance might therefore be expected to be related to the mechanical properties of the fibres. Fabrics get abraded against various materials, pressures and conditions in day today use. The life of a fabric is dependent on its resistance to abrasion.

Table 19 reveals about cloth abrasion resistance of the test samples. The control sample showed higher resistance to abrasion (272 cycles) than the newly designed dress materials. Among the designed dress materials Cotton x Ahimsa silk (D_C) exhibited relatively higher resistance to abrasion (31 cycles) followed by Art silk x Ahimsa silk (D_A, 25 cycles).

The value of loss in thickness of control sample on abrasion was found to be higher than their corresponding values of newly designed dress materials. The loss in mass of the test samples on abrasion, expressed in terms of percentage and was relatively higher in control sample (5 %)

Table 19. Cloth abrasion resistance of newly designed dress materials (cycles)

Dress materail	No. of cycles	Loss in thickness (%)	Loss in mass (%)
Control (Ahimsa x Ahimsa silk)	272	8.00	5.00
Cotton x Ahimsa silk (D_C)	31	6.52	2.77
Art silk x Ahimsa silk (D_A)	28	3.22	1.69
Filature silk x Ahimsa silk (D_F)	25	5.55	3.79

Source	F value	Probability	Sem±	CD	CV (%)
Loss in thickness (%)	1275.966**	0.000	0.0562	0.294	1.67
Loss in mass (%)	149571.87**	0.000	0.0029	0.015	0.16

** - Significant at 1 per cent

followed by Filature silk x Ahimsa silk (D_F, 3.79 %) Cotton x Ahimsa silk (D_C, 2.77 %) and Art silk x silk (D_A, 1.69 %) dress materials.

The statistical results indicated that the thickness loss and mass loss in newly designed dress materials was significantly lower when compared to control sample.

Influence of yarn count and cloth thickness on loss in thickness of newly designed dress materials

Influence of yarn count and cloth thickness on loss in thickness is presented in Table 20, revealed that, there is relationship between independent and dependent variables of the test samples, since the values are highly significant, except in weft direction. However, yarn count and cloth thickness positively influenced the loss in thickness on abrasion in warp direction *i.e.* increase in yarn count and cloth thickness resulted into increased loss in thickness. On the other hand independent variables (yarn count) showed non-significant relation with loss in thickness but cloth thickness showed highly significant relation with loss in thickness in weft-way abrasion *i.e.* increase in cloth thickness inturn resulted into increased loss in thickness. In the nutshell influence of yarn count and cloth thickness on loss in thickness is explained R^2 value *i.e.* 97 and 92 per cent, respectively.

Influence of yarn count and cloth thickness on loss in mass of newly designed dress materials

Influence of yarn count and cloth thickness on loss in mass is presented in Table 21. The table showed that there is relationship between

Table 20. Influence of yarn count and cloth thickness on loss in thickness of newly designed dress materials

Source	Warp				Weft			
	Coefficient	Standard error	t value	p value	Coefficient	Standard error	t value	p value
X_1	5.6231	1.2640	4.449**	0.001	1.6026	1.1990	1.337^{NS}	0.208
X_2	2.3924	1.4027	17.056**	0.000	2.1606	2.1373	10.109**	0.000
R^2	0.97				0.92			

* = Significant at 5 per cent
** = Significant at 1 per cent
NS = Non significant

X_1 – Yarn count
X_2 – Cloth thickness
R^2 – Coefficient of determination

Table 21. Influence of yarn count and cloth thickness on loss in mass of newly designed dress materials

Source	Warp				Weft			
	Coefficient	Standard error	t value	p value	Coefficient	Standard error	t value	p value
X_1	7.0913	2.8449	2.467*	0.031	3.5392	1.7839	1.984^{NS}	0.073
X_2	1.4145	3.1570	4.480**	0.001	1.1191	3.1798	3.519**	0.005
R^2	0.69				0.64			

* = Significant at 5 per cent
** = Significant at 1 per cent
NS = Non significant

X_1 – Yarn count
X_2 – Cloth thickness
R^2 – Coefficient of determination

independent and dependent variables of the samples since, the values are highly significant, except in weft direction *i.e.*, yarn count of weft is non-significant. It is evident that both warp-way yarn count and cloth thickness positively influenced the loss in mass on abrasion *i.e.*, increase in yarn count and cloth thickness resulted into increase in loss in mass per cent. On the other hand weft-way yarn count showed non-significant relation on loss in mass but cloth thickness exhibited positive and highly significant relationship with loss in mass on abrasion. Further the influence of yarn count and cloth thickness on loss in mass is explained by R^2 values *i.e.*, 67 per cent and 64 per cent, respectively.

4.4.2.4 Cloth drapability (%)

Drape is an important property of textile materials, which allows fabric to orient itself into graceful folds or pleats as a result of force of gravity. The style of garment and its type determine the amount of drape that is needed and accordingly the fabric is selected. Drape is one of the subjective performance characteristics of fabric that contributes to its aesthetic appeal. A fabric is said to posses good drapability when its configuration is pleasant to the eye. Drapability is a result of the interaction between warp-way and weft-way characteristics. The drape coefficient of fabric has direct relation with firmness of weave and cloth sett. The objective evaluation of cloth drapability is expressed in terms of drape coefficient (%), however the drapability of same fabric may be evaluated subjectively and expressed in terms of number of nodes formed when draped. Table 22 narrates on the drapability of newly designed dress materials. It is noticed

Table 22. Cloth drapability of newly designed dress materials (%)

Dress material	No. of nodes	Drape coefficient (%)
Control (Ahimsa x Ahimsa silk)	6	79.58
Cotton x Ahimsa silk (D_C)	5	108.00
Art silk x Ahimsa silk (D_A)	6	86.78
Filature silk x Ahimsa silk (D_F)	6	80.68

Source	F value	Probability	Sem±	CD	CV (%)
Drape coefficient (%)	570.9041**	0.000	0.5530	2.898	1.08

** = Significant at 1 per cent

from this table that all the dress materials expect Cotton x Ahimsa silk (D_C) dress material draped in graceful fold with six nodes, where the former draped with 5. On the other hand drape coefficient value was highest in Cotton x Ahimsa silk (D_C) dress material (108 %) followed by Art silk x Ahimsa silk (D_A, 86.78 %) and Filature silk x Ahimsa silk (D_F, 80.68 %). A least drape coefficient percentage was observed in control sample, indicating it to be more flexible and pliable.

Moreover the statistical results indicated that cloth drape coefficient of newly designed dress materials was significantly greater than the control.

Influence of cloth stiffness and crease recovery on drapability of newly designed dress materials

Influence of cloth stiffness and crease recovery on drapability is presented in Table 23 depicts that there existed no relationship between independent and dependent variables of the test samples, since the values were found to be non significant, except in weft direction *i.e.*, weft-way cloth stiffness has positive influence on cloth drapability and the values are highly significant. Further the influence of weft-way cloth stiffness on drapability was found to be positively related which inferred that increase in cloth stiffness resulted into increase in drapability. Further, the influence of cloth stiffness and crease recovery on drapability is explained by R^2 values *i.e.*, 90 per cent each.

4.4.2.5 Cloth pilling (Ratings)

Generally a garment is not discarded because of a hole or a tear, but more often because of loss of appearance. Consequently in assessing the

Table 23. Influence of cloth stiffness and crease recovery on drapability of newly designed dress materials

Source	Warp				Weft			
	Coefficient	Standard error	t value	p value	Coefficient	Standard error	t value	p value
X_1	-4.3225	3.7510	-1.152^{NS}	0.274	6.1525	8.5867	7.165^{**}	0.000
X_2	-2.8812	2.5660	-1.123^{NS}	0.285	-7.3808	5.2441	1.407^{NS}	0.187
R^2	0.90				0.90			

** = Significant at 1 per cent
NS = Non significant

X_1 – Cloth stiffness
X_2 – Cloth crease recovery
R^2 – Coefficient of determination

durability of a fabric one has to judge how soon it becomes "shabby" and unacceptable. One of the causes for shabby appearance or texture is pilling.

Table 24 shows the resistance of samples for pilling. Slight pilling was observed in Filature silk x Ahimsa silk (D_F) dress materials followed by moderate pilling in Cotton (D_C), Art silk (D_A) and control sample.

4.4.3 Mechanical properties of newly designed shirtings

4.4.3.1 Yarn count (Ne)

From the Table 25 it is clear that Filature silk x Ahimsa silk shirting material (S_F) is woven with finer warp (241s or 20/22d) and weft (35s) followed by Tericot x Ahimsa silk shirting material (S_T, 60s warp and 34s weft). On the other hand control sample and Cotton x Ahimsa silk shirting material (S_C) was interwoven with relatively coarser warp (40s and 36s) and weft (35s each). However statistical results showed that warp yarn count in newly woven shirting materials was significantly greater than the control. Further the weft yarn count in Cotton x Ahimsa silk (S_C) and Filature silk x Ahimsa silk (S_A) materials was relatively higher and significant compared to control. However, among three newly designed shirtings Tericot x Ahimsa silk (S_T) comprised of coarser weft yarns.

4.4.3.2 Cloth count (Numerical expression)

It was observed from Table 26 that, all the test samples woven with greater number of ends per inch than picks per inch. Since warp yarns being finer may be aligned more densely than coarser fillings. Greater number of ends and picks per unit area attribute to many important

Table 24. Cloth pilling of newly designed dress materials (Ratings)

Sl. No.	Dress material	Pilling (Ratings)
1	Control (Ahimsa x Ahimsa silk)	3
2	Cotton x Ahimsa silk (D_C)	3
3	Art silk x Ahimsa silk (D_A)	3
4	Filature silk x Ahimsa silk (D_F)	2

1 – No pilling

2 – Slight but tolerable pilling

3 – Moderate pilling of borderline accepted

4 – Severe pilling

5 – Extremely high pilling

Table 25. Yarn count of newly designed shirting materials (Ne)

Shirting material	Direction		Yarn count	
	Warp	Weft	Warp	Weft
Control (Ahimsa silk x Ahimsa silk)	Ahimsa silk	Ahimsa silk	35_S	35_S
Cotton x Ahimsa silk (S_C)	Cotton	Ahimsa silk	40_S	36_S
Tericot x Ahimsa silk (S_T)	Tericot	Ahimsa silk	60_S	34_S
Filature silk x Ahimsa silk (S_F)	Filature silk	Ahimsa silk	241_S (20/22d)	35_S

Source	F-value	Probability	Sem±	CD	CV (%)
Warp	23243.800**	0.000	0.6455	3.383	1.19
Weft	7.0000*	0.0219	0.3333	1.066	1.64

Note:

** - Significant at 1 per cent level

* - Significant at 5 per cent level

Table 26. Cloth count of newly designed shirting materials (numerical expression)

Shirting material	Cloth count	
	Warp way	Weft way
Control (Ahimsa silk x Ahimsa silk)	24	20
Cotton x Ahimsa silk (S_C)	52	48
Tericot x Ahimsa silk (S_T)	54	44
Filature silk x Ahimsa silk (S_F)	120	76

Source	F-value	Probability	Sem±	CD	CV (%)
Warp	3976.800**	0.0000	0.6455	3.383	1.79
Weft	2871.33**	0.0001	0.6943	2.732	2.99

** - Significant at 1 per cent level

functional properties like strength, serviceability, cloth balance and drapability. Among the shirting materials, Filature silk x Ahimsa silk (S_F) was woven with greater number of ends and picks per unit area (120 and 76) followed by Tericot x Ahimsa silk (S_T, 54 x 44) and Cotton x Ahimsa silk (S_C, 52 and 48). On the other hand control sample was woven with remarkably lesser ends and picks per unit area *i.e.*, 24 and 20, respectively. However statistical results indicated that cloth count (warp and weft) in newly woven shirting materials was significantly higher than the control.

4.4.3.3 Cloth weight (g/sq. mt)

The weight of the fabric depends upon fibre type, yarn type, yarn count, fabric count, method of construction and finish applied on to the fabric.

Table 27 narrates about cloth weight of newly woven shirting materials. Among the test samples, Cotton x Ahimsa silk (S_C) shirting material exhibited maximum weight of 140 g than control sample (132 g) and Tericot (S_T, 125 g) shirting materials. On the other hand Filature silk x Ahimsa (S_F) silk shirting material was found to be lighter in weight (102 g) among all the test samples of this category.

The percentage of both the sets of the yarn in a woven cloth many times is not equal and is evident from Table 27. The percentage of warp is slightly greater than weft in control sample, cotton, tericot shirting material, but in case of Filature silk x Ahimsa silk (S_F) shirting material it was reverse *i.e.*, the percentage of weft was significantly higher than warp.

Table 27. Cloth weight of newly designed shirting materials (g/sq mt)

Shirting material	Total weight (g/sq mt)	Percent warp	Per cent weft
Control (Ahimsa silk x Ahimsa silk)	132	51.81	45.66
Cotton x Ahimsa silk (S_C)	140	50.00	42.35
Tericot x Ahimsa silk (S_T)	125	46.72	44.47
Filature silk x Ahimsa silk (S_F)	102	24.90	73.15

Source	F-value	Probability	SEM±	CD	CV (%)
Total weight (g/sq mt)	2301.4796**	0.0000	0.3333	1.747	0.46

Note:
** - Significant at 1 per cent level

However, statistical results indicated that total weight of Cotton x Ahimsa silk (S_C) shirting material was significantly greater than control. Further the descending order of cloth weight observed was S_T and S_F shirting materials.

4.4.3.4 Cloth thickness (mm)

Testing the fabric thickness helps in the study of other fabric properties such as resiliency, cloth stiffness, abrasion resistance and cloth geometry that in turn might be influenced by fibre content, yarn count and weave density. Table 28 reveals about the cloth thickness of newly woven shirting materials. It is observed that the control sample was relatively thicker (0.50 mm) than the other shirting materials. Among the newly designed shirting materials, cotton material (S_C) possessed maximum thickness (0.46 mm) followed by Tericot x Ahimsa silk (S_T, 0.38) and Filature silk x Ahimsa silk (S_F, 0.29).

The statistical results indicated that cloth thickness of all the three newly woven shirting materials was significantly lower than the control sample.

4.4.3.5 Cloth stiffness (cm)

From the Table 29 it is found that Cotton x Ahimsa silk (S_C) shirting material possessed higher bending length in both directions *i.e.* warp-way 1.40 cm and weft-way 1.10 cm compared to Tericot x Ahimsa silk (S_T, warp-way 1.07 and weft-way 1.20). On the other hand the lowest bending path

Table 28. Cloth thickness of newly woven shirting materials (mm)

Shirting material	Cloth thickness (mm)
Control (Ahimsa silk x Ahimsa silk)	0.50
Cotton x Ahimsa silk (S_C)	0.46
Tericot x Ahimsa silk (S_T)	0.38
Filature silk x Ahimsa silk (S_F)	0.29

Source	F-value	Probability	SEM±	CD	CV (%)
Cloth thickness (mm)	258.7500**	0.0000	0.058	0.304	2.45

Note:

** - Significant at 1 per cent level

Table 29. Cloth stiffness of newly designed shirting materials (cm)

Shirting material	Bending length (cm)	
	Warp	Weft
Control (Ahimsa silk x Ahimsa silk)	0.99	1.00
Cotton x Ahimsa silk (S_C)	1.40	1.10
Tericot x Ahimsa silk (S_T)	1.07	1.20
Filature silk x Ahimsa silk (S_F)	1.00	1.00

Source	F-value	Probability	Sem±	CD	CV (%)
Warp	0.2476*	0.024	0.2628	0.840	3.98
Weft	7.4651*	0.0189	0.0546	0.174	5.08

* - Significant at 5 per cent level

was observed in both control and Filature shirting (S_F) material in both directions *i.e.*,each way 1 cm, respectively.

Further the statistical results indicated that warp and weft-way cloth stiffness of newly designed shirting materials was lower than control *i.e.*, both control and S_F were found to be more soft and pliable.

4.4.3.6 Cloth crease recovery (degree)

An appraisal of Table 30 shows the crease recovery angle of newly designed shirting materials. In general the weft-way recovery was found to be higher than warp-way except Filature silk x Ahimsa silk (S_F) shirting material, where it showed a reverse trend. Among the test samples Filature x Ahimsa (S_F) silk showed highest recovery angle both warp and weft ways (114.00° and 112.30°) followed by control sample (each 111°) and Tericot x Ahimsa silk shirting material (S_T, 99.30° and 108°). However, least recovery was found in Cotton x Ahimsa silk (S_C, 81° and 110°). Irrespective of warp and weft-way recovery, the descending order of cloth recovery was S_F, control sample, S_T and S_C shirting materials. But the statistical results showed that cloth recovery in Cotton x Ahimsa silk and Tericot x Ahimsa silk shirtings was significantly lower than control. However, the recovery loss was higher in S_F.

4.4.4 Functional properties of newly designed shirtings

4.4.4.1 Cloth tensile strength (kgf) and elongation (%)

Table 31 illustrates on cloth tensile strength of newly woven shirting materials. In general the weft-way strength was higher than warp-way.

Table 30. Cloth crease recovery of newly designed shirting materials (degree)

Shirting material	Warp	Weft	Cloth recovery (degree)
Control (Ahimsa silk x Ahimsa silk)	111.00	111.00	111.00
Cotton x Ahimsa silk (S_C)	81.00	110.00	94.53
Tericot x Ahimsa silk (S_T)	99.30	108.00	103.00
Filature silk x Ahimsa silk (S_F)	114.00	112.30	113.30

Source	F-value	Probability	Sem±	CD	CV (%)
Cloth recovery (degree)	105926.88**	0.0000	0.0050	0.026	0.01

** - Significant at 1 per cent level

Table 31. Cloth tensile strength of newly designed shirting materials (kgf)

Shirting materials	Tensile strength (kgf)	
	Warp	Weft
Control (Ahimsa silk x Ahimsa silk)	40.99	46.48
Cotton x Ahimsa silk (S_C)	41.71	51.84
Tericot x Ahimsa silk (S_T)	49.68	66.90
Filature silk x Ahimsa silk (S_F)	32.86	57.52

Source	F-value	Probability	Sem±	CD	CV (%)
Warp	106.291**	0.0000	0.6667	3.494	2.80
Weft	102.941**	0.0000	0.8607	4.511	2.68

** - Significant at 1 per cent level

Among the test samples, Tericot x Ahimsa silk (S_T) shirting material exhibited relatively greater tensile strength in both directions (warp-way 49.68 and weft-way 66.90) followed by Cotton x Ahimsa silk (S_C, 41.71 warp-way and 51.84 weft way) and control sample (warp-way 40.99 and weft-way 46.48). On the other hand least warp-way tensile strength was noticed in Filature silk x Ahimsa silk shirting in warp-way (S_F, 32.86 kgs). However statistical results showed that warp-way cloth tensile strength in S_T and S_C shirting materials was greater and significant compared to control but the values were reverse S_F. Further, when compared to control the weft cloth tensile strength of newly woven shirting materials was significantly higher.

Influence of yarn count and cloth count on cloth tensile strength of newly designed shirtings

Table 32 discloses on influence of yarn count and cloth count on cloth tensile strength of newly woven shirting materials. Yarn count significantly influenced the cloth tensile strength at 5 per cent level but the relation was negative *i.e.*, increase in yarn count resulted into decrease in tensile strength, which means finer the yarn lesser the strength. On the other hand, cloth count did not influence the cloth tensile strength. Further the influence of yarn count and cloth count on cloth tensile strength is explained by R^2 value *i.e.*,62 per cent and 54 per cent respectively.

Table 33 depicted about elongation percentage of newly woven shirting materials. In general irrespective of test samples warp-way elongation was higher than weft way. Among the test samples, Filature silk x Ahimsa silk

Table 32. Influence of yarn count and cloth count on cloth tensile strength of newly designed shirting material

Source	Warp				Weft			
	Coefficient	Standard error	t value	P value	Coefficient	Standard error	t value	P value
X_1	-1.1733	5.2901	-2.218*	0.049	-4.434	1.6783	-2.648*	0.023
X_2	1.6248	1.2787	1.271^{NS}	0.230	2.3447	9.0042	2.604^{NS}	0.25
R^2	**0.62**				**0.54**			

* - Significant at 5 per cent level

NS - Non-significant

X_1 = yarn count

X_2 = cloth count

R^2 = coefficient of determination

Table 33. Cloth elongation of newly designed shirting materials (%)

Shirting material	Elongation (%)	
	Warp	Weft
Control (Ahimsa silk x Ahimsa silk)	14.87	13.81
Cotton x Ahimsa silk (S_C)	18.93	14.70
Tericot x Ahimsa silk (S_T)	26.94	12.41
Filature silk x Ahimsa silk (S_F)	28.78	15.40

Source	F-value	Probability	Sem±	CD	CV (%)
Warp	19.067**	0.0031	0.194	0.787	6.67
Weft	21.1956**	0.0014	0.2887	1.513	3.53

** - Significant at 1 per cent level

(S_F) shirting material showed highest elongation in warp-way (28.78%) followed by Terciot x Ahimsa silk (S_T, 26.94%) and Cotton x Ahimsa silk (S_C, 18.93). A similar trend of elongation was observed in weft-way in all the test samples ranging from 12.41 to 15.40 per cent.

Further it was found from statistical results that the warp cloth elongation of newly woven shirting materials was significantly higher than the control. On the other hand weft cloth elongation in Cotton x Ahimsa silk (S_C) and Filature silk x Ahimsa silk (S_F) shirting was significantly greater than control, but was lower in Tericot x Ahimsa silk (S_T).

Influence of yarn count and cloth count on cloth elongation of newly designed shirtings

The influence of yarn count and cloth count on cloth elongation as presented in Table 34 was found to be statistically significant *i.e.,* there was relationship between independent and dependent variables of the test samples. However, cloth count and elongation are positively related and were significant at 5 per cent level in warp direction *i.e.,* increase in cloth count resulted into increase in elongation percentage in warp-way, but in weft direction, the cloth count and elongation were negatively related and significant at 5 per cent level *i.e.,* increase in cloth count resulted into decrease in elongation percentage. Further influence of yarn count and cloth count on elongation is explained by R^2 values *i.e.,*71 per cent and 42 per cent, respectively.

Table 34. Influence of yarn count and cloth count on elongation of newly designed shirting materials

Source	Warp				Weft			
	Coefficient	Standard error	t value	P value	Coefficient	Standard error	t value	P value
X_1	-6.5844	4.7160	-1.396^{NS}	0.190	-1.7536	3.4852	-0.503^{NS}	0.625
X_2	2.9290	1.1399	2.570*	0.026	-4.2686	1.8699	-2.283*	0.043
R^2	**0.71**				**0.42**			

* - Significant at 5 per cent level

NS - Non-significant

X_1 = yarn count

X_2 = cloth count

R^2 = coefficient of determination

4.4.4.2 Cloth tear strength (g)

Table 35 depicts about the tear strength of newly woven shirting materials. It is very important to mention here that the test samples could not be torn warp-way. Hence the values of weft-way tear are only presented. Among the shirting materials, Tericot x Ahimsa silk (S_T) showed greater warp strength (1408 g) followed by Cotton x Ahimsa silk (S_C 1398 g) and Filature silk x Ahimsa silk (S_F 1280 g). Moreover it was not possible to tear the control sample in either ways *i.e.,* warp-way and weft-way since the strength was beyond the capacity of the instrument employed.

4.4.4.3 Cloth abrasion resistance (cycles)

One of the most important factors determining the durability and life of any fabric is its resistance to abrasion.

Table 36 reveals about the cloth abrasion resistance of the newly woven shirting samples. The control sample showed higher resistance to abrasion (272 cycles) than the newly woven shirting materials. Among the shirting materials, Cotton x Ahimsa silk exhibited higher resistance to abrasion (S_C, 30 cycles) followed by Tericot x Ahimsa silk (S_T, 26 cycles) and Filature silk x Ahimsa silk (S_F, 23 cycles).

The Table also illustrated about loss in cloth thickness and mass on abrasion. The value of loss in thickness of control sample on abrasion was found to be higher (8 per cent) than their corresponding values of newly woven shirting materials.

Table 35. Cloth tear strength of newly designed shirting materials (g)

Shirting materials	Tear strength (g)	
	Warp	Weft
Control (Ahimsa silk x Ahimsa silk)	*	*
Cotton x Ahimsa silk (S_C)	*	1398.00
Tericot x Ahimsa silk (S_T)	*	1408.00
Filature silk x Ahimsa silk (S_F)	*	1280.00

* - Warp way tear strength was beyond the capacity of the instrument.

Table 36. Cloth abrasion resistance of newly designed shirting materials (cycles)

Shirting material	Number of cycles	Loss in mass (%)	Loss in thickness (%)
Control (Ahimsa silk x Ahimsa silk)	272.00	5.00	8.00
Cotton x Ahimsa silk (S_C)	30.00	3.03	5.26
Tericot x Ahimsa silk (S_T)	26.00	1.36	6.52
Filature silk x Ahimsa silk (S_F)	23.00	3.13	6.89

Source	F-value	Probability	Sem±	CD	CV (%)
Loss in mass (%)	19579.88**	0.0000	0.0107	0.056	0.59
Loss in thickness (%)	1159.7213**	0.0000	0.0332	0.174	0.86

** - Significant at 1 per cent level

The loss in mass of the test samples on abrasion, expressed in percentage was relatively higher with control sample (5 per cent) followed by Filature x Ahimsa silk (S_F, 3.13 %), Cotton x Ahimsa silk (S_C, 3.03 %) and Tericot x Ahimsa silk (S_T, 1.36 %) shirting materials.

Further, statistical results indicated that mass loss and thickness loss in newly shirting materials was significantly greater than the control sample.

Influence of yarn count and cloth thickness on loss in thickness of newly designed shirtings on abrasion

It is apparent from Table 37 that yarn count and cloth thickness on loss in thickness are positively related and highly significant in warp direction *i.e.,* increase in yarn count and cloth count resulted into greater loss in cloth thickness. On the other hand the relationship between weft-way yarn count and cloth count on loss in thickness were statistically non-significant. Further, influence of yarn count and cloth count on abrasion is explained by R^2 values *i.e.,* 79 per cent and 17 per cent, respectively.

Influence of yarn count and cloth thickness on loss in thickness of newly designed shirtings on abrasion

Table 38 discloses the influence of yarn count and cloth thickness on loss in mass on abrasion. There existed no relationship between independent and dependent variables of the test samples since the values were statistically non-significant. Further it was explained by R^2 value *i.e.,* 5 per cent and 23 per cent respectively.

Table 37. Influence of yarn count and cloth thickness on loss in thickness of newly designed shirting materials

Source	Warp				Weft			
	Coefficient	**Standard error**	**t value**	**P value**	**Coefficient**	**Standard error**	**t value**	**P value**
X_1	1.6870	3.1544	5.320**	0.000	-1.0234	3.1414	-0.326^{NS}	0.751
X_2	1.9694	3.3256	5.922**	0.000	4.2695	4.1469	1.030^{NS}	0.325
R^2	**0.79**				**0.17**			

** - Significant at 1 per cent level

NS - Non-significant

X_1 = yarn count

X_2 = cloth thickness

R^2 = coefficient of determination

Table 38. Influence of yarn count and cloth thickness on loss in mass of newly designed shirting materials

Source	Warp				Weft			
	Coefficient	Standard error	t value	P value	Coefficient	Standard error	t value	P value
X_1	3.2661	8.9856	0.363^{NS}	0.723	6.0413	3.9726	1.521^{NS}	0.157
X_2	6.0923	9.4735	0.643^{NS}	0.533	6.8698	5.2442	1.310^{NS}	0.217
R^2	**0.05**				**0.23**			

NS - Non-significant

X_1 = yarn count

X_2 = cloth thickness

R^2 = coefficient of determination

4.4.4.4 Cloth drapability (%)

Control sample and Filature silk x Ahimsa silk (S_F) shirting material draped into graceful folds with six nodes whereas Cotton (S_C), Tericot x Ahimsa silk (S_T) materials with five nodes. On the other hand the drape coefficient values of Cotton x Ahimsa silk was greater (92.67 %) followed by Tericot (88.91 %) and control sample (79.58 %). The drape coefficient percentage was least in Filature x Ahimsa silk shirting material (75.23 %). From these observations it is clear that control and S_F were soft and more pliable than S_T and S_C shirting materials as represented in Table 39.

However statistical results showed that drape coefficient in Cotton x Ahimsa silk (S_C) and Tericot x Ahimsa (S_T) shirting materials was significantly higher than control but the value was relatively low with Filature silk x Ahimsa silk material (S_F).

Influence of cloth stiffness and crease recovery on drapability (%) of newly designed shirtings

The influence of cloth stiffness and crease recovery on drapability presented in Table 40, clearly indicated that there existed no relationship between independent and dependent variable of the test samples, since the values were found to be statistically non significant. Further, influence of cloth stiffness and crease recovery on drapability is explained by R^2 value *i.e.*, 12 per cent each.

Table 39. Cloth drapability of newly designed shirting materials (%)

Shirting material	Number of nodes	Drape-coefficient (%)
Control (Ahimsa silk x Ahimsa silk)	6	79.58
Cotton x Ahimsa silk (S_C)	5	92.67
Tericot x Ahimsa silk (S_T)	5	88.91
Filature silk x Ahimsa silk (S_F)	6	75.23

Source	F-value	Probability	Sem±	CD	CV (%)
Drape coefficient (%)	798.6432**	0.0000	0.2858	1.498	0.59

** - Significant at 1 per cent level

Table 40. Influence of cloth stiffness and crease recovery on drapability of newly woven shirting materials

Source	Warp				Weft			
	Coefficient	Standard error	t value	P value	Coefficient	Standard error	t value	P value
X_1	-9.6033	6.5524	-0.147^{NS}	0.886	-8.3516	3.6992	-0.226^{NS}	0.826
X_2	-2.0600	2.3157	-0.890^{NS}	0.393	3.7123	6.2056	0.598^{NS}	0.562
R^2	**0.12**				**0.12**			

NS - Non-significant

X_1 = cloth stiffness

X_2 = cloth crease recovery

R^2 = coefficient of determination

4.4.4.5 Cloth pilling (rating)

Table 41 showed the resistance of test samples for pilling. Slight pilling was observed in Filature silk x Ahimsa silk (S_F) shirting material followed by moderate pilling among Cotton x Ahimsa silk (S_C), Tericot x Ahimsa silk (S_T) and control samples.

4.4.5 Mechanical properties of newly designed furnishings

4.4.5.1 Yarn count (Ne)

From Table 42 it is observed that Cotton x Ahimsa silk (F_C) furnishing materials both floral and geometrical designs were woven with finer cotton warp (40s) whereas, Ahimsa silk used for floral designs was 33s and that for geometrical was 34s. On the other hand the Control and Polyester x Ahimsa (F_P) silk were interlaced with warp and weft of almost similar yarn numbers (*i.e.*, 34s - Polyester and 35s - Ahimsa silk).

The statistical results indicated that warp yarn count in cotton furnishings was significantly higher than the control but that of polyester furnishing was little lower. Further the weft yarn count of Cotton x Ahimsa silk (F_C) furnishings was slightly lower than the control.

4.4.5.2 Cloth count (Numerical expression)

It is clear from the Table 43 that, Cotton x Ahimsa silk (F_C) floral and geometrically designed furnishing materials were interlaced with greater number of ends per unit area than the picks per unit area *i.e.*, each 60 warp and 30 (floral), 40 (geometrical) weft respectively. On the contrary, Polyester

Table 41. Cloth pilling of newly designed shirting materials (ratings)

Shirting material	**Pilling (rating)**
Control (Ahimsa silk x Ahimsa silk)	3
Cotton x Ahimsa silk (S_C)	3
Tericot x Ahimsa silk (S_T)	3
Filature silk x Ahimsa silk (S_F)	2

Ratings

1 - No pilling
2 - Slight but tolerable pilling
3 - Moderate pilling of border line accept
4 - Severe pilling
5 - Extremely high pilling

Table 42. Yarn count of newly designed furnishing materials (Ne)

Furnishing material	Direction		Yarn count	
	Warp	Weft	Warp	Weft
Control (Ahimsa x Ahimsa silk)	Ahimsa silk	Ahimsa silk	35s	35s
Cotton x Ahimsa silk (F_C Floral)	Cotton	Ahimsa silk	40s	33s
Cotton x Ahimsa silk (F_C Geometrical)	Cotton	Ahimsa silk	40s	34s
Polyester x Ahimsa silk (F_P)	Polyester	Ahimsa silk	34s (155d)	35s

Source	F-value	Probability	Sem±	CD	CV (%)
Warp	34.3256**	0.0004	0.5465	2.864	2.54
Weft	4.0000*	0.0301	0.4410	2.311	2.21

** - Significant at 1 per cent level
* - Significant at 5 per cent level

Table 43. Cloth count of newly designed furnishing materials (numerical expression)

Furnishing material	Cloth count	
	Warp way	Weft way
Control (Ahimsa x Ahimsa silk)	24	20
Cotton x Ahimsa silk (F_C Floral)	60	30
Cotton x Ahimsa silk (F_C Geometrical)	60	40
Polyester x Ahimsa silk (F_P)	48	68

Source	F-value	Probability	Sem±	CD	CV (%)
Warp	1179.4571**	0.0000	0.4930	2.584	1.78
Weft	994.13**	0.0000	0.6697	2.641	2.17

** - Significant at 1 per cent level

x Ahimsa silk (F_P) furnishing material was woven with greater picks per unit area (68) than its corresponding ends per unit area (48). Further control sample was woven with relatively low cloth count *i.e.,*24 x 20 compared to newly woven furnishing materials.

The statistical results indicated that cloth count (warp and weft) of newly designed furnishing materials was significantly higher than control.

4.4.5.3 Cloth weight (g/sq. mt)

Table 44 illustrates about the weight of the test samples. Among the newly designed furnishings Cotton x Ahimsa silk (F_C) samples possessed greater cloth weight (311g-floral and 276g-geometrical) compared to Polyester x Ahimsa silk (F_P, 166g). Control sample was found to be the lightest of all (132g). Further percentage warp was higher in all the samples except Polyester x Ahimsa silk sample. The percentage weft of the polyester x Ahimsa silk sample was greater causing weft-ribbed effect in the design.

However statistical results indicate that total weight in newly designed furnishings was significantly higher than the control.

4.4.5.4 Cloth thickness (mm)

From the Table 45 it is evident that Cotton x Ahimsa silk (F_C) furnishing materials exhibited to be greater cloth thickness *i.e.,* 0.93mm (floral) and 0.96mm (geometrical), respectively than control sample (0.50 mm) and Polyester x Ahimsa silk (F_P) furnishing (0.51mm). However statistical results showed that cloth thickness in newly designed furnishing

Table 44. Cloth weight of newly designed furnishing materials (g/sq.mt.)

Furnishing material	Total weight (g/sq.mt.)	Per cent warp	Per cent weft
Control (Ahimsa x Ahimsa silk)	132	51.81	45.66
Cotton x Ahimsa silk (F_C Floral)	311	55.52	44.47
Cotton x Ahimsa silk (F_C Geometrical)	276	60.37	38.19
Polyester x Ahimsa silk (F_P)	166	48.79	51.20

Source	F-value	Probability	Sem±	CD	CV (%)
Total weight (g/sq.mt)	88366.94**	0.0000	0.2887	1.513	0.22

** - Significant at 1 per cent level

Table 45. Cloth thickness of newly designed furnishing materials (mm)

Furnishing material	Cloth thickness (mm)
Control (Ahimsa x Ahimsa silk)	0.50
Cotton x Ahimsa silk (F_C Floral)	0.93
Cotton x Ahimsa silk (F_C Geometrical)	0.96
Polyester x Ahimsa silk (F_P)	0.51

Source	F-value	Probability	Sem±	CD	CV (%)
Cloth thickness (mm)	1941.00**	0.0000	0.0058	0.030	1.38

** - Significant at 1 per cent level

materials was significantly higher than the control *i.e.*, the difference was significant and greater among Cotton x Ahimsa (F_C) silk materials.

4.4.5.5 Cloth stiffness (cm)

Table 46 depicts that Polyester x Ahimsa silk (F_P) furnishing materials showed higher bending length in both warp-way (1.25cm) and weft-way (1.00 cm) whereas, relatively lesser bending length was exhibited by control (0.99cm-warp and 1.00cm-weft) and Cotton x Ahimsa silk (F_C) samples (1.10 each in warp and weft-way for floral, 1.00 and 1.10cm for geometrical). However statistical results indicated that cloth stiffness (warp and weft) of newly designed furnishing was slightly greater than the control.

4.4.5.6 Crease recovery (degree)

The data presented in Table 47 showed that in general the weft-way recovery was found to be higher than warp-way. Control sample (111° each) and Polyester x Ahimsa silk (F_P) furnishings (103° and 112°) showed greater crease recovery angle compared to Cotton x Ahimsa silk (F_C) furnishing materials *i.e.*,(92° and 112°-floral; 93° and 113°-geometrical). On the other hand ultimate cloth recovery was higher with control sample and Polyester x Ahimsa (F_P) silk furnishing materials (111° and 107°).

The statistical results indicated that cloth recovery in newly designed furnishing materials was significantly lower than the control sample.

Table 46. Cloth stiffness of newly designed furnishing materials (cm)

Furnishing material	Bending length (cm)	
	Warp	Weft
Control (Ahimsa x Ahimsa silk)	0.99	1.00
Cotton x Ahimsa silk (F_C Floral)	1.10	1.10
Cotton x Ahimsa silk (F_C Geometrical)	1.0	1.10
Polyester x Ahimsa silk (F_P)	1.25	1.20

Source	F-value	Probability	Sem±	CD	CV (%)
Warp	19.067**	0.0031	0.194	0.787	6.67
Weft	11.3721**	0.0069	0.546	2.861	5.22

** - Significant at 1 per cent level

Table 47. Crease recovery of newly designed furnishing materials (degree)

Furnishing material	Warp	Weft	Cloth recovery (degree)
Control (Ahimsa x Ahimsa silk)	111	111	111
Cotton x Ahimsa silk (F_C Floral)	92	112	102
Cotton x Ahimsa silk (F_C Geometrical)	93	113	103
Polyester x Ahimsa silk (F_P)	103	112	107

Source	F-value	Probability	Sem±	CD	CV (%)
Cloth recovery (degree)	567.1875**	0.0000	0.5774	3.026	0.90

** - Significant at 1 per cent level

4.4.6 Functional properties of newly designed furnishings

4.4.6.1 Cloth tensile strength (kgf) and elongation (%)

The data presented in Table 48 revealed the tensile strength of newly designed furnishing materials. Among the furnishing materials Polyester x Ahimsa silk (F_P) material possessed relatively greater tensile strength (106.80 and 67.54 kgf) than Cotton x Ahimsa silk (F_C) furnishing materials (73.57 x 50.57 kgf - floral and 78.32 x 62.01 kgf - geometrical). On the other hand control sample warp-way showed relatively lesser tensile strength (40.99 kgf). In general warp-way strength was higher than weft-way (46.48 kgf).

Further the statistical results indicated that cloth tensile strength (warp and weft) of newly designed furnishing materials was significantly greater than the control sample.

Influence of yarn count and cloth count on cloth tensile strength of newly designed furnishing materials

It was observed from Table 49 that, the yarn count and cloth count of the furnishing materials influenced their corresponding tensile strength which is evident from the values, being highly significant, except in weft yarn count. Further it is revealed that yarn count and cloth tensile strength were negatively related in warp direction indicating increase in yarn count resulted into decrease in tensile strength. On the other hand both warp-way and weft-way cloth counts positively influenced their tensile strength which is statistically proved *i.e.* increase in cloth count resulted into increase in

Table 48. Cloth tensile strength of newly designed furnishing materials (kgf)

Furnishing material	Tensile strength	
	Warp	Weft
Control (Ahimsa x Ahimsa silk)	40.99	46.48
Cotton x Ahimsa silk (F_C Floral)	73.57	50.57
Cotton x Ahimsa silk (F_C Geometrical)	78.32	62.01
Polyester x Ahimsa silk (F_P)	106.80	67.54

Source	F-value	Probability	Sem±	CD	CV (%)
Warp	19417.97**	0.0000	0.1925	1.009	0.44
Weft	287.7170**	0.0000	0.5774	3.026	1.77

** - Significant at 1 per cent level

Table 49. Influence of yarn count and cloth count on cloth tensile strength of newly designed furnishing materials

Source	Warp				Weft			
	Coefficient	Standard error	t value	P value	Coefficient	Standard error	t value	P value
X_1	-8.6003	1.1030	-7.797**	0.000	-6.0512	1.1185	-0.541^{NS}	0.599
X_2	2.1747	2.1549	10.092**	0.000	4.5516	5.9731	7.620**	0.000
R^2	0.91				0.87			

** - Significant at 1 per cent level

* - Significant at 5 per cent level

NS - Non-significant

X_1 = yarn count

X_2 = cloth count

R^2 = coefficient of determination

cloth tensile strength. Further the influence of yarn count and cloth count on cloth tensile strength is explained by R^2 values *i.e.*, 91 per cent and 87 per cent respectively.

Table 50 illustrates the elongation of newly designed furnishing materials. In general warp-way elongation was higher than weft-way except control, where it was found to be lower. Among the furnishing samples elongation percentage was higher in Polyester x Ahimsa silk (F_P) in warp direction (36.84 %) compared to Cotton x Ahimsa silk (F_C) materials *i.e.*, warp-way 17.86 (floral) and 17.09 (geometrical) per cent, respectively. A similar trend of elongation was observed in weft-way among all the test samples ranging from 12.45 to 16.80 percent.

Moreover statistical results revealed that warp cloth elongation of newly designed furnishings was significantly higher than the control. On the other hand a slight variation was observed in weft cloth elongation of all test samples.

Influence of yarn count and cloth count on cloth elongation of newly designed furnishing materials

It is observed from Table 51 that influence of yarn count and cloth count on cloth elongation are highly significant with positive relationship in warp direction *i.e.,* increase in yarn count and cloth count resulted into increase in cloth elongation. However, yarn count and cloth count on cloth elongation were non significant in weft direction. Further the influence of

Table 50. Cloth elongation of newly designed furnishing materials (%)

Furnishing material	Elongation (%)	
	Warp	Weft
Control (Ahimsa x Ahimsa silk)	13.81	14.87
Cotton x Ahimsa silk (F_C Floral)	17.86	12.45
Cotton x Ahimsa silk (F_C Geometrical)	17.09	16.80
Polyester x Ahimsa silk (F_P)	36.84	14.22

Source	F-value	Probability	Sem±	CD	CV (%)
Warp	327.1094**	0.000	0.5774	3.026	4.67
Weft	8.9344*	0.0124	0.6009	1.921	7.14

** - Significant at 1 per cent level
* - Significant at 1 per cent level

Table 51. Influence of yarn count and cloth count on elongation of newly designed furnishing materials

Source	Warp				Weft			
	Coefficient	Standard error	t value	P value	Coefficient	Standard error	t value	P value
X_1	-4.1653	5.3403	-7.800**	0.000	6.7734	6.1299	1.105^{NS}	0.293
X_2	6.8559	1.0433	6.571**	0.000	-7.8185	3.2736	-0.239^{NS}	0.816
R^2	**0.87**				**0.12**			

** - Significant at 1 per cent level

* - Significant at 5 per cent level

NS - Non-significant

X_1 = yarn count

X_2 = cloth count

R^2 = coefficient of determination

yarn count and cloth count on cloth elongation is explained by R^2 value *i.e.* 87 per cent and 12 per cent, respectively.

4.4.6.2 Cloth tear strength (g)

Table 52 depicts about the tear strength of newly designed furnishing materials. All the test samples could not be torn in both warp and weft directions when sudden force was applied. The capacity of the Elmendorf tear testing machine was found be insufficient to tear the samples both warp-way and weft way.

4.4.6.3 Cloth abrasion resistance (cycles)

Table 53 revealed about the cloth abrasion resistance of newly designed furnishing materials. The control sample showed higher resistance to abrasion (272 cycles) than newly designed furnishing materials. Among the furnishing samples Cotton x Ahimsa (F_C) silk showed higher resistance to abrasion (127 cycles - floral and 115 cycles - geometrical) compared to Polyester x Ahimsa silk sample (F_P, 100 cycles). The value of loss in thickness of control samples on abrasion was found to be higher (8 per cent) than their corresponding values of newly designed furnishing materials. The loss in mass of the test samples on abrasion, expressed in percentage was relatively higher in control sample (5.01) followed by Cotton x Ahimsa silk samples (5.01 - floral and 4.56 - geometrical) and Polyester x Ahimsa silk furnishing material (2.18).

Table 52. Cloth tear strength of newly designed furnishing materials (g)

Furnishing material	Tear strength (g)	
	Warp	Weft
Control (Ahimsa x Ahimsa silk)	*	*
Cotton x Ahimsa silk (F_C Floral)	*	*
Cotton x Ahimsa silk (F_C Geometrical)	*	*
Polyester x Ahimsa silk (F_P)	*	*

* - Warp-way tear strength was beyond the capacity of the instrument.

Table 53. Cloth abrasion resistance of newly designed furnishing materials (cycles)

Furnishing material	Number of cycles	Loss in mass (%)	Loss in thickness (%)
Control (Ahimsa x Ahimsa silk)	272	5.01	8.00
Cotton x Ahimsa silk (F_C Floral)	127	5.01	6.45
Cotton x Ahimsa silk (F_C Geometrical)	115	4.56	4.65
Polyester x Ahimsa silk (F_P)	100	2.18	1.96

Source	F-value	Probability	Sem±	CD	CV (%)
Loss in moss (%)	42562.94**	0.0000	0.0069	0.361	0.27
Loss in thickness (%)	3627.90**	0.0000	0.0431	0.225	1.42

** - Significant at 1 per cent level

However statistical results indicated that mass loss and thickness loss of newly designed furnishing materials were significantly lower than the control.

Influence of yarn count and cloth thickness on cloth abrasion resistance of newly designed furnishings

Table 54 discloses the influence of yarn count and cloth thickness on cloth abrasion resistance. There existed no relationship between independent and dependent variables of the test samples, since the values were statistically non-significant. Further the influence of yarn count and cloth thickness, on cloth abrasion resistance is explained by R^2 value *i.e.*, 10, 22 per cent and 35, 11 per cent respectively.

4.4.6.4 Cloth Drapability (%)

From the Table 55 it is evident that, Polyester x Ahimsa silk (F_P) furnishing material exhibited greater drape coefficient values (98.01%) since draped into relatively less number of nodes (5). On the other hand control (79.58%) and Cotton x Ahimsa silk (F_C, 81.62-floral and 71.15-geometrical) showed lower drape coefficient values with higher nodes (6) which clearly indicated that these materials draped gracefully than Polyester x Ahimsa silk.

Moreover the statistical results indicated that drape coefficient of Cotton x Ahimsa silk (floral design) and Polyester x Ahimsa silk furnishings was significantly higher than the control.

Table 54. Influence of yarn count and cloth thickness on abrasion resistance of newly designed furnishing materials

	Source	Warp				Weft			
		Coefficient	Standard error	t value	P value	Coefficient	Standard error	t value	P value
Loss in mass	X_1	3.4954	4.3896	0.796^{NS}	0.443	-9.8077	4.6409	-2.113^{NS}	0.058
	X_2	-5.4480	5.7124	-0.954^{NS}	0.361	-3.9962	2.0157	-1.983^{NS}	0.073
	R^2	0.10				0.35			
Loss in thickness	X_1	1.1711	7.5091	1.560^{NS}	0.147	-1.0160	1.0022	-1.014^{NS}	0.332
	X_2	-1.3551	9.7721	-1.387^{NS}	0.197	-2.0299	4.3528	-0.466^{NS}	0.650
	R^2	0.22				0.11			

** - Significant at 1 per cent level
* - Significant at 5 per cent level
NS - Non-significant

X_1 = yarn count
X_2 = cloth thickness
R^2 = coefficient of determination

Table 55. Drapability of newly designed furnishing materials (%)

Furnishing material	Number of nodes	Drape-coefficient (%)
Control (Ahimsa x Ahimsa silk)	6	79.58
Cotton x Ahimsa silk (F_C Floral)	6	81.62
Cotton x Ahimsa silk (F_C Geometrical)	6	71.15
Polyester x Ahimsa silk (F_P)	5	98.01

Source	F-value	Probability	Sem±	CD	CV (%)
Drape coefficient (%)	413.8148**	0.0000	0.5523	2.894	1.16

** - Significant at 1 per cent level

Influence of cloth stiffness and crease recovery on drapability of newly designed furnishing materials

It is apparent from Table 56 that crease recovery and drapability is highly significant at 1 percent level with positive relationship *i.e.,*increase in crease recovery resulted into increase in drape coefficient value. On the other hand, drapability was found to be independent of cloth stiffness *i.e.,* statistically non significant. Further, the influence of cloth stiffness and crease recovery on drapability is explained by R^2 value *i.e.,*90 per cent.

4.4.6.5 Cloth pilling (ratings)

The perusal of Table 57 shows pilling appearance of newly designed furnishing materials. Pilling is the rubbing up of the fibres on the fabric surface into a small ball, an unsightly defect occurs in fabrics made from spun yarns. The pills are formed during wear and laundering by entanglement of loose fibres and giving the fabric an unsightly appearance.

From this Table it was evident that, newly designed furnishing materials showed slight to moderate pilling *i.e.,* Cotton x Ahimsa silk (F_C) furnishings exhibited slight pilling (rating 2) where as Polyester x Ahimsa silk (F_P) material showed moderate pilling (rating 3).

4.5 Subjective evaluation of newly designed made-ups

The quality of the fabric in the textile and apparel industry has been traditionally assessed subjectively by the sense of touch, involving extensive personal preferences. The quality of the woven fabric is judged initially by its

Table 56. Influence of cloth stiffness and crease recovery on drapability of newly designed furnishing materials

Source	Warp				Weft			
	Coefficient	Standard error	t value	P value	Coefficient	Standard error	t value	P value
X_1	-6.9164	2.7879	-0.248^{NS}	0.809	6.8564	1.2705	0.540^{NS}	0.600
X_2	1.7114	2.767	6.181**	0.000	-3.5696	4.6338	-7.703**	0.000
R^2	**0.90**				**0.90**			

** - Significant at 1 per cent level

NS - Non-significant

X_1 = cloth stiffness

X_2 = cloth crease recovery

R^2 = coefficient of determination

Table 57. Cloth pilling of newly designed furnishing materials (ratings)

Furnishing material	Pilling (ratings)
Control (Ahimsa x Ahimsa silk)	3
Cotton x Ahimsa silk (F_C Floral)	2
Cotton x Ahimsa silk (F_C Geometrical)	2
Polyester x Ahimsa silk (F_P)	3

Ratings

1 - No pilling

2 - Slight but tolerable pilling

3 - Moderate pilling of border line accept

4 - Severe pilling

5 - Extremely high pilling

appearance, handle and texture and thereafter by how it wears and performs in actual service. Hence, the fabric quality is associated with fibre content, type of yarn, fabric construction and finish applied in each case. Overall judgement relies upon the experience with the particular end use for which the fabric is designed and intended for (Plate 41).

The general information of the respondents who formed the subjects for evaluation of tactile properties of newly designed made-ups is presented here under:

1. Age

Table 58 reveals the distribution of respondents according to their age. It is observed that majority of them belonged to younger (44.00 %) followed by middle (36.00 %) and older (20.00 %) age groups.

2. Education

Among the respondents majority of them were post graduates (56.00 %) followed by doctorates (28.00 %) and degree holders (16.00 %) (Table 58).

3. Occupation

It is imperative from Table 58 that 68.00 per cent of the respondents were employed whereas and rest were unemployed.

4.5.1 Respondents opinion on fabric appearance of newly designed dress materials

Majority of the respondents as learnt from Table 59 opined that newly designed dress materials were fibrous in nature. Among the dress materials

Table 58. Distribution of respondents according to age, education and occupation

Sl. No.	Variables	Number of respondents (%)
1.	Age	
	Younger (<29 years)	11 (44.00)
	Middle (29-36 years)	09 (36.00)
	Older (>36 years)	05 (20.00)
2.	Education	
	Degree	04 (16.00)
	Post graduate	14 (56.00)
	Doctorate	07 (28.00)
3.	Occupation	
	Employed	17 (68.00)
	Unemployed	08 (32.00)

Figures in parenthesis indicate percentage

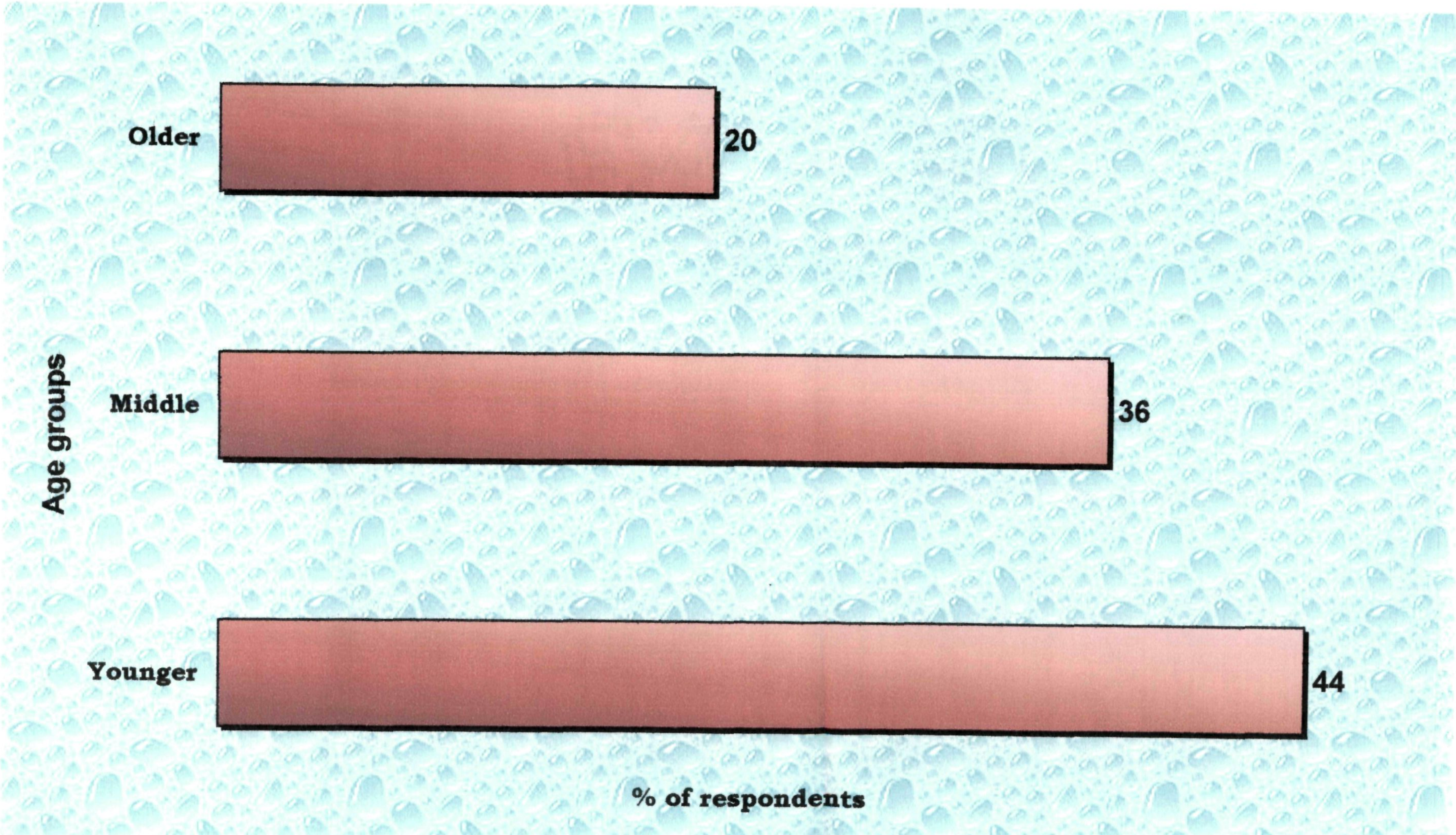


Fig. 3 Distribution of respondents according to age

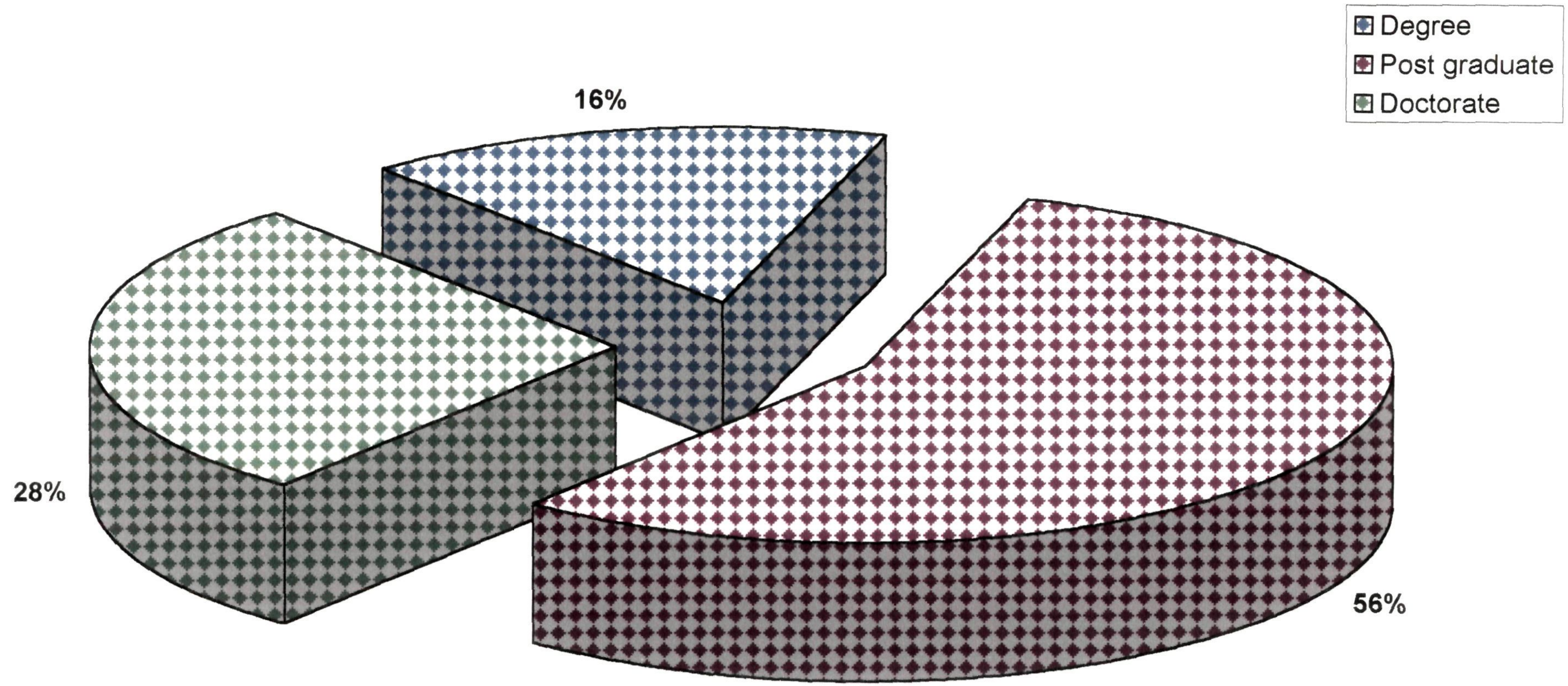


Fig. 4 Distribution of respondents according to education

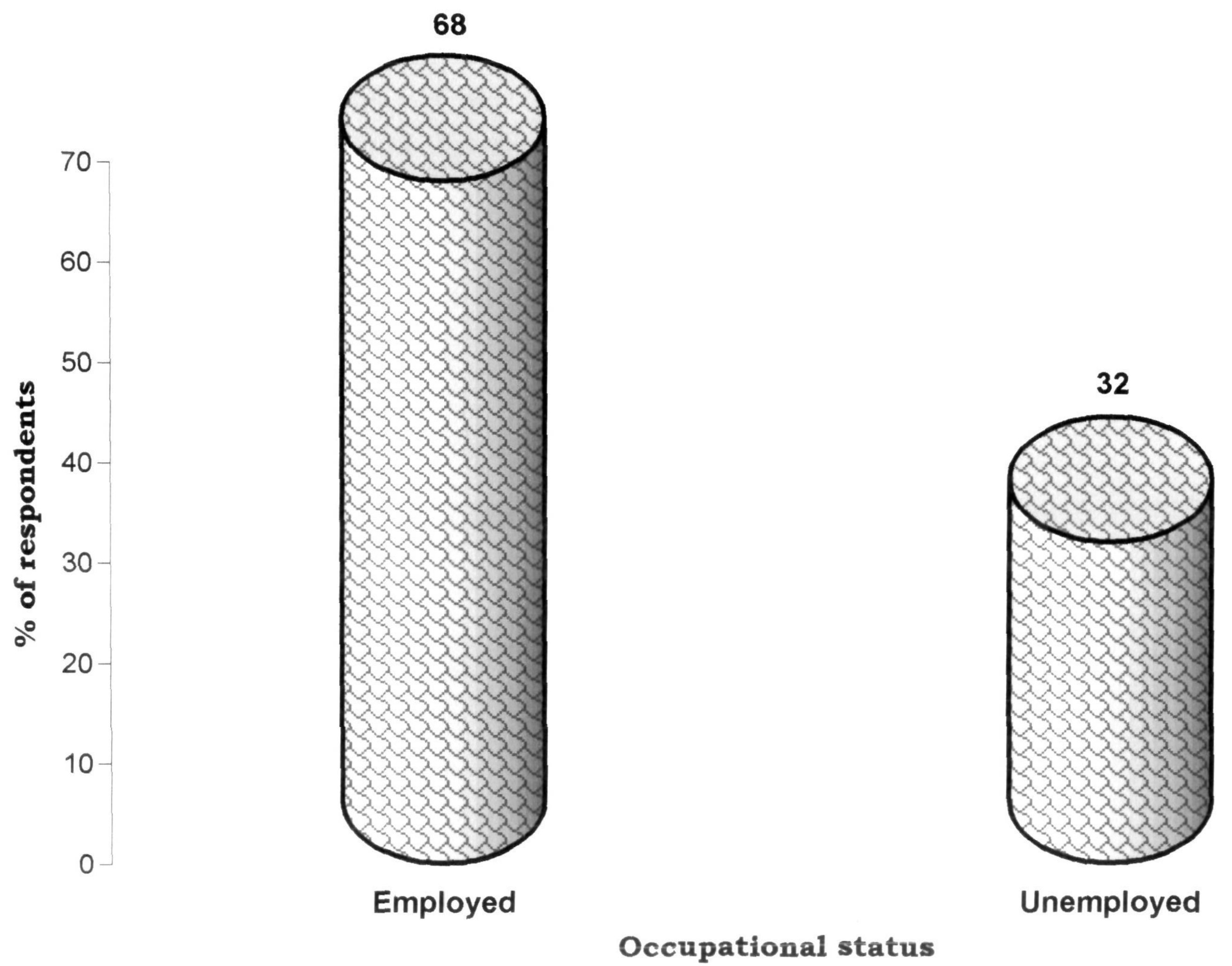


Fig. 5 Distribution of respondents according to occupation

Table 59. Respondents opinion on fabric appearance of newly designed Dress materials

(n=25)

Sl. No.	Type of appearance	Control		Dress material					
				D_C		D_A		D_F	
1.	Clear or Fibrous	05 20	(20) (80)	02 23	(08) (92)	01 24	(04) (96)	07 18	(28) (72)
2.	Fine or Coarse	11 14	(44) (56)	- 25	- (100)	05 20	(20) (80)	17 08	(68) (32)
3.	Smooth or rough	09 16	(36) (64)	20 05	(80) (20)	05 20	(20) (80)	25 -	(100) -
4.	Lustrous or dull	21 04	(84) (16)	11 14	(44) (56)	16 09	(64) (36)	25 -	(100) -
5.	Plain or Patterned	25 -	(100) -	18 07	(72) (28)	11 14	(44) (56)	17 08	(68) (32)

Figures in parenthesis indicate percentages

Plate 41: Textile experts evaluating the newly designed made-ups

Art silk x Ahimsa silk (D_A) was found to be extensively fibrous (96 %) in nature followed by Cotton x Ahimsa silk (D_C, 92 %), control (80 %) and Filature silk x Ahimsa silk (D_F, 72 %) material. On the other hand very few of them mentioned as these fabrics to be clear in surface. Further it was evident that all the samples were coarser in appearance i.e. Cotton x Ahimsa silk (100 %) followed by Art silk x Ahimsa silk (80 %) and control sample (56 %) except Filature silk x Ahimsa silk dress material which was fine (68 %) as mentioned by respondents. Cent percent of the respondents opined that the Filature silk x Ahimsa silk material was of smooth in appearance. However majority of the respondents expressed, Cotton x Ahimsa silk, Art silk x Ahimsa Silk (80 % each) and control sample were rough in appearance. Most of the respondents also expressed that, newly designed salwar suits were lustrous in appearance i.e. Filature silk x Ahimsa silk (100 %) control sample (84 %), and Art silk x Ahimsa silk (64 %). On the other hand Cotton x Ahimsa silk dress materials was felt as dull in appearance (56 %). Further, greater per cent of the respondents were able to identity the newly designed dress materials woven in plain weave except Art silk x ahimsa silk, which was woven with patterned design on either sides of the border.

4.5.2 Respondents opinion on fabric handle of newly designed dress material

It is interesting to note that, maximum per cent of the respondents expressed that the dress material of Filature silk x Ahimsa silk (68 %) and control sample were soft to handle. On the other hand Cotton x Ahimsa silk (72 %) and Art silk x Ahimsa silk (64 %) dress material exhibited crisp handle as stated by respondent. Filature silk x Ahimsa silk dress material

(100%), control sample (92%) and Art silk x Ahimsa silk (52%) were flexible than Cotton x Ahimsa silk dress materials, which in turn found to be stiffer (84 %) as mentioned by respondents. Cent percent of the respondent opined, newly designed dress materials were compactly woven, except control sample (92 %), which is loosely woven (Table 60).

4.5.3 Respondents opinion on fabric texture of newly designed dress materials

From the Table 61 it is clear that cent per cent of the respondents stated newly designed dress materials were compactly and firmly woven than control sample, which is attributed to loosely open structure.

However majority of the respondents opined that Filature silk x Ahimsa silk (96 %) and control sample (84 %) were light in weight. On the other hand maximum percent of respondents expressed Cotton x Ahimsa silk (72 %) and Art silk x Ahimsa silk (52 %) dress materials were relatively heavy in weight. Further it was also mentioned that all the samples were flat in structure.

4.5.4 Order of preferences for newly designed dress materials by the textile experts

Table 62 reported on the order of preference for newly designed dress materials. The order of preferences expressed in terms of weighted average ranking (WAR) in which higher the values lesser is the preference and vice-versa. Most of the respondent preferred Art silk x Ahimsa silk dress material (1.60) followed by Cotton x Ahimsa silk (2.04) and Filature silk x Ahimsa silk (2.32). Further the control sample (3.08) was found to be least preferred.

Table 60. Respondents opinion on fabric handle of newly designed Dress materials

(n=25)

Sl. No.	Type of handle	Control		Dress material					
				D_C		D_A		D_F	
1.	Soft or	17	(68)	07	(28)	09	(36)	23	(92)
	crisp	08	(32)	18	(72)	16	(64)	02	(08)
2.	Flexible or	23	(92)	04	(16)	13	(52)	25	(100)
	stiff	02	(08)	21	(84)	12	(48)	48	-
3.	Loose or	23	(92)	-	-	-	-	-	-
	compact	02	(08)	25	(100)	25	(100)	25	(100)

Figures in parenthesis indicate percentages

Table 61. Respondents opinion on fabric texture of newly designed Dress materials

(n=25)

Sl. No.	Type of texture	Control		Dress material					
				D_C		D_A		D_F	
1.	Close or	-	-	25	(100)	25	(100)	25	(100)
	open	25	(100)	-	-	-	-	-	-
2.	Light or	21	(84)	03	(12)	10	(40)	25	(100)
	heavy	04	(16)	22	(88)	15	(60)	-	-
3.	Loose or	23	(92)	-	-	-	-	05	(20)
	firm	02	(08)	25	(100)	25	(100)	20	(80)
4.	Flat or	20	(80)	23	(92)	18	(72)	20	(80)
	raised	05	(20)	02	(08)	07	(28)	05	(20)

Figures in parenthesis indicate percentages

Table 62. Order of preferences for newly designed Dress materials by the textile experts

(n=25)

Order of preferences	Control	Dress material		
		D_C	D_A	D_F
Excellent	-	03	10	06
Good	07	18	15	12
Fair	09	04	-	07
Poor	09	-	-	-
WAR	**3.08 IV**	**2.04 II**	**1.60 I**	**2.32 III**

Ranking

Excellent - I
Good - II
Fair - III
Poor - IV
WAR - Weighted Average Ranking

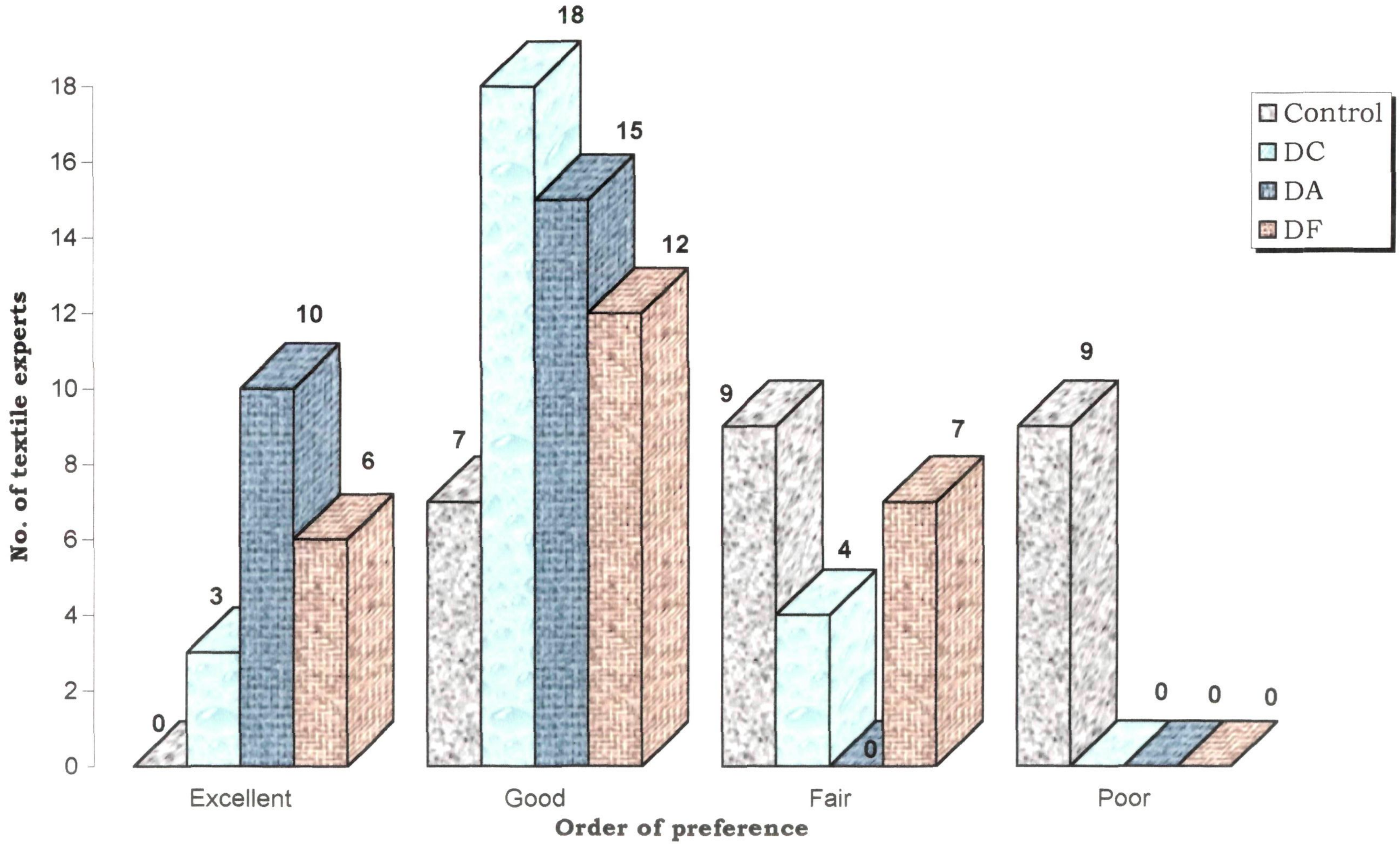


Fig. 6 Order of preferences for newly designed dress materials assigned by textile experts

4.5.5 Respondents opinion on fabric appearance of newly designed shirting materials

An observation of Table 63 deals about the respondents opinion about the fabric appearance of newly designed shirting materials. Majority of the respondents opined that newly woven shirting materials were fibrous and coarse in appearance. Among the test samples, Tericot x Ahimsa silk was found to be extensively fibrous and coarser (86 % and 76 %) followed by control sample (80 % and 56 %), and Cotton x Ahimsa silk (64 % and 52 %). On the other hand Filature silk x Ahimsa silk shirting exhibited clear and fine appearance (60 % and 76 %) as stated by the respondents.

Further most of the respondents expressed Tericot x Ahimsa silk (80 %), control sample (64 %) and Cotton x Ahimsa silk (60 %) to be rough in appearance where as cent per cent of them opined that, the Filature x Ahimsa silk to be smooth in appearance. Most of the respondents expressed that all the samples were lustrous in appearance. However, cent per cent of respondents could identify weave employed in the newly designed shirting materials to be plain weave.

4.5.6 Respondents opinion on fabric handle of newly designed shirting materials

From Table 64 it is clear that most of the respondents opined that Control sample and Filature silk x Ahimsa silk (S_F) shirting material were soft and flexible to handle *i.e.*,68 % & 92 % and 84 % & 60 %, respectively. On the other hand Tericot x Ahimsa silk (80 % and 60 %) and Cotton x Ahimsa silk (56 % and 64 %) were found to be crispy and stiff to handle as

Table 63. Respondents opinion on fabric appearance of newly designed shirting materials

(n=25)

Sl. No.	Type of appearance	Control		Shirting material					
				S_C		S_T		S_F	
1.	Clear or Fibrous	05 20	(20) (80)	09 16	(36) (64)	04 21	(16) (84)	15 10	(60) (40)
2.	Fine or Coarse	11 14	(44) (56)	12 13	(48) (52)	06 19	(24) (76)	19 06	(76) (24)
3.	Smooth or rough	09 16	(36) (64)	10 15	(40) (60)	05 20	(20) (80)	25 -	(100) -
4.	Lustrous or dull	21 04	(84) (16)	18 07	(72) (28)	22 03	(88) (12)	25 -	(100) -
5.	Plain or Patterned	25 -	(100) -	25 -	(100) -	25 -	(100) -	25 -	(100) -

Figures in parenthesis indicate percentages

Table 64. Respondents opinion on fabric handle of newly designed shirting materials

(n=25)

Sl. No.	Type of handle	Control		Shirting material					
				S_C		S_T		S_F	
1.	Soft or crisp	17 08	(68) (32)	11 14	(44) (56)	05 20	(20) (80)	21 04	(84) (16)
2.	Flexible or stiff	23 02	(92) (08)	09 16	(36) (64)	10 15	(40) (60)	15 10	(60) (40)
3.	Loose or compact	23 02	(92) (08)	- 25	- (100)	- 25	- (100)	- 25	- (100)

Figures in parenthesis indicate percentages

stated by respondents. However, cent per cent of the respondents expressed newly woven shirting materials were compactly woven except control sample which was loosely woven.

4.5.7 Respondents opinion on fabric texture of newly designed shirting materials

From Table 65 it is evident that, cent per cent of respondents stated that newly woven shirting materials were firm in texture compared to control sample, which was attributed to its loose and open structure (100 % and 92 %). On the other hand maximum percent of respondents opined that Filature silk x Ahimsa silk (S_F) shirting material (100 %) and control sample (84 %) were light in weight. However, majority of the respondents expressed Cotton x Ahimsa silk (S_C, 80 %) and Tericot x Ahimsa silk (S_T, 60 %) shirting materials were found to be heavier than the Filature silk. Further, most of the respondents opined that, all the samples were flat in surface without any figures *i.e.* Cotton x Ahimsa silk (92 %), Filature x Ahimsa silk and control sample (80 %) and Tericot x Ahimsa silk (72 %), respectively.

4.5.8 Order of preferences for newly designed shirting materials by the textile experts

Table 66 revealed about the order of preferences for newly woven shirting materials. The orders of preferences were expressed in terms of Weighted Average Ranking (WAR). As per the ratings the results disclose that higher the value lesser is the preference and vice-versa. From the table it is learnt that majority of the respondents preferred Filature silk x Ahimsa silk shirting material (1.96) followed by Tericot x Ahimsa silk (2.00) and

Table 65. Respondents opinion on fabric texture of newly designed shirting materials

(n=25)

Sl. No.	Type of texture	Control		Shirting material					
				S_C		S_T		S_F	
1.	Close or open	- 25	- (100)	25 -	(100) -	25 -	(100) -	25 -	(100) -
2.	Light or heavy	21 04	(84) (16)	12 19	(48) (72)	06 13	(28) (52)	24 01	(96) (04)
3.	Loose or firm	23 02	(92) (08)	- 25	- (100)	- 25	- (100)	- 25	- (100)
4.	Flat or raised	20 05	(80) (20)	21 04	(84) (16)	20 05	(80) (20)	29 05	(80) (20)

Figures in parenthesis indicate percentages

Table 66. Order of preferences for newly designed shirting materials by the textile exports

(n=25)

Order of preference	Control	Shirting material		
		S_C	S_T	S_F
Excellent	-	02	03	12
Good	07	16	19	09
Fair	09	07	03	04
Poor	09	-	-	-
WAR	**3.08** ^{IV}	**2.48** ^{III}	**2.00** ^{II}	**1.96** ^{I}

Ranking

Excellent - I
Good - II
Fair - III
Poor - IV
WAR - Weighted Average Ranking

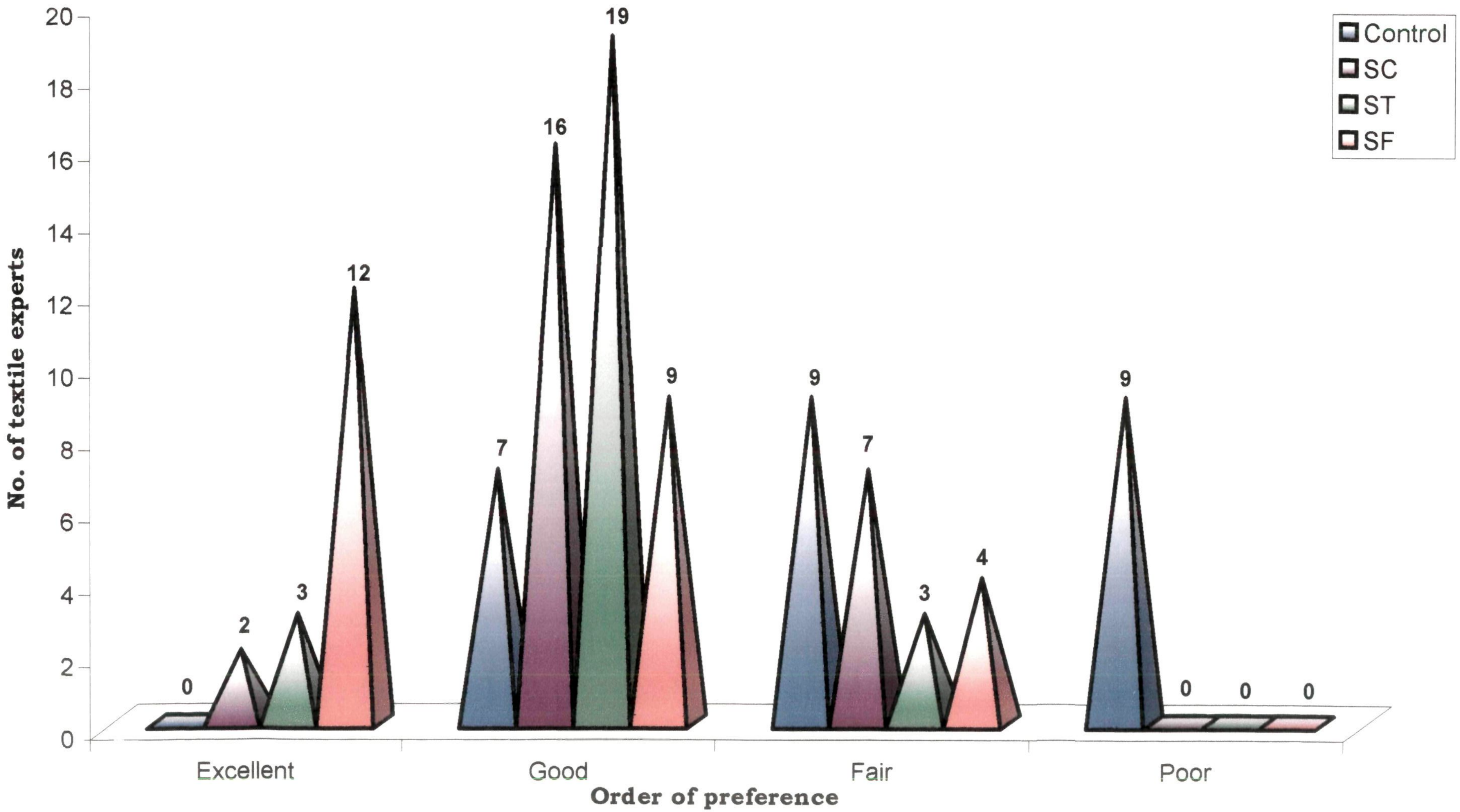


FIg. 7 Order of preferences for newly designed shirting materials assigned by textile experts

finally Cotton x Ahimsa silk (2.48). On the other hand control sample was found to be least preferred (3.08).

4.5.9 Respondents opinion on fabric appearance of newly designed furnishing materials

An observation of Table 67 deals about the respondent's opinion on fabric handle of newly designed furnishing materials. Most of the respondents stated that newly designed furnishing materials were fibrous and coarser in appearance *i.e.* control sample (80% and 56%), Cotton x Ahimsa silk (F_C, 72% and 92% - floral and 72% and 68% - geometrical) and Polyester x Ahimsa silk (F_P, 60% and 68%). On the other hand majority of the respondents opined that newly designed furnishing materials were lustrous and rough in appearance *i.e.*, Polyester x Ahimsa silk (72% and 52%), Cotton x Ahimsa silk (68% and 72% - floral and 52% and 84% - geometrical) furnishing materials. In general furnishing materials were woven in to patterned designs except the control sample.

4.5.10 Respondents opinion on fabric handle of newly designed furnishing materials

An appraisal of Table 68 showed that maximum per cent of the respondents expressed newly designed furnishing materials were crispy to handle than the control sample *i.e.*, Polyester x Ahimsa silk (F_P, 76%) and Cotton x Ahimsa silk (F_C, 64% - floral and 60% - geometrical). However, control sample and Cotton x Ahimsa silk (F_C) furnishings were found to be flexible *i.e.*, (92% & 72% - floral) and 64% - geometrical, respectively. On the

Table 67. Respondents opinion on fabric appearance of newly designed furnishing materials

(n=25)

Sl. No.	Type of appearance	Control		Furnishing material					
				F_C - floral		F_C - geometrical		F_P	
1.	Clear or Fibrous	05 20	(20) (80)	07 18	(28) (72)	07 18	(28) (72)	10 15	(40) (60)
2.	Fine or Coarse	11 14	(44) (56)	02 23	(08) (92)	08 17	(32) (68)	08 12	(32) (68)
3.	Smooth or rough	09 16	(36) (64)	04 21	(16) (84)	07 18	(28) (72)	12 13	(48) (52)
4.	Lustrous or dull	21 04	(84) (16)	13 12	(52) (48)	17 08	(68) (32)	18 07	(72) (28)
5.	Plain or Patterned	25 -	(100) -	- 25	- (100)	- 25	- (100)	- 25	- (100)

Figures in parenthesis indicate percentages

Table 68. Respondents opinion on fabric handle of newly designed furnishings

(n=25)

Sl. No.	Type of handle	Control		Furnishing material					
				F_C - floral		F_C - geometrical		F_P	
1.	Soft or crisp	17 08	(68) (32)	10 15	(40) (60)	09 16	(36) (64)	06 19	(24) (76)
2.	Flexible or stiff	23 02	(92) (08)	16 09	(64) (36)	18 07	(72) (28)	18 17	(32) (78)
3.	Loose or compact	23 02	(92) (08)	- 25	- (100)	- 25	- (100)	- 25	- (100)

Figures in parenthesis indicate percentages

contrary Polyester x Ahimsa silk (F_P) furnishing material felt to be stiff to handle (78%) as stated by respondents. Further all the newly designed furnishing materials were compactly woven than control sample.

4.5.11 Respondents opinion on fabric texture of newly designed furnishing materials

Table 69 indicated that most of the respondents mentioned that all the three newly designed furnishing materials were woven with compact structure with raised effect *i.e.,*both varieties of Cotton x Ahimsa silk (F_C, 84 and 96% - floral and 100% - geometrical) and Polyester x Ahimsa silk (F_P, 100% each). On the contrary, control sample showed an open structure with flat texture *i.e.* 100% and 80%, respectively. Further it was also expressed that newly designed furnishing materials were heavier and firmly interlaced *i.e.,* Cotton x Ahimsa silk (52% and 48% - floral and 56% and 44% - geometrical) and polyester x Ahimsa silk (56 and 100% each) than the control sample, which was explained as light (84%) and loose (92%).

4.5.12 Order of preferences for newly designed furnishing materials assigned by textile experts

From Table 70 it is clear that higher the Weighted Average Ranking (WAR) least is the preference. It is noticed that the Cotton x Ahimsa silk furnishing materials (1.76 - floral and 1.96 - geometrical) were preferred most by the respondents compared to polyester x Ahimsa silk furnishing materials (2.28).

Table 69. Respondents opinion on fabric texture of newly designed furnishing materials

(n=25)

Sl. No.	Type of texture	Control		Furnishing material					
				F_C - floral		F_C - geometrical		F_P	
1.	Close or	-	-	21	(84)	25	(100)	25	(100)
	open	25	(100)	04	(16)	-	-	-	-
2.	Light or	21	(84)	12	(48)	11	(44)	11	(44)
	heavy	04	(16)	13	(52)	14	(56)	14	(56)
3.	Loose or	23	(92)	02	(08)	-	-	-	-
	firm	02	(08)	23	(92)	25	(100)	25	(100)
4.	Flat or	20	(80)	01	(04)	-	-	-	-
	raised	05	(20)	24	(96)	25	(100)	25	(100)

Figures in parenthesis indicate percentages

Table 70. Order of preferences for newly designed furnishing materials by the textile experts

(n=25)

Order of preference	**Control**	**Furnishing material**		
		F_C - floral	**F_C - geometrical**	**F_P**
Excellent	-	06	08	07
Good	07	14	15	11
Fair	09	05	02	07
Poor	09	-	-	-
WAR	**3.08 IV**	**1.96 II**	**1.76 I**	**2.28 III**

Ranking

Excellent	-	I
Good	-	II
Fair	-	III
Poor	-	IV
WAR	-	Weighted Average Ranking

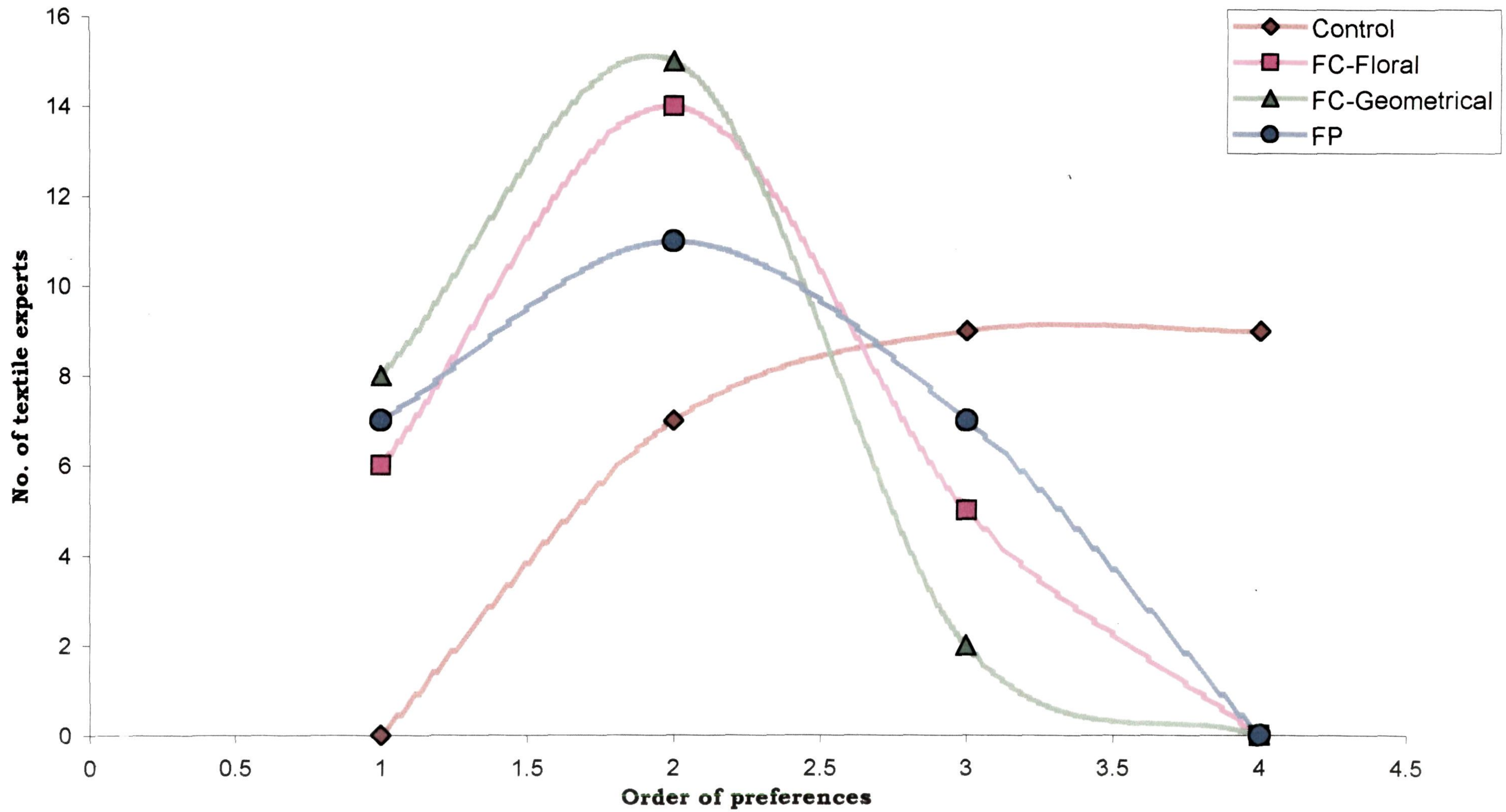


Fig. 8 Order of preferences for newly designed furnishing material assigned by textile experts

4.6 Economic analysis of newly designed made ups

4.6.1 Economic analysis of newly designed dress material

Table 71 records the economics of newly designed dress material. Various factors like variable cost (raw materials, wages for preparatory processes and weaving) fixed cost (depreciation value), and interest on variable cost (bank loan) were taken into account while analyzing the cost of production of newly designed salwar suits.

Looking in to the total cost of the control sample that accounted to Rs. 106.14 it was found that greater percent of the total cost was spent on the Ahimsa silk, the raw material (Rs. 62/-) followed by wages on weaving (Rs. 20/-), preparatory processes (Rs. 12/-) and interest on variable cost (Rs. 10/-). However, fixed cost was accounted to be very meager (Rs. 2.14). From the calculated values of total cost and selling price, the weaver earned a profit of Rs. 23.86/ meter.

On the other hand the total cost of dress materials *viz.*, Cotton x Ahimsa silk (D_C) and Art silk x Ahimsa silk (D_A) was Rs. 94.36 and Rs. 102.62, respectively. The total variable cost of Art silk x Ahimsa silk (D_A) was Rs. 99.77 and that of Cotton x Ahimsa silk (D_C) was Rs. 92.22, where as the total fixed cost of both the dress materials was Rs.2.14 and 2.85 respectively. However the net profit of the Dc was Rs.55.20 and that of D_A was Rs. 27.38.

Similarly the total cost of Filature silk x Ahimsa silk (D_F) was Rs. 106.58 encompassing 98 per cent of the variable cost and 2 per cent of the

Table 71. Economic analysis of newly designed dress materials (per meter)

Amount in Rupees

Sl. No.	Particulars	Control	Dress materials		
			D_C	D_A	D_F
I.	Variable cost				
a.	Raw material				
	Warp	32.00	6.00	6.00	19.00
	Weft	30.00	45.00	45.00	40.00
	Total	**62.00**	**51.00**	**51.00**	**59.00**
b.	Preparatory process	12.00	12.00	15.00	15.00
c.	Weaving charges	20.00	20.00	25.00	20.00
d.	Interest on variable cost	10.00	9.22	8.77	10.44
	Total	**104.00**	**92.22**	**99.77**	**104.44**
II.	Fixed cost	2.14	2.14	2.85	2.14
III.	Total cost	106.14	94.36	102.62	106.58
IV.	Selling price	130.00	150.00	130.00	260.00
V.	**Net returns**	**23.86**	**55.64**	**27.38**	**153.42**

fixed cost. Net profit earned was Rs. 153.42. On the whole the total cost of control samples and Filature silk x Ahimsa silk (D_F) salwar suit was maximum (Rs. 106.14 & 106.58) followed by Cotton x Ahimsa silk (D_C) and Art silk x Ahimsa silk (D_A) *i.e.*,Rs.94.36 and 102.62 respectively. In terms of net profit D_F earned maximum profit (Rs. 153.42) followed by D_C (Rs. 55.20) and D_A (Rs. 27.38).

4.6.2 Economic analysis of newly designed shirting material

Table 72 explains about the cost of production of newly designed shirting materials. Among the newly designed shirting materials the total cost of the Filature silk x Ahimsa silk (S_F) accounted to be Rs 94.36 followed by Cotton x Ahimsa silk (S_C) (Rs.67.14) and Tericot x Ahimsa silk (S_T) (Rs 63.25), it is found that greater amount was spent on the raw materials (Rs. 53.00- S_F, Rs. 33.50 - S_C and Rs. 30.00 - S_T) followed by weaving charges (Rs. 20 - S_F and Rs. 15 each for S_C and S_T) and interest on working capital (Rs. 9.22, 6.50 and 6.11). However, fixed cost accounted was very meager *i.e.*, Rs. 2.14 for all the samples. Further, the net profit of shirtings was accounted to be higher incase of Filature silk x Ahimsa silk (S_F) (Rs. 165.64) followed by S_T and S_C *i.e.*, Rs. 76.75 and Rs. 62.86, respectively.

On the other hand the total cost of control sample was maximum *i.e.*, Rs. 106.40 encompassing 97.74 per cent of the variable cost and 2.01 per cent of the fixed cost. The net profit earned was Rs. 23.26. In the nut shell the total cost of control sample was maximum (Rs. 106.40) followed by shirting material Filature silk x Ahimsa silk (S_F) (Rs. 94.36) and Cotton x Ahimsa silk (S_C) (Rs. 67.14). The total cost of the material Tericot x Ahimsa

Table 72. Economic analysis of newly designed shirting materials (per meter)

Amount in Rupees

Sl. No.	Particulars	Control	Shirtings		
			S_C	S_T	S_F
I.	Variable cost				
a.	Raw material				
	Warp	32.00	8.50	5.00	23.00
	Weft	30.00	25.00	25.00	30.00
	Total	**62.00**	**33.50**	**30.00**	**53.00**
b.	Preparatory process	12.00	10.00	10.00	10.00
c.	Weaving charges	20.00	15.00	15.00	20.00
d.	Interest on variable cost	10.00	6.50	6.11	9.22
	Total	**104.00**	**65.00**	**61.11**	**92.22**
II.	Fixed cost	2.14	2.14	2.14	2.14
III.	Total cost	106.40	67.14	63.25	94.36
IV.	Selling price	130.00	130.00	140.00	260.00
V.	Net returns	23.86	62.86	76.75	165.64

silk (S_T) was the least with Rs. 63.25. In terms of net profit, shirting material S_C earned maximum profit (Rs. 165.64) followed by S_T (Rs. 76.75) and S_C (Rs. 62.86).

4.6.3 Economic analysis of newly designed furnishing materials

It is observed from Table 73 that of the newly designed furnishing materials the total cost of both the varieties of Cotton x Ahimsa silk (F_C – Floral and geometrical) furnishings accounted to be higher *i.e.*, Rs. 117.80 and 117.25, respectively. It is found that greater amount was spent on the raw materials (Rs. 66.00 and Rs. 65.50) followed by weaving charges (Rs. 20.00 each), preparatory processes (Rs. 12.00 each) and interest on variable cost (Rs. 10.88 and Rs. 10.83). However, fixed cost was accounted to be less *i.e.*, Rs. 8.92 each. From the calculated values of total cost and total returns, a profit of Rs. 62.75 and 62.20 was earned. On the other hand the total cost of control sample and furnishing material Polyester x Ahimsa silk (F_P) was Rs. 106.14 and 105.58, respectively. Total cost of the above said material encompassed 97.74 and 91.55 per cent of the variable cost and 2.01and 8.45 per cent of the fixed cost. The net profit earned was Rs. 23.86 and Rs. 74.42, respectively.

On the whole the total cost of Cotton x Ahimsa silk (F_C) furnishings was maximum (Rs. 117.80 - floral and 117.25 - geometrical) followed by control and Polyester x Ahimsa silk material (F_P) *i.e.*, Rs. 106.14 and Rs. 105.58, respectively. In terms of net profit furnishing materials Polyester x Ahimsa silk material (F_P) earned a maximum profit (Rs. 74.42) followed by Cotton x Ahimsa silk (Rs. 62.20 - floral and 62.75 - geometrical) and control sample (Rs. 23.86).

Table 73. Economic analysis of newly designed furnishing materials (per meter)

Amount in Rupees

Sl. No.	Particulars	Control	Furnishings		
			Fc - Floral	Fc - Geometrical	Fp
I.	Variable cost				
a.	Raw material				
	Warp	32.00	21.00	20.50	12.00
	Weft	30.00	45.00	45.00	40.00
	Total	**62.00**	**66.00**	**65.50**	**52.00**
b.	Preparatory process	12.00	12.00	12.00	15.00
c.	Weaving charges	20.00	20.00	20.00	20.00
d.	Interest on variable cost	10.00	10.88	10.83	9.66
	Total	**104.00**	**108.88**	**108.33**	**96.66**
II.	Fixed cost	2.14	8.92	8.92	8.92
III.	Total cost	106.14	117.80	117.25	105.58
IV.	Selling price	130.00	180.00	180.00	180.00
V	**Net returns**	**23.86**	**62.20**	**62.75**	**74.42**

DISCUSSION

V. DISCUSSION

In this chapter the findings of the present study are discussed under the following headings:

5.1 Cooking and spinning of mulberry pierced cocoons

5.2 Physical testing of Ahimsa silk yarn

5.3 Physical testing of newly designed made-ups

5.3.1 Mechanical properties of newly designed dress materials

5.3.2 Functional properties of newly designed dress materials

5.3.3 Mechanical properties of newly designed shirtings

5.3.4 Functional properties of newly designed shirtings

5.3.5 Mechanical properties of newly designed furnishings

5.3.6 Functional properties of newly designed furnishings

5.4 Subjective evaluation of newly designed made-ups

5.5 Economic analysis of newly designed made-ups

5.1 Cooking and spinning of mulberry pierced cocoons

It was possible to extract greater length of silk yarn in a shorter duration by cooking in a solution of soap + soda than cooking in other media *viz.*, Ezee detergent, oxyphon oil and plain water. This encouraging effect might be the outcome of combined effect of soap and soda that provided an alkali media, which reacted with sericin resulting into degumming. Further soap being surface-active agent and soda, the alkali might have hastened the swelling and softening of sericin. Further, the release of sericin facilitated easy drawing of the filaments from the cocoon (Table 2).

5.2 Physical testing of Ahimsa silk yarn

Table 3 inferred that it was possible to spin finer count with higher TPM when cooked in soap + soda solution and Ezee detergent and this may be because of the effect of surface active agent *i.e.,* soap or non ionic detergent helped not only in swelling and loosening of sericin but also its dissolution in a shorter duration at low temperature. Further, both soap + soda and non ionic detergent probably acted as lubricating agents that assisted to trace the filament from the cocoons and facilitated to spin finer counts with higher twist per meter. Among the properties of silk, breaking strength and extension at break are considered to be important ones. It was clear from the table that higher breaking strength with proportionately increased in extension at break was noticed among the cocoons cooked in Ezee detergent may be due to rapid wetting action and emulsifying properties of nonionic detergent that enabled them to be very effective in softening the cocoons. Since, the detergent is nonionic in nature has no affinity for fibre properties, but in turn it worked on the dissolution of the sericin without affecting the fibroin. Hence, the hypothesis was rejected as the cooking media did influence the physical properties of Ahimsa silk yarn.

The perusal of Table 4 revealed about weight loss (%) of silk yarn (cooked in different media) degummed with soap + soda. It is evident that the weight loss (%) was greater in plain water cooking media. This may be due to presence of greater amount of sericin. However silk yarn traced from plain water cooking media does not react chemically, but when subjected to degumming process with soap + soda sericin readily dissolved and registered greater percentage of weight loss. On the contrary silk yarns extracted from soap + soda, Ezee and oxyphon oil cooking media accounted lesser percentage of weight loss may be because of chemical reaction and dissolution of greater amount of sericin during cooking. Further degummed silk yarn exhibited soft, pliable and lustrous properties.

5.3 Physical testing of newly designed made-ups

5.3.1 Mechanical properties of newly designed dress materials

5.3.1.1 Yarn count (Ne)

Table 8 revealed that, Filature silk x Ahimsa silk (D_F) dress materials was woven with finer warp and weft compared to Cotton x Ahimsa silk (D_C) and Art silk x Ahimsa (D_A) silk dress materials.

It may be because, the Filature silk being inherently fine, more regular and uniform than Cotton and Art silk. Further the control sample was woven with hand spun Ahimsa silk yarn which is coarser, attributed to uneven distribution of slubs and snars throughout the length of the yarn *i.e.* the pierced cocoons which posses short filaments compared to filature are joined end to end resulting into irregular yarn surface.

5.3.1.2 Cloth count (numerical expression)

It is apparent from Table 9 that in a newly designed dress (Salwar suit) materials, ends per inch were reasonably greater than picks per inch since warp being finer could be aligned more densely than coarser fillings. Greater number of ends per unit area attribute to many important functional properties like drapability, serviceability, strength and cloth balance. The control sample *i.e.*, Ahimsa silk x Ahimsa silk was loosely woven with lower cloth count than all the three newly designed Salwar suits may be because of the yarn type basically hand woven was relatively coarser and uneven because of slubs and snars. Thus the coarser reed count was selected to weave the control sample that facilitated easy drawing of yarn through dents but resulted into loosely woven sample.

Among the three salwar suit materials, Filature silk x Ahimsa silk (D_F) was compactly woven than Cotton x Ahimsa silk (D_C) and Art silk x Ahimsa silk (D_A) salwar suits since Filature silk filaments being much finer, the reed with higher reed count was employed to weave the fabric with better density and alignment.

5.3.1.3 Cloth weight (g/sq. mt)

From the Table 10 it is clear that control sample and Cotton x Ahimsa silk (D_C) dress material was relatively heavier than the other two samples *i.e.*, Art silk x Ahimsa silk (D_A) and Filature silk x Ahimsa silk (D_F). The factors that usually influence cloth weight are type of fibre, ends and picks per unit area, starch in the woven cloth and deposition of dye molecules on the fabric surface. An increase in cloth weight was observed in control sample, which may be due to fibre content, *i.e.*, the control sample composed of Ahimsa silk in both the directions is coarser than the yarns in newly woven made-ups. Thus the slubs and snars in Ahimsa silk the yarn formed during spinning probably contributed to certain percentage of weight. On the other hand Cotton x Ahimsa silk dress materials was relatively heavier than the Art silk, Filature silk dress materials may be due to sized cotton yarns so also greater number of ends and picks per unit area that might have directly enhanced the cloth weight of dress materials.

5.3.1.4 Cloth thickness (mm)

Table 11 revealed about thickness of control and newly designed dress materials. The thickness of the control sample was remarkably high compared to dress materials, may be due to combined influence of coarser yarns and irregular fabric surface. On the other hand the dress materials woven with filaments showed lower values of thickness, which may be attributed to finer yarns and uniform surface.

5.3.1.5 Cloth stiffness (cm)

The perusal of Table 12 revealed about cloth bending length, which was greater in weft direction than warp in all the samples because Ahimsa silk was coarser and heavier.

Among the test samples Cotton x Ahimsa silk (D_C) dress material exhibited highest bending path, which in turn depicted its stiffness, may be due to sizing material present in cotton during weaving. The moderate bending length observed in Art silk x Ahimsa silk (D_A) dress material and control samples may be attributed mainly to its fibre content, cloth count, weight and thickness.

Filature silk x Ahimsa silk (D_F) dress material having least weight and thickness in turn showed very little resistance for bending. In other words among the four samples, Filature silk x Ahimsa silk dress material was found to be soft and pliable may be due to its regular surface.

5.3.1.6 Cloth crease recovery (degree)

An appraisal of Table 13 showed the crease recovery resistance of the newly designed dress materials. The recovery or resistance towards creasing largely depends on the fibre content, resiliency and presence of sizing material, which makes the fabric stiff, there by reducing the pliability. The stiffness in turn influences the recovery resistance of the fabric *i.e.*, stiffer the fabric, higher the recovery resistance. Soft and pliable fabrics however exhibit greater recovery angle. In other words the cloth stiffness is inversely proportional to crease recovery angle.

Among the test samples, Cotton x Ahimsa silk (D_C) dress material was found to be relatively stiffer, which may be due to extra starch present in cotton yarns during preloom process that in turn contributed to cloth stiffness. These results are supported by the values of bending length presented in Table 12 where in the Cotton x Ahimsa silk (D_C) union dress material exhibited a longer bending path.

From the Table 12 and 13 it may be stated that bending length and crease recovery angle are inversely proportional. The present findings are in agreement with the findings of Nemailal and Prabir (1999).

The cloth crease recovery, a product of square root of warp-way and weft-way recovery angle was found to be higher in Filature silk x Ahimsa silk (D_F) dress material and control sample, which is attributed to pliability, flexibility, limpyness and soft texture of the fabric compared to D_C and D_A content dress materials.

5.3.2 Functional properties of newly designed dress materials

5.3.2.1 Cloth tensile strength (kgf) and elongation (%)

The main elements contributing to the tensile strength of a fabric are fabric content, yarn type, yarn count, yarn extensibility, weave type, fabric sett and amount of starch in the cloth. Generally the breaking strength of the finer yarn is higher than coarser but when individual strength is compared coarser fibres would show a higher strength. Table 14 reflects on the tensile strength of newly designed dress materials. In general the weft-way tensile strength was higher than the warp-way may be due to fibre content and coarser yarn of Ahimsa silk, which is hand spun.

Among the newly designed dress materials, Art silk x Ahimsa silk (D_A) exhibited highest tensile strength in warp-way compared to Cotton x Ahimsa silk (D_C) and Filature silk x Ahimsa silk (D_F), due to combined effect of fibre content and coarser yarn count of Art silk (45s, Table 8).

The perusal of Table 16 revealed about elongation of test samples. In general the weft-way elongation was lesser than warp-way may be due to its fibre content *i.e.* silk which is considered to be more plastic than elastic because its very crystalline polymer system does not resist the polymer movement which on the contrary is possible in an amorphous system. Hence, when silk is stretched additionally, the polymers, which are already in stretched state may not elongate further.

On the other hand the percentage warp-way elongation was higher in case of test sample with D_A, may be due to combined effect of coarser yarn and better crimp percentage.

5.3.2.2 Cloth tear strength (g)

In general Table 18 discloses that, the test samples did not tear in warp direction. It is necessary to mention here that when warp-way samples subjected for testing, weft threads were broken and vice-versa. Thus, in the test samples the weft-way yarns *i.e.*,Ahimsa silk, being coarser and much stronger than its corresponding warp yarns exhibited greater strength, was beyond the capacity of the instrument (Elemendorf Tear tester) employed to tear.

However off the three dress materials the Art silk x Ahimsa silk (D_A) required relatively greater force to tear the warp yarns than the Filature silk (D_F) and Cotton (D_C) due to coarse yarn count (Table 8) and lower cloth density (Table 9). Control sample could not be torn in either direction since it was woven exclusively with Ahimsa silk.

5.3.2.3 Cloth abrasion resistance (Cycles)

Table 19 expressed the results of abrasion resistance of the test samples. Abrasion is definitely a repeated stress application, usually caused by forces like bending, tensioning, compressing and twisting, which are relatively low order of repeated stresses and occur many times during the life time of that material. Abrasion is just one aspect of wear and tear that in turn determines the durability of the cloth. Failure of abrasion resistance is mainly due to weakening of the structure caused by mechanical break down of the individual fibres and the mechanism of break down is substantially the same for all fibre. The general weakening of the fabric structure and the majority of the tears and splits, which occurs in many worn-out garments are a direct consequence of fibre breakdown. The physical properties influencing the cloth abrasion resistance to a greater extent are fibre content, yarn count and thickness and to some extent, the fabric sett.

The control sample showed higher resistance to abrasion may be due to the Ahimsa silk yarn, which is coarser, in turn increased the cloth thickness, resulting into better abrasion resistance, whereas newly designed dress materials exhibited low resistance to abrasion attributed to its finer yarn count, low thickness value and pliable texture.

On abrasion, there existed loss in thickness, which was found to be more in control sample, influenced by frictional abrasion that resulted into breakage of fibres. Consequently, there was loss in mass too. During abrasion the fibrous substance in the form of dust is raised from the fabric surface and gradually result into fuzz, nap, pill and finally yarn breakage. In other words the components that contribute to loss in cloth thickness (%) do influence loss in mass (%). Similar results were observed in the study conducted by Joshua (1993) and Nemailal and Probir (1999) revealed that the continuous surface abrasion result into decrease in fabric weight and thickness.

5.3.2.4 Cloth drapability (%)

Drapability of the fabric is influenced by several mechanical parameters *viz.* weave, cloth count, cloth thickness, cloth weight and cloth bending length. The soft and pliable fabric drapes gracefully than the stiffer fabric. The cloth stiffness directly determines the drape quality of the corresponding fabric. On the other hand there is an inverse relation between drape coefficient and number of nodes.

It is clear from Table 22 that, among the test samples, Cotton x Ahimsa silk (D_C) dress material draped into less number of nodes expressing greater calculated drape coefficient value, probably because of being woven with sized cotton yarns, followed by Art silk x Ahimsa silk (D_A) and Filature silk x Ahimsa silk (D_F) dress materials. On the other hand the control sample exhibited least drape coefficient value, expressing its softness and graceful appearance. This property is attributed to low stiffness values recorded in Table 12. It may be stated here that the cloth stiffness directly determines the drape quality of the corresponding fabric, which is also agreed by Chanchal and Dua (1996) that stiffness resists the downward bending of the fabrics, thus results into higher drape coefficient.

5.3.2.5 Cloth pilling (Ratings)

Table 24 depicted on pilling resistance of newly woven dress materials. Pilling is a fabric surface fault characterized by little pills of entangled fibre clinging to the cloth surface. Under the influence of rubbing action loose staple fibres develop into small spherical bundles anchored to the fabric by a few unbroken fibres. It is clear that all the newly woven dress materials and control sample showed slight to moderate pilling owing to their fiber content and staple length. These finding are on par with the results of Preveena and Vatsala (1992).

5.3.3 Mechanical properties of newly designed Shirtings

5.3.3.1 Yarn count (Ne)

Table 25 reveals that, control sample and Cotton x Ahimsa silk shirting materials (S_C) were interwoven with coarser warp and weft than the Filature silk (S_F) and Tericot (D_T) content shirting materials may be because of fibre content and staple length. Further the reasons are discussed under 5.3.1 do hold good here too.

5.3.3.2 Cloth count (Numberical expression)

Table 26 illustrates that, among the shirting materials, Filature silk x Ahimsa silk (S_F) was woven with greater number of ends and picks per unit area than the Tericot (S_T) and Cotton (S_C) shirting materials. This may be because of Filature silk yarns that are finer in count/denier, constructed with higher reed count to achieve better cloth balance, which in turn resulted into compact alignment of threads per unit area. On the other hand control sample was loosely woven with lower cloth count than the newly woven shirting materials, which is supported with discussion made under 5.3.1.2.

5.3.3.3 Cloth weight (g/sq. mt)

From Table 27 it is clear that, Cotton x Ahimsa silk shirting material exhibited maximum weight /sq. meter than the other samples may be due to a combined influence of coarser yarns and sized warp yarns. Further percentage warp in the woven samples was higher than its corresponding weft except Filature silk x Ahimsa silk (S_F) shirting materials, may be because of finer filature filaments that are much lighter in weight than Cotton and Art silk.

5.3.3.4 Cloth thickness (mm)

Table 28 reports on cloth thickness of test samples. Because of coarser yarn and irregular surface of Ahimsa silk (S_C), control sample possessed maximum thickness than the newly woven shirting materials. Among the newly designed shirting materials Cotton x Ahimsa silk (S_C) was relatively thicker fabric may be due to coarser yarn count and presence of sizing materials on the surface than the Tericot (S_T) and Filature silk (S_T) content shirting materials.

5.3.3.5 Cloth stiffness (cm)

From Table 29 it is clear that, among the shirting materials Cotton x Ahimsa silk (S_C) being relatively stiffer and thicker exhibited greater resistance to bending than the Tericot (S_T), Filature silk (S_T) and control test samples. It was observed that, bending length was higher in warp direction than weft, may be attributed to the sized warp sheet that added to its stiffness. The sized warp sheet being hard and stiff, probably resisted the downward bending of the fabric thus resulting into longer bending path.

5.3.3.6 Cloth crease recovery (degree)

Table 30 illustrates that, crease recovery resistance of newly woven shirting materials. When crease recovery of the fabric was considered, it is learnt that higher the recovery resistance stiffer the fabric. The soft and pliable fabrics however exhibit greater recovery angle. In other words cloth stiffness is inversely proportional to crease recovery angle.

The Cotton x Ahimsa silk (S_C) shirting material was relatively stiffer since composed of sized yarns, which in turn affected the fabric handle. These results are supported with the values of bending length presented in Table 29. On the other hand Filature silk x Ahimsa silk (S_F) and control sample showed better recovery angle compared to Cotton x Ahimsa silk (S_C) shirting material may be due to cotton content, which has poor crease resistance when the cellulose is bent to form crease, the cross link may break, thus on removal of load crease persists in the fabric, which may be removed by application of heat, pressure and moisture. However, these results are on par with the finding of Vernekar *et al.*(1998).

The cloth crease recovery is a product of square root of warp and weft-way recovery. The recovery angle was found to be higher in Filature silk x Ahimsa silk and control samples, which exhibit better pliability, flexibility and soft texture of the fabric compared to Cotton and Tericot shirting materials.

5.3.4 Functional properties of newly designed shirtings

5.3.4.1 Cloth tensile strength (kgf) and elongation (%)

It was observed from the Table 31 that, Tericot x Ahimsa silk (S_T) shirting material possessed greater tensile strength may be because of yarn composition, *i.e.* Tericot yarn is a blend of Polyester x Cotton in proportion of 65:35. Polyester both in filament and staple form is strong to very strong because of its extremely crystalline polymer system, exhibiting very good tenacity. Further, percentage of polyester content in Tericot blend being greater might have resulted into greater tenacity. In general the weft-way strength was higher than warp-way may be due to combined effect of fibre content and coarser yarn *i.e.* Ahimsa silk is considered to be stronger than Cotton, Tericot and Filature silk.

The perusal of Table 33 revealed about elongation of test samples, where in warp-way elongation (%) was found to be greater in Filature silk x Ahimsa silk shirting material may be because of cloth sett *i.e.* higher the threads per unit area better the stretchability. In a fabric just off the loom, the warp threads generally have higher crimp because the filling yarns are shot straight through the shed and the warp yarns are go over and under the filling yarns by the up and down motion of the harness. Hence, the warp threads stretch relatively more compared to their weft. On the other hand weft-way elongation (%) was lesser among all the samples because these samples were woven with spun yarn of lower TPM (Turns Per Meter). The discussion made under Table 15 (5.3.2.1) support these results too.

5.3.4.2 Cloth Tear strength (g)

Table 35 reflected the cloth tear strength of newly woven shirting materials. Among the shirting materials, Filature silk x Ahimsa silk required lesser force to tear the warp threads followed by Cotton x Tericot. This may be because of the threads per unit area also required as fabric sett. Lower the yarn density in a woven cloth, higher is the force required to tear the same. Thus, the shirting material composed of greater number of ends (S_F) was torn at relatively low force (kgf) compared to Cotton (S_C) and Art silk (S_A). On the other hand the weft yarns in any of these test samples could not be torn, because were interwoven with Ahimsa silk yarn whose strength was beyond the capacity of the instrument employed.

5.3.4.3 Cloth abrasion resistance (cycles)

Table 36 illustrates about cloth abrasion resistance of test samples. The relatively coarser, thicker and loosely woven control sample showed better resistance to abrasion compared to newly woven shirting materials. However, newly woven shirting materials exhibited low resistance to abrasion attributed to its finer yarn count, low thickness value and pliable texture.

On abrasion loss in cloth thickness was found to be remarkable in control sample may be influenced by frictional abrasion that lead to fibre breakage. Consequently there was also loss in mass. During the process of abrasion the fibrous substance in the form of dust is raised from the fabric surface and gradually resulted into fuzz, nap and finally the yarn breaks. Due to this action, test samples showed decrease in cloth thickness and loss in mass per unit area.

5.3.4.4 Cloth drapability (%)

Drapability is expressed in terms of drape coefficient and number of nodes *i.e.* higher the drape coefficient, poor the drapability or greater the number of nodes, better the drapability. It means that, drape coefficient and the fabric drape are inversely related.

From Table 39 it is evident that Cotton x Ahimsa silk (S_C) shirting material exhibited higher drape coefficient because of its stiffness compared to Tericot (S_T) and Filature silk (S_F) shirting materials. Thus Cotton shirting material draped into less number of nodes compared to control and Filature silk x Ahimsa silk shirting.

5.3.4.5 Cloth pilling (Ratings)

A perusal of Table 41 showed pilling appearance of test samples. Pilling is the fabric fault characterized by little pills of entangled fibre clinging to the cloth surface that gives the garment an unsightly appearance. The pills are formed during wear and washing by the entanglement of loose fibres which protrude from the fabric surface.

From this table it is clear that all the test samples showed slight to moderate pilling owing to their fibre content and yarn type.

5.3.5 Mechanical properties of newly designed furnishings

5.3.5.1 Yarn count (Ne)

It is revealed from the Table 42 that among the newly designed furnishing materials Polyester x Ahimsa silk (F_P) exhibited coarser warp count than Cotton (F_C). However, there was no remarkable difference in warp-way yarn count between Polyester and Cotton. This may be attributed to the constructional details where coarser yarn being most suitable for the production of furnishing materials.

5.3.5.2 Cloth count (Numerical expression)

It is apparent from Table 43 that the ends /unit area of Cotton x Ahimsa silk furnishings was reasonably greater than its corresponding picks since warp yarns being finer may be aligned more densely than coarser fillings. Further Polyester x Ahimsa silk (F_P) furnishing material was interlaced with greater number of picks per inch than ends per inch. This was a pre-determined interlacement order to achieve ribbed effect in the design where three and more picks were inserted at a time in a single shed during weaving that resulted into densely beaten shots.

5.3.5.3 Cloth weight (g/sq. mt)

It is indicated in Table 44 that Cotton x Ahimsa silk (F_C) furnishing fabrics were relatively heavier than the Polyester x Ahimsa silk (F_P). The factor that influenced cloth weight is probably the fibre content, yarn count and yarn type *i.e.* cotton yarns were relatively heavier than the polyester filaments. Further, percentage warp was higher than its corresponding weft in Cotton x Ahimsa silk (F_C) materials, which in turn indicated the warp-way cloth count to be higher than its counterpart (Table 43). On the other hand, Polyester x Ahimsa silk (F_P) material possessed greater percent of weft than the warp, resulted into greater number of picks per unit area than ends per unit area due to interlacement system.

5.3.5.4 Cloth thickness (mm)

Table 45 reported on cloth thickness of furnishing samples. Cotton x Ahimsa silk (F_C) accounted for greater thickness than the Polyester x Ahimsa silk (F_P) furnishing and the factors influenced the thickness were fibre content, yarn type and weave density. Though the cotton yarns were finer than the polyester, greater cloth thickness was achieved may be because of cotton staple fibres that were reasonably coarser and stiffer than polyester filaments. Further, when the pressure foot was released on the cloth during testing, the fine polyester yarns would be easily compressed where as cotton yarns being voluminous contributed to greater thickness value.

5.3.5.5 Cloth stiffness (cm)

The cloth stiffness of furnishing was found to be greater in Polyester x Ahimsa silk (F_P) in warp direction than its corresponding control and

Cotton x Ahimsa (F_C) silk furnishings. This may be due to greater weave density, which is depicted through higher cloth cover (19.96) (Table 46).

5.3.5.6 Crease recovery (degree)

An appraisal of Table 47 showed the crease resistance of the furnishing materials. Among the furnishing materials Polyester x Ahimsa silk (F_P) exhibited resistance to creasing than Cotton x Ahimsa silk (F_C). This may be due to fact that cellulosic textiles have poor resiliency than polyester because bending or crushing of cotton textile places considerable strain on the fibre polymer system that would probably result into polymer fracture and molecular disarrangement. Because of this reason the cotton textiles do crease and wrinkle readily. On the other hand extreme crystallinity of the polymer system probably prevented the polyester filaments or staple fibre from bending readily, hence exhibited very good crease recovery.

5.3.6 Functional properties of newly designed furnishings

5.3.6.1 Cloth tensile strength (kgs) and elongation (%)

It was observed from the Table 48 that, Polyester x Ahimsa silk (F_P) furnishing material possessed greater tensile strength may be attributed to its fiber polymer system, filamentous nature, yarn number, threads per unit area, cloth cover and weave density. Polyester filaments were strong because of their extremely crystalline polymer system. Further Polyester x Ahimsa silk (F_P) furnishing material possessed better cloth cover (16.35)

(Table 1c) than cotton furnishing (12.85 - floral and 13.96 - geometrical) that in turn contributed to greater tenacity value.

Further the two essential factors considered in the production of furnishings are cloth count and tensile strength. In general furnishings with satisfactory thread count have been found to have good tensile strength and vice-versa, which in turn resulted into better durability and serviceability.

From the Table 50 it is clear that Polyester x Ahimsa silk (F_P) furnishing material showed greater warp-way elongation compared to Cotton x Ahimsa silk (F_C). This may be attributed to its inherent property of polymer system that could stretch much greater than the spun cotton yarns. This property of greater stretchability positively influenced the tensile strength of the cloth.

5.3.6.2 Cloth tear strength (g)

Table 52 reveled that the newly woven furnishing samples were not torn on Elemendorf tear tester. The reason could be coarser yarn count, fancy weave with greater length of floats and fabric thickness that might have contributed to the greater strength of the fabric which was beyond the capacity of the instruments.

5.3.6.3 Cloth abrasion resistance (cycles)

Table 53 depicted that, Cotton x Ahimsa silk (F_C) furnishing materials showed better resistance to abrasion compared to polyester x

Ahimsa silk (F_P). This may be due to better cloth thickness and cloth density of Cotton x Ahimsa silk samples (floral and geometrical). On the other hand due to continuous rubbing of the fabric surface with the abrader resulted into breaking of the fibre ends from the surface. Hence the test samples exhibited loss in cloth thickness and loss in mass per unit area to some extent.

5.3.6.4 Cloth drapability (%)

Table 55 depicted that, Polyester x Ahimsa silk (F_P) furnishing material exhibited greater drape coefficient value with lesser nodes. This may be due to greater cloth count (Table 43), higher stiffness (Table 46) and greater crease recovery (Table 47). It may be inferred that stiffer the fabric poor the drape and vice-versa.

5.3.6.5 Cloth pilling (Ratings)

An appraisal of Table 57 showed that newly designed furnishing materials revealed slight to moderate (2-3) pilling may be because of their fibre composition *i.e.* Ahimsa silk woven as weft in furnishing samples showed moderate pilling because of staple fibres that contributed to ribbed effect. These short fibres lead to pilling on abrasion. The findings are on par with the results of Praveena and Vatsala (1992).

5.4 Subjective evaluation of newly designed made-ups

5.4.1 General information of the respondents according to their age, education and occupation

From Table 58 it is learnt that majority of the respondents belonged to younger and middle age group and were educated fell in the category of graduates and post graduates. It is also apparent from the same table that nearly 75 per cent of the respondents were employed in the field of textiles. This may be attributed to the purposive sampling system where the respondents had knowledge about tactile properties of textile fabrics.

5.4.2 Respondents opinion of fabric appearance of newly designed dress materials

Table 59 reports on respondents opinion on fabric appearance of newly designed dress materials. Majority of respondents opined that, newly designed dress materials were fibrous and coarser in appearance, probably because of being woven with spun Ahimsa silk and Cotton yarns which gave an irregular yarn surface in turn resulted into fibrous and coarser appearance of cloth as such.

Further, majority of the respondents expressed that newly designed dress materials were lustrous and smooth to touch which may be because of silk, a major component of the fabric that has a unique property of fineness, inherent lustre, soft and smooth texture.

5.4.3 Respondents opinion on fabric handle of newly deigned dress materials

The factors considered for fabric handle are presented in Table 60. It is clear from this Table that greater percent of respondents expressed Cotton x Ahimsa silk (D_C) dress material as crisp and stiff to handle than Art silk (D_A) and Filature silk (D_F) dress materials. This may be due to the reasons that Cotton yarns which were sized prior to weaving probably added to the stiffness. Because of this sizing, the yarns became hard to touch, thus making the fabric crisp and stiffer.

5.4.4 Respondents opinion on fabric texture of newly designed dress materials

The perusal of Table 61 reveals that, cent percent of the respondent stated newly designed dress materials were close and firmly woven than control sample. This may be attributed to the higher reed count, thread per unit area and cloth cover the values being higher than the control sample which resulted into firmer body. Majority of the respondents expressed Filature silk x Ahimsa silk (D_F) dress material and control sample exhibited lighter weight than Cotton (D_C) and Art silk (D_A) may be due to their fibre composition *i.e.* filament silk being much lighter in weight than the spun yarns.

5.4.5 Order of preferences for newly designed dress materials assigned by textile experts

From the Table 62 it is interesting to note that, most of the respondents preferred Art silk x Ahimsa silk and Cotton x Ahimsa silk dress materials. This may be due to the colour combination, weave construction, hand and feel, texture and overall appearance that, enhanced the elegance, artistic appeal and brightness.

5.4.6 Respondent's opinion on fabric appearance of newly designed shirting materials

Majority of the respondents opined that, newly woven shirting materials are fibrous and coarser yet lustrous in appearance may be due to interlacing with Ahimsa silk. Ahimsa silk exhibited unevenness and irregular surface during spinning due to short filaments that resulted into fibrous structure. Further cent per cent of the respondents expressed that, Filature silk x Ahimsa silk (S_F) shirting material is much smoother than the rest may be because of pure silk in nature. The said sample possessed unique property of fineness, natural sheen and smoothness (Table 63).

5.4.7 Respondents opinion on fabric handle of newly designed shirting materials

Table 64 depicted that majority of the respondents stated Filature silk x Ahimsa silk (S_F) shirting material exhibited soft and flexible handle than the Cotton and Tericot (S_T) shirtings may be because of its fibre content and coarser yarn count. Silk being filamentous always possessed luxurious appearance that added to its elegance and beauty.

5.4.8 Respondents opinion on fabric texture of newly designed shirting materials

The perusal of Table 65 revealed that, cent per cent of the respondent stated newly designed shirting material are compactly and firmly woven than the control sample, the reason which is already discussed in chapter 5.4.3.

5.4.9 Order of preferences for newly designed shirting materials by the textile experts

It is imperative to note from the Table 66 that among the three shirtings, majority of the respondents preferred Filature silk x Ahimsa silk (S_F) shirting may be because of its smooth, fine and lustrous appearance, soft and flexible handle though firmly constructed in light weight. On the other hand, least preference was given for control sample entirely woven with Ahimsa silk may be because of its loose, limpy, coarse structure without firm body. It was felt probably that may not be suitable as shirting. In general, respondents opined that shirting material should require minimum care and maintenance yet appear elegant *i.e.* comfortable, durable and serviceable.

5.4.10 Respondents opinion on fabric appearance of newly designed furnishing materials

From Table 67 it is observed that, majority of the respondents expressed that newly designed furnishing materials were fibrous, coarse, lustrous and rough in appearance mainly due to weft interlacement of Ahimsa silk yarn which is basically fibrous, coarser, rough and lustrous in appearance.

5.4.11 Respondents opinion on fabric handle of newly designed furnishing materials

Table 68 revealed that maximum per cent of the respondents stated that newly designed furnishing materials were crisp to handle than control attributed to its fibre content, yarn count and constructional details. On the other hand, majority of the respondents opined that Cotton x Ahimsa silk furnishing materials (floral and geometrical) were flexible than Polyester x Ahimsa silk (F_P) may be due to greater number of floats on the fabric surface that resulted into loose, limp and pliable structure.

5.4.12 Respondents opinion on fabric texture of newly designed furnishing materials

Most of the respondent expressed that newly designed furnishing materials were woven with close structure with raised effect may be due to its floral and geometrical designs woven with jacquard shedding mechanism not only to enrich the surface of the furnishing materials but also produce a suitable texture, hand and feel for the furnishing (Table 69).

5.4.13 Order of preferences for newly designed furnishing materials assigned by textile experts

From Table 70 it is clear that the respondents gave highest preference for Cotton x Ahimsa silk (F_C) furnishing materials than the Polyester x Ahimsa silk (F_P). This may be due to colour combination weave construction, handle, feel and texture that enhanced the elegance, artistic appeal and brightness of the furnishing material. Further cotton is an ideal fabric source for furnishings (upholstery coverings) because of its easy care, better absorbency, air permeability and user-friendly features.

5.5 Economic analysis of newly designed made-ups

5.5.1 Economic analysis of newly designed dress materials

The economic analysis and total cost of Salwar suits is presented in Table 71. It is clear from this Table that Salwar suit woven in Filature silk x Ahimsa silk (D_F) was reasonably expensive compared to Cotton x Ahimsa silk (D_C) and Art silk x Ahimsa silk (D_A). Further, it is learnt that a greater amount of profit is earned on Filature silk x Ahimsa silk (D_F) Salwar suits over the total cost by the weaver. In other words though the variable costs and fixed cost for Cotton, Art silk and Filature silk remained same, ultimately the profit earned with Filature silk (D_F) salwar suits was maximum and very encouraging. Thus, the silk weavers can take up silk salwar suits using Ahimsa silk as weft that fetches better returns.

5.5.2 Economic analysis of newly designed shirting materials

From the Table 72 it is interesting to note that the total cost of control sample and Filature silk x Ahimsa silk shirting (S_F) was maximum (Rs. 106.14 and Rs. 106.58) followed by Cotton x Ahimsa silk (S_C) (Rs. 94.36) and Tericot x Ahimsa silk (S_T) (Rs. 102.62), which may be due the cost of raw materials that accounted to about 59.21 and 56.16 per cent of the total production cost. Moreover, the cost per kg of Filature silk and Ahimsa silk is exorbitantly higher than the cotton and tericot yarns. On the whole it may be inferred that the cost of union fabrics is found to be inexpensive than the cent per cent pure silks. Similar results were observed in the study conducted by Hadimani *et al.*, (1986) concluded that polyster and silk in the proportion of 70:30 and 50:50 blends were found to be in expensive compared to pure silk fabrics.

5.5.3 Economic analysis of newly designed furnishing materials

It is evident from the Table 73 that among the newly designed furnishing materials the total cost of Cotton x Ahimsa silk furnishings (F_C - floral, F_C - geometrical) was maximum (Rs. 117.80 and Rs. 117.25) when compared to control (Rs. 106.14) and Polyester x Ahimsa silk (F_P) material (Rs. 105.58), which may be owing to the utilization of greater amount of weft *i.e.*, Ahimsa silk. It is essential to mention here that cost / kg of Ahimsa silk yarn was higher than cotton and polyester.

SUMMARY

VI. SUMMARY

The present research entitled "Designing Textile made-ups from Ahimsa silk" was conducted during the year 2001-2004 with the objectives to explore the existing technology of cooking mulberry pierced cocoons, to find out the technique of spinning, degumming and dyeing of Ahimsa silk, to ascertain the possibilities of producing spun silk made ups on simple and complex looms, to asses the physical characteristics of newly designed spun silk made ups and to enumerate the economics of newly designed made-ups.

Bivoltine and multivotline mulberry pierced cocoons were subjected for four cooking media *viz.*, plain water, soap + soda, Ezee detergent and oxyphon oil and was spun on "CSTRI motorized twisting cum spinning machine" developed by Central Silk Technological Research Institute (CSTRI), Bangalore. Finally the cocoons cooked in soap + soda media was selected for the study.

Using Ahimsa Silk as weft,the dress materials were woven in Cotton, Art silk and Filature silk, shirting materials in Cotton, Tericot and Filature silk on pit loom and furnishings materials in Cotton and Polyester on Hardekar Jacquard looms. These newly designed Ahimsa silk made ups were tested for mechanical and functional properties. A panel consisting 25 textile experts assessed the newly woven made-ups for visual appearance, hand feel and texture. The WAR (Weighted Average Ranking) was applied to assess the consumers preference for the newly designed made-ups.

The results of the present study are summarized as follows:

Cooking and spinning of mulberry pierced cocoons.

- The cocoons were remarkably softened by cooking in Soap + Soda in a shorter period with possibility to extract greater length of silk yarn.

Physical testing of Ahimsa silk yarn

- The cocoon cooked in Soap + Soda and Ezee detergent could be spun to finer yarn count with higher TPM.
- Greater tensile strength with elongation was registered for cocoons cooked in Ezee detergent.
- Maximum weight loss was noticed with cocoons cooked in plain water followed by Ezee detergent.

Fabric information of newly designed made-ups

Dress materials

- Newly designed Cotton x Ahimsa silk (D_C) and Filature silk x Ahimsa silk (D_F) dress materials woven on pit loom with reed count of 72 and 74 for both border and body respectively and reed with of 42 inch.
- Art silk x Ahimsa silk (D_A) dress material was woven on pit loom with dobby attachment with reed count of 72 for body and 100 for border and reed width of 42 inch.

- The cloth width of all the dress materials was 40 inch with denting order as 2 threads per dent.
- All the dress materials were produced in plain weave, D_A that was woven with dobby designs on, either sides of the selvedge.

Shirting materials

- Newly designed shirting materials of Cotton x Ahimsa silk (S_C), Tericot x Ahimsa silk (S_T) and Filature silk x Ahimsa silk (S_F) were woven on fly shuttle pit loom with reed count of 52, 54, 120 and reed width being 40, 42 and 46 inch respectively.
- The cloth width of plain-woven shirting materials were 38 (S_C), 40 (S_T) and 46 (S_F) inch with 2 threads/dent.

Furnishing materials

- Cotton x Ahimsa silk (F_C- floral and F_C- geometrical) furnishing materials were woven on Hardekar Jacquard loom with reed count of each 48 inch and reed width of each 50 inch.
- However, the Polyester x Ahimsa silk (F_P) furnishing though woven on Hardekar Jacquard loom was produced on reed count of 60 and reed width of 50 inch.
- The cloth width of all the three furnishing materials was 48 inch and denting order being 4 per dent.

Assessment of mechanical properties of newly designed made-ups

Dress materials

- Newly designed dress materials were woven with finer yarn count than the control sample.
- Among the dress materials Filature silk x Ahimsa silk (D_F) was interlaced with finer warps yarn than Cotton (D_C) and Art silk (D_A) materials.
- All the dress materials were densely woven than the control sample.
- Among all the newly designed dress material the ends per inch were greater than picks per inch.
- Both control sample and Cotton x Ahimsa silk (D_C) dress material were found to be heavier than the Art silk x Ahimsa silk (D_A) and Filature silk x Ahimsa silk (D_F) material.
- The cloth thickness was noticeably high with control sample compared to newly designed dress materials.
- Among the test samples Cotton x Ahimsa silk (D_C) dress material exhibited highest bending path than the rest.
- Filature silk x Ahimsa silk (D_F) dress material showed highest crease recovery angle both warp-way and weft-way than the rest of the test samples.

Shirting materials

- Among the newly designed shirting materials Cotton x Ahimsa silk (S_C) was interwoven with coarse warp and weft than the Tericot (S_T) and Filature silk (S_F) shirtings.
- Filature silk x Ahimsa silk (S_F) shirting was woven with greater number of ends and picks than the other two (S_T and S_C).
- Of the test samples Cotton x Ahimsa silk (S_C) shirting exhibited maximum weight.
- Control sample and Cotton x Ahimsa silk (S_C) shirting possessed greater thickness value than the Filature silk x Ahimsa silk (S_F) and Tericot x Ahimsa silk (S_T) materials.
- Cotton x Ahimsa silk (S_C) shirting material showed longer bending path in both the directions (warp and weft-way) than rest of the samples (S_T, S_C and control).

Furnishing materials

- In the test samples Cotton x Ahimsa silk (F_C- floral and F_C - geometrical) furnishings were interlaced with finer yarn count.
- Cotton x Ahimsa silk (Floral and geometrical) furnishings were inter woven with greater number of ends per unit area than the picks per unit area, but a reverse trend was noticed in Polyester x Ahimsa silk (F_P).

- Among the test samples Cotton x Ahimsa silk (F_C- floral and geometrical) possessed greater cloth weight.
- Both types of Cotton x Ahimsa silk (F_C) furnishing materials showed greater cloth thickness than the polyester and control sample.
- Polyester x Ahimsa silk (F_P) furnishings showed longer bending path in both warp way and weft-way than the Cotton x Ahimsa silk (F_C) materials.
- Among the test samples, control sample and polyester x Ahimsa silk (F_P) furnishing materials exhibited greater crease recovery angle compared to Cotton x Ahimsa silk (F_C- Floral and geometrical).

Assessment of functional properties of newly designed made-ups

Dress materials

- Of the test samples, control and Art silk x Ahimsa silk (D_A) dress materials exhibited higher tensile strength both warp-way and weft-way compared to Cotton (D_C) and Filature silk (D_F) dress materials.
- The warp-way yarn count and cloth count were found to be negatively related with cloth tensile strength of newly designed dress materials. However cloth count alone showed positive relation with weft-way tensile strength.
- In general the warp-way elongation was higher than weft-way. Of the test samples Art silk X Ahimsa silk (D_A) dress material showed highest warp-way elongation (%).

- There existed a negative relation ship between yarn count and warp-way elongation, where as cloth count showed the relation on warp-way elongation.
- All the warp way test samples could not be torn because of strength, which was beyond the capacity of the instrument. But among the weft-way samples Art silk x Ahimsa silk (D_A) showed higher tear strength.
- The control sample exhibited higher resistance to abrasion than the newly designed dress materials.
- Yarn count and cloth thickness positively influenced the loss in thickness and mass of the designed dress materials.
- Cotton x Ahimsa silk material (D_C) was stiffer than the rest of the two, which is supported by its drape coefficient value being highest.
- Weft-way cloth stiffness as well as crease recovery angle positively related to their corresponding drapability.
- All the newly designed dress material exhibited slight to moderate pilling.

Shirting materials

- Among the test samples, Tericot x Ahimsa silk (S_T) Shirting material exhibited relatively greater tensile strength in both directions.

- Yarn count and tensile strength of newly designed shirting materials were found to be negatively related.
- Filature silk x Ahimsa (S_F) shirting showed highest elongation in warp way followed by Tericot (S_T) and Cotton (S_C) shirtings.
- Cloth count positively influenced the warp way elongation of newly designed shirtings, but the relationship was negative in weft-way.
- Among the shirting materials Cotton x Ahimsa silk (S_C) possessed greater warp tear strength followed by Tericot (S_T) and Filature silk (S_F) shirtings.
- Cotton x Ahimsa silk (S_C) shirting exhibited higher resistance to abrasion than the rest of the samples.
- The influence of warp way yarn count and cloth thickness on loss in thickness of shirting materials were found to be statistically significant and were positively related.
- But, loss in thickness of test samples was independent of their corresponding weft-way yarn count and cloth thickness.
- The drape coefficient percentage was least in Filature silk x Ahimsa silk (S_F) shirting material, which in turn exhibited soft and more pliable texture than the Cotton x Ahimsa silk (S_C) and Tericot x Ahimsa silk (S_T).
- There existed no relation ship between cloth stiffness and crease recovery on drapability of newly designed shirting materials.

- All the test samples showed slight to moderate pilling.

Furnishing materials

- Among the furnishing materials polyester x Ahimsa silk (F_P) possessed relatively greater tensile strength.
- Weft-way yarn count and cloth tensile strength of newly designed furnishing materials were found to be negatively related, where in warp direction the relation was non-significant.
- The warp-way and weft-way cloth count positively influenced corresponding tensile strength of newly designed furnishing materials.
- Of the test samples, polyester x Ahimsa silk (F_P) furnishing exhibited greater elongation percentage in warp-way compared to cotton X Ahimsa silk (F_C) materials.
- There existed a positive relation between yarn count and cloth count on warp-way elongation of newly designed furnishing materials.
- All the test samples could not be torn in both warp and weft direction since the strength of samples were beyond the capacity of the instrument.
- Both types of Cotton x Ahimsa silk (F_C) furnishing materials showed higher resistance to abrasion compared to Polyester x Ahimsa silk (F_P) sample.

- Cloth abrasion of test samples was independent of their corresponding yarn count and cloth thickness.

- Among the newly designed furnishing materials, Cotton x Ahimsa silk (F_C - floral and F_C - geometrical) draped into greater number of nodes and expressed lower drape coefficient value than the rest of the samples.

- Significant relationship existed between crease recovery and drapability of furnishing materials in both the directions.

Subjective evaluation of newly designed made-ups

General information

- Majority of the respondents belonged to younger age group with post graduation followed by middle and older age who were either doctorates or graduates respectively.

- Among the respondents majority of them were employed since were the staff members of department of Textile and Apparel Designing and Central Silk Board.

Dress materials

- Majority of the respondents stated that the newly designed dress materials were fibrous, coarser, rough and lustrous in appearance.

- Most of the respondents expressed that the Filature silk x Ahimsa silk (D_F) dress material was smooth in appearance.

- Maximum per cent of the respondents stated that the dress material of Filature silk x Ahimsa silk and control sample were soft and pliable than that of cotton x Ahimsa silk (D_C) and Art silk x Ahimsa silk (D_A) materials.
- Cent per cent of the respondents opined, newly designed dress materials were compact, firmly woven than control sample.
- The respondents expressed that control and Filature silk x Ahimsa silk (D_F) were light in weight than the rest of the samples.
- Most of the respondents preferred Art silk x Ahimsa silk (D_A) dress material followed by Cotton x Ahimsa silk (D_C) and Filature silk x Ahimsa silk (DF) because of their colour combination, weave construction, appearance, handle and texture that enhanced the elegance, artistic appeal and brightness.

Shirting materials

- Majority of the respondents expressed that Cotton x Ahimsa silk (S_C) and Tericot x Ahimsa (S_T) shirting materials were fibrous, coarse, rough and lustrous in appearance.
- Filature silk x Ahimsa silk (S_F) shirting material exhibited clear, fine and smooth in appearance as stated by the respondents.
- Most of the respondents stated that control sample and Filature silk x Ahimsa silk (S_F) shirting material were soft and flexible to handle, where as Cotton x Ahimsa silk (S_C) and Tericot x Ahimsa silk (S_T) exhibited crisp and stiff to handle.

- Cent per cent of the respondents expressed newly designed shirting materials were lighter weight with firmly woven than the control sample.
- Majority of the respondents preferred Filature silk x Ahimsa silk (S_F) shirting materials, followed by Tericot x Ahimsa silk (S_T) and Cotton x Ahimsa silk (S_C) shirtings.

Furnishing materials

- Most of the respondents stated that newly designed furnishing materials were fibrous, coarser, rough and lustrous in appearance.
- Maximum per cent of the respondents expressed newly designed furnishing materials were crispy to handle than the control sample.
- However, control sample and Cotton x Ahimsa silk (F_C-Floral and F_C-geometrical) were found to be flexible than the polyester x Ahimsa silk (F_P) furnishings.
- Majority of the respondents mentioned that all the three newly designed furnishing materials were woven with compact structure with raised effect.
- Cotton x Ahimsa silk (F_C-floral and F_C-geometrical) were preferred most by the respondent compared to Polyester x Ahimsa silk (F_P) furnishings.

Economic analysis of newly designed made-ups

Dress materials.

- The total production cost of control sample and Filature silk x Ahimsa silk (D_F) dress material was maximum followed by Cotton x Ahimsa silk (D_C) and Art silk x Ahimsa silk (D_A).
- In terms of net profit Filature silk x Ahimsa silk (D_F) dress material earned maximum profit.

Shirting material

- Filature silk x Ahimsa silk (S_F) shirting material accounted maximum production cost than other samples.
- The net profit of shirtings was higher in case of Filature silk x Ahimsa silk (S_F) shirting material followed by S_T and S_C materials.

Furnishing materials

- The total production cost of Cotton x Ahimsa silk (F_C-floral and F_C- geometrical) furnishing material was maximum followed by control and polyester x Ahimsa silk (F_P) materials.
- Polyester x Ahimsa silk (F_P) furnishing material earned maximum profit than the rest.

IMPLICATIONS AND RECOMMENDATIONS

Effective utilization of Ahimsa silk yarn for value added end uses has wide scope and of paramount importance in Indian sericulture and silk industry in view of marginal profit to the reeling communities as well as silk manufactures.

It is difficult to produce Ahimsa silk with absolute uniformity like mill spun and maintain TPI throughout length. The spun yarn did show unequal distribution of slubs and snars, of course an added advantage that gave a fancy appearance and texture for the yarns. Thus, Ahimsa silk having these unique properties may not go as warp but can be definitely used as weft to produce designer fabrics. It is a new venture in the handloom sector, since Ahimsa silk is compatible to inter-weave with Cotton, Rayon, Polyester and Filature silk and produce innumerable variegated fabrics. Further, Ahimsa silk spun on any conventional spinning machine or hand charaka of count ranging from 25s - 35s, is suitable for producing dress, shirting and furnishing materials on handlooms of different width. Moreover, the information generated on mechanical and functional properties of newly designed spun silk made-ups directs the private and government handloom sectors to take-up future developmental activities in process and product control for fabric engineering. The study that provides authentic information on appearance and tactile properties of newly designed spun silk made-ups can create a new horizon in the fashion world. The consumer who demands each day a new design for his/her adornment, the rich, lustrous, gorgeous Ahimsa silk made-ups would go a long way not only to meet the needs of the dynamic domestic purchaser but also a boon for the Indian exporters. Moreover spinning Ahimsa silk in cottage industry will surely help the rural folk to earn their livelihood and uplift the socio-economic status of this neglected sector. Integration of the available information and developing technologies for effective utilization of cut/pierced cocoons to value added material is the need of the hour for sustainability of the sericulture and silk industry.

FUTURE DIMENSIONS OF WORKS

The following future studies can be taken up.

- To study the physical properties of Ahimsa silk yarn spun on different conventional methods.
- To compare the physical parameters of made-ups produced from bivoltine and multivoltine pierced cocoons.
- Production of Designers fabric from Ahimsa silk.
- Application of *Kundhi* finish to newly designed Ahimsa silk made-ups and its assessment for comfort properties.
- Dyeing Ahimsa silk made-ups with user-friendly dyes.
- Ahimsa silk made-ups: A new vista for Home furnishings.

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VII. REFERENCES

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APPENDICES

APPENDIX - I

"DESIGNING TEXTILE MADE-UPS FROM AHIMSA SILK"
VISUAL ANALYSIS – QUESTIONNAIRE

Name :

Age :

Education :

Occupation :

Income :

I. Dress materials

A. Fabric appearance

Sl. No.	Particulars	Dress materials			
		Control	Sample A	Sample B	Sample C
1.	Clear or fibrous/ napped/fuzzy				
2.	Fine or coarse				
3.	Lustrous or dull				
4.	Plain or patterned				
5.	Smooth or roughed				

B. Fabric handle

Sl. No.	Particulars	Dress materials			
		Control	Sample A	Sample B	Sample C
1.	Soft or crisp				
2.	Flexible or stiff				
3.	Loose or compact				

C. Fabric texture

Sl. No.	Particulars	Dress materials			
		Control	Sample A	Sample B	Sample C
1.	Close or open				
2.	Light or heavy				
3.	Loose or firm				
4.	Flat or raised				
5.	Rankings (1 to 4)				

II. Shirting materials

A. Fabric appearance

Sl. No.	Particulars	Shirting materials			
		Control	Sample A	Sample B	Sample C
1.	Clear or fibrous/ napped/fuzzy				
2.	Fine or coarse				
3.	Lustrous or dull				
4.	Plain or patterned				
5.	Smooth or roughed				

B. Fabric handle

Sl. No.	Particulars	Shirting materials			
		Control	Sample A	Sample B	Sample C
1.	Soft or crisp				
2.	Flexible or stiff				
3.	Loose or compact				

C. Fabric texture

Sl. No.	Particulars	Shirting materials			
		Control	Sample A	Sample B	Sample C
1.	Close or open				
2.	Light or heavy				
3.	Loose or firm				
4.	Flat or raised				
5.	Rankings (1 to 4)				

III. Furnishing materials

A. Fabric appearance

Sl. No.	Particulars	Furnishing material			
		Control	Sample A	Sample B	Sample C
1.	Clear or fibrous/ napped/fuzzy				
2.	Fine or coarse				
3.	Lustrous or dull				
4.	Plain or patterned				
5.	Smooth or roughed				

B. Fabric handle

Sl. No.	Particulars	Furnishing material			
		Control	Sample A	Sample B	Sample C
1.	Soft or crisp				
2.	Flexible or stiff				
3.	Loose or compact				

C. Fabric texture

Sl. No.	Particulars	Furnishing material			
		Control	Sample A	Sample B	Sample C
1.	Close or open				
2.	Light or heavy				
3.	Loose or firm				
4.	Flat or raised				
5.	Rankings (1 to 4)				