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The Textile Association (India), Mumbai Unit to organize International Conference on "Sustainability and Circularity - The New Challenges for The Textile Value Chain".

The Textile Association (India), Mumbai Unit is organizing an international conference "Sustainability and Circularity - The New Challenges for The Textile Value Chain" on Wednesday, 31st January 2024 at Hotel The Lalit, Mumbai.

In order to appraise the Indian Textile fraternity including the designers and the fashion schools about new circular sustainable model, The Textile Association (India), Mumbai Unit has planned this International Conference. We have made all-out efforts to cover most of the topics. We will have galaxy of speakers who would make the topic very simple and illustrative on this very challenging subject. We are

sure that the participating delegates will be benefitted immensely from this conference and help them in conveying that sustainability and circularity is not a choice anymore but a necessity.

The Textile Association (India), Mumbai Unit is the largest Unit of the Association having around 4000 members. The Unit has reputation of organizing events of topical interest both at national and global level.

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We appreciate your support to The Textile Association (India), Mumbai Unit in its activities and it is our pleasure to invite you to be part of this event. Let us join hands to make this conference a great success.

Rajiv Ranjan	G. V. Aras	V. C. Gupte
President	Conference Chiarman	Chairman & Convenor

For more details please contact:

Mumbai Unit

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Mumbai Unit

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India's Step by Step approach to a Bright Future

India's textile industry is among the world's oldest and most extensive in its tradition of producing top quality fabrics which are exported worldwide. The fundamental strength of the textile industry in India is its strong production base of a wide range of fibre/yarns from natural fibres like cotton, jute, silk and wool, to synthetic/man-made fibres like polyester, viscose, nylon and acrylic. As per the TAG 2023 Conference recently organized by FICCI, the industry wishes to reach a US$ 350 billion market by 2030. However, the industry has been faced with increasing costs of production, outdated technologies and intense competition from countries such as China, Bangladesh or Vietnam in recent years.

Numerous initiatives to support the textiles sector have been implemented by the Government of India following these challenges. While granting R&D project grants, establishing textile hubs, Technology up-gradation fund scheme and establishing 7 PM Mega Integrated Textile Region and Apparel (MITRA) Parks, several other steps are being taken by the Govt. of India alongside the textile industry, to ensure India's path to a bright future.

KASTURI COTTON BHARAT is a collaborative effort of the Ministry of Textiles, The Cotton Corporation of India, trade bodies and the textile industry. The aim is to position Indian cotton as a premium and trusted product in international markets by self-regulation, where stakeholders take responsibility for branding, traceability, and certification of Indian cotton. One of the key features of this initiative is inclusivity, where cotton ginners across the country are empowered to produce the Kasturi Cotton Bharat brand by adhering to specified protocols and complete traceability is ensured using QR based certification technology and block chain based software program. This will definitely help in creating the required trust and acceptability of Kasturi Cotton in global markets.

According to a report on "Wealth in Waste: India's potential to bring textile waste back into supply chain", 7793 kilotons of textile waste is handled annually in India, out of which more than 60% waste is made of cotton and cotton rich materials. India is now focussing on becoming a textile recycling hub. Panipat has always been a hub for textile recycling units engaged in recycling of a variety of materials, both domestic pre-consumer and post-consumer, as well as imported. Tirupur, the hub of knitwear production has also been growing into an efficient and modern cluster for recycling with focus on pre-consumer waste. Also, Amroha, in Uttar Pradesh is largely working with down cycling of textiles, where discarded products are recycled and repurposed into something of lower value. As the textile waste crisis is reaching the tip of the iceberg, and catching the attention of the legislators, soon destruction of unsold goods will become banned and textiles might be collected in a separate waste stream. Great efforts to reduce this have been put in by Swedish company Renew cell, the first commercial scale textile-to-textile recycling factory. Renew cell takes in textile waste and converts it into material like Circulose which can be used to make viscose rayon. On similar lines, Birla Cellulose is also manufacturing Viscose using Pre-consumer cotton waste. Launching recycled viscose fibre as their part of commitment to circularity and sustainable practices. The various sectors focussing on textile waste recycling will lead to a better India in the coming days.

While the growth of the industry takes place, the Ministry of Textile, Govt. of India, also realises the importance of creating and enhancing the skills required by the existing workers and incoming human resources. The textile sector, being the second largest employment generator, the labour intensive industry requires not only skilled workforce but also training for skill up-gradation. For the same, the integrated skill development scheme has been putting in a large amount of efforts to support the industry workers. Correspondingly, with the increase in the focus on the Technical Textiles sector, skill development for serving this sector is necessary to push the production possibility frontier outward. Recently, under the NTTM scheme of Ministry of Textiles, various institutes such as IIT Delhi, NIT Jalandhar, VJTI Mumbai, ICT, NIFT Mumbai etc. were given a grant for up-gradation of machineries and equipment and training of trainers so that the aspiring professionals of the industry can be trained with the latest machineries and support the growth of the industry.

The next big step by the Ministry of textile, Govt. of India is organizing the "Bharat Tex 2024". Highlighting India's global strengths, its sustainability initiatives as well as positioning the country as a competitive global sourcing destination, Bharat Tex 2024 is envisaged to be the biggest textile event at the global level. "Bharat Tex 2024" is being organized based on the 5F vision, spanning Farm to Fibre to Factory to Fashion to Foreign. It underscores India's preparedness to compete globally in the textile sector, manufacturing products not only for domestic consumption but also for the world. The program will be a symbol of India's commitment to redefining the global textile industry by showcasing India's strengths, sustainable business practices, and innovation. The program serves as an opportunity for international investors and buyers to discover India's value as a global manufacturing & consumer market. The program consists of over 3,500 exhibitors spread across 2,00,000 sq. mts. gross area and visitors from 40 countries, the event will feature knowledge sessions, seminars, conferences, B2B and G2G meetings, product launches, and collaborations in association with various apex bodies from government and private players.

The future of the Indian textiles industry looks promising, buoyed by strong domestic consumption as well as export demand. India is working on various major initiatives to boost its technical textile industry. The opportunities mentioned provide a great potential for growth in the sector. By focusing on innovation, sustainability, talent, and Operational Consulting efforts, the textile industry can overcome these challenges and seize the opportunities that lie ahead.

Dr. Neha Mehra
Guest Editor
HOD, Textile Engineering Dept., VJTI

Mr. R. K. Vij, President - TAI

INDIAN TEXTILE INDUSTRY AND TEXTILE TRENDS

R. K. VIJ - President

The Indian Textile Industry is not just a sector of Commerce but a reflection of our nation's diverse heritage. It is a story woven with threads of tradition, culture, and craftsmanship, passed down through generations. From the vibrant silks of Varanasi to the intricate Kanchipuram sarees, the earthy khadi fabric to the exquisitely embroidered phulkari, India's textile traditions are as diverse as our landscapes.

But our Textiles are more than just products; they are the symbol of resilience. Our weavers and artists have persevered through the test of time, adapting market dynamics and embracing modern technology while retaining the essence of handcrafted beauty.

The Indian textile industry is a significant contributor to our nation's economy, providing employment to millions. It also plays a vital role in preserving our cultural heritage and promoting sustainable practices. As the world becomes increasingly conscious of sustainability, our tradition of hand-woven, organic textiles is gaining global recognition.

However, we cannot rest on the laurels of our past achievements. The textile industry faces challenges such as global competition, the need for up-skilling, and environmental concerns. It's crucial that we invest in research, innovation, and education to ensure a brighter future for this sector.

The Indian textile industry is a testament to the extraordinary talent and cultural wealth of our nation. As we celebrate this vibrant tapestry, let us also commit to nurturing and supporting it. Let us be the weavers of progress, sustainability and excellence for the Indian textile industry. Together, we can ensure that this incredible legacy continues to shine brightly in the global arena.

About the textile trends to follow this season. As we all know, fashion is constantly evolving, and so are the fabrics and textiles used in the industry. This season, we are seeing some exciting new trends that i/ believe are worth paying attention to.

Firstly, sustainable textiles are becoming more and more popular. Consumers are becoming increasingly aware of the environmental impact of fashion and are looking for more eco-friendly options. Fabric made from recycled material, organic cotton, and hemp are just a few examples of sustainable textiles that are gaining popularity.

Another trend to follow is the use of bold prints and patterns. From animal prints to geometric shapes, designers are playing with prints in new and exciting ways. These prints can be used to create statement pieces or to add interest to more basic outfits.

Lastly, we are seeing a lot of texture in the fabrics this season. From chunky knits to velvet, designers are using textures to add depth and interest to their collections. These textures can be incorporated into both clothing and accessories and can add a touch of luxury to any outfits.

This season's textile trends are all about sustainability, bold prints, and interesting textures. By incorporating these elements into your wardrobe, you can stay on-trend while also making a statement about your values.

Let me share some relevant data and statistics to support the textile trends that I discussed earlier.

Sustainable textiles have been gaining popularity in recent years, and the trend shows no sign of slowing down. In fact, the global market for sustainable textiles is expected to grow at a CAGR of 9.81% from 2021 to 2028, according to a report by Grand View Research. This growth is being driven by increasing consumer awareness of the environmental impact of fashion, as well as Government initiatives to promote sustainable manufacturing practices..

In addition to sustainable textiles, bold prints and patterns are also on the rise. According to an edited report, animal prints saw a 137% increase in new arrivals in 2021 compared to the previous year. This trend is also reflected in social media, with searches for animal print clothing increasing by 54% on Pinterest in 2021.

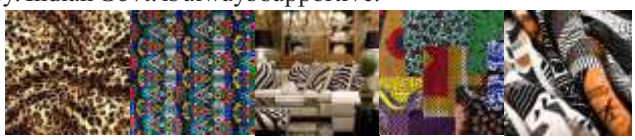
When it comes to textures, designers are experimenting with a range of materials to create interesting and unique fabrics. For example, the use of velvet has seen a resurgence in recent years, with a 108% increase in 2021 compared to the previous year, according to Edited. Chunky knits are also a popular choice, with a 76% increase in new arrivals in 2021 compared to the previous year.

These statistics demonstrate that the textile trends are not just passing feds but are part of larger shifts in the fashion industry. By embracing these trends, we can not only stay on-trend but also contribute to a more sustainable and socially responsible industry.

Let's all join hands together to grow our whole Indian textile Industry. Indian Govt. is always supportive.

Regards.

R. K. VIJ



Journal of the TEXTILE Association

A Study to Determine Factors Motivating Consumer Intention for Luxury Counterfeits' Purchase

***Nidhi Arora*[1] *& Aditi Dhama*[2]**

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Abstract:

Purpose- The objective of this study is to carry out an examination of Luxury Fashion Brands in Delhi region of India taking into consideration the reasons behind why Indian consumers are much inclined towards counterfeit copies of Luxury brands.

Design/methodology/approach- Data has been gathered from 183 respondents using online surveys. The questionnaire was created using 5-point Likert scale and distributed amongst shoppers through various online platforms. The questionnaire contained 21 items that were divided into five aspects. To extract the components and determine the level of satisfaction, researchers employed factor analysis, weighted average score and regression analysis.

Findings- Factors with a higher factor loading are better satisfiers. Out of five dimensions, the 3 dimensions namely- Price Consciousness, Novelty Seeking, Fashion Consciousness are significantly related to the Customer Intention.

Research limitations/Implications- Education on awareness is required so that potential buyers are able to differentiate between original and counterfeit fashion merchandise. Promotional campaigns explaining the legal issues on purchasing luxury fashion imitated items are also essential.

Originality/Value- This comparative study between those who can, and those who can't afford luxury brands, can provide a unique understanding related to luxury concepts especially in Delhi (India), where the consumers are price sensitive.

Keywords: *Affordability, Consumer Behavior, Counterfeiting, Fast Fashion, Luxury Brands, Westernization*

Citation: Nidhi Arora & Aditi Dhama, "A Study to Determine Factors Motivating Consumer Intention for Luxury Counterfeits' Purchase", *Journal of the Textile Association*, **84/3** (143-150), (Sept-Oct'23),

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1. Introduction

The Luxury concept has always been a very crucial and significant part in providing information as well as marking the socio-economic status. Luxury brands are especially a way of communicating one's self-image and lifestyle to the surroundings. Today, in India, both the demand and supply of luxury brands is continuously growing. Luxury brands have been always fascinating customers and captivating them with its supreme quality, position and appeal. The Indian luxury market is extensively rising. A fraction of Indian population comprises of Affluent Indians representing a vast source budding for worldwide luxury brands.

India has always been fashionable tradition of luxury. Designers round the world are being inspired from India's wealthy fashion Bollywood industry with its flashy colors, traditional attire with well-balanced surface ornamentation techniques and elegant jewelry. Since India is filled with a wide range of textiles and enriched with mass fashion brands, still Indian consumers have always been fascinated by luxury brands due to their quality, status and appeal.

India and other developed markets hold a significant difference in terms of consumer outline and demographics. People below 30 years of age are considered to be the main consumers of luxury brands. However, they hold only two-third of India's population. Many of them might not be able to manage to pay for these items. The Indian luxury market is rising at a very fast speed due to developing markets. The industry is growing rapidly at the rate of 25% p.a. Global luxury goods industry is of prime importance nowadays. It has also fascinated the consideration of international luxury brands with the introduction of supreme quality brands like Chanel and Louis Vuitton.

The Fashion markets across India are growing fast especially the metropolitan cities like Delhi, Mumbai, Bangalore, Kolkata etc. and luxury brands are facing competition with China counterfeits. Today, luxury is more about experience. It is more than a financial value.

Shopping for luxury is an emotional affair. All of us desire for customized and bespoke merchandise. The mind-set of Indian grandeur is exceptionally unprecedented. They choose luxury for most part of their marriage ceremony trousseau for their satisfaction and ease. Amongst various demographic variables, Age is one of the most significant one. Different people with different age groups hold different purchase attitude towards luxury items. Everybody wants tailored and bespoke products. India's monetary policies like demonetization and GST have rocked the boats of international and domestic luxury brands. Luxury brands are struggling to survive right now because although they have entered India but there are only few who can afford for it.

As a general perception, luxury brands are taken up by society as a superficial point of interest in the present age and time particularly the youthful age, who are the main

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consumers with a biased attitude towards the acquisition of luxury products. Luxury brands are connected with a high level of creative mind, imagination, stylish magnificence, selectiveness, pricing, quality and/or potentially a mix of all these. It has been built up that viewpoint related basically to quality, craftsmanship, plan and aesthetic value are considered as credits comparative with luxury items. The characteristics of luxury product offers a high degree of satisfaction and fulfilment to the customers' needs and desires, keeping up their economic well-being.

Buying counterfeits of luxury is one of the major businesses in most countries like China. It isn't only the needy individuals who are purchasing fakes but also the affluent customers purchasing advanced brands. Companies of these countries (like China) are purchasing enormous offers from luxury firms abroad, acquiring marketing awareness and access to incredible brands that are both nationally and internationally recognized and thus taking the brands back to these countries to offer to the customers craving for luxury and who can't manage to buy topmost luxury brands.

Luxury brands are struggling to survive right now because although they have entered India, but there are very few people willing to pay the high prices that they are demanding. Indian consumers are value-conscious and love a good bargain with discounts and offers. Hence, countries like China are supplying counterfeit copies at lower prices to fill this gap which is damaging the originality. Chinese are the most passionate consumers of luxury goods. Forging of luxury items have reached at an extremely high level. This has further led to the rise in global trade and increase in developing new markets, along with the rise in counterfeited goods.

As it has been observed that only seven percent of the British adults have purchased counterfeit copies, people who have yet not got a chance to buy original luxury brands can now switch over to the counterfeit copies of these and fulfill their desire of using luxury products which most of the times act as a status symbol [31] [32]. However, the originality of these luxury brands is diminishing due to the use of counterfeiting [33].

As per Global Anti-Counterfeiting Alliance, forging costs the United States $ 200 billion annually in lost jobs, unpaid taxes, and missed sales [12]. Luxury brand items are simple to copy since they are easy to trade and does not involve large production expenses [27] [13]. Counterfeiting devalues the original luxury product's symbolic significance, corroding the value of authentic premium brand equity. Customer demand for fashion items is increasing at a rapid speed as everyone has a desire for social up-liftmen in the society, and to keep themselves updated to the new fashion along with fads [7] [11]. In order to do so, the customers need to attain the products that are well-known and for which they are ready to spend more for the explicit appearance and not for the inherited value. And therefore, they will select a forged item associated with a popular brand name and is visually different [8]. Hence it supports the idea that counterfeiting is a sign of success. Thus, only the item which has a famous brand recognition are suitable for counterfeiting and are taken up for unlawful production [11]. Counterfeit copies, similar to the original trademarked products also using their characteristics are sold in the market so as to enjoy the perks and profits generated by the authentic items [14]. In other words, it is also referred to as an exact copy of a creation with superior value attached to it [21]. These duplicate products build a convincing image in the minds of the buyer makes them think that they purchase the authentic and the real product. The expense for a fake copy of a luxury item is only a nominal sum of the value of original product and people will prefer buying duplicate copies itself so as to save their money from buying high priced original products.

Countries producing counterfeits have been assembling and selling a huge number of duplicate copies by simply making few required differences so as to stay out from copyright issues or any other legal issues. The common man doesn't know the difference between the original and the counterfeit item. There is absence of education, absence of brand awareness and absence of right luxury brand knowledge among the Indian consumers. They are not able to judge the durability of luxury authentic goods in comparison to the faked copies. It's extremely simple for them to sell these duplicates by simply utilizing the well-known brand name. In spite of so many differences like in logo, material quality utilized, etc., individuals prefer imitated or duplicate products with a well-recognized brand association and which are visually different, at an affordable price.

According to the news report, UTSR (United States Trade Representative) has termed few Delhi markets like Nehru Place, Palika Bazar, Tank Road that are required to be scrutinized for its large-scale counterfeiting business of s. There are so many commercial centers, wholesale groups who have been effectively selling these counterfeit copies through social media applications like Facebook pages and Instagram accounts leading to a negative impact in the market for the luxury brands. Both the shoppers' brand affiliations and how customers see the nature of luxury brands are affected by fake items. Shoppers' convictions of the quality, service level as well as the attributes related to luxury items is contrarily affected. It is interesting to know that the young generation who are the main consumers of luxury brand, their behavior and preferences are totally distinct. Subsequently, it implicates that the reason for forging is the presence of original brands.

2. Objectives

To analyze the motivational factors persuading customers to buy luxury counterfeits.

3. Review of Literature

Different demographic factors have an impact on the consumers' buying attitude [20]. Buying decision was carried out by brand familiarity which further helped in applying positive image towards the brand.

The existence of imitated products does not aim at giving false information to the consumers or mislead them [18]. It rather aims at fulfilling their desire to use luxury products by

using counterfeits possessing the same level of characteristics. The author in his study gave the reason why consumers are inclined towards fake copies, due to the fact that they cannot pay for the authentic ones [18].
This implicated that the reason for counterfeiting is the presence of the original products itself. So, if the counterfeits are not fulfilling the characteristics as that of originals and are not meeting the societal requirements of the customers, the counterfeits will not be able to make a space for them in the market.

The discrepancies that occur between measures of attitudes, individual norms, and consumers' behavior [25]. The study focused mainly on finding out the reasons that motivates the Indian consumers to buy supreme quality products.

Luxury brands is not affordable to all because of its high price [17]. It is limited only to elite class. So, promotion of luxury brands to create awareness doesn't make sense. Rather, Luxury brands should formulate a strategy to choose right social media to reach to their customers. The author in his study helped to analyze the changing business patterns in Luxury Branding from physical stores to E-business or online stores in terms of Luxury marketing mix [17].

Age is associated with different factors like the type of luxury items, influence of luxury products purchases and reasons to purchase the brand again [4]. Both demographic factors and psychographic factors hold significant importance towards brand equity of luxury handbags [4].

Factor analysis was used to identify consumers' buying behavior towards fake luxury items available in China amongst two groups and within two dimensions, Education Effect and Devaluation Effect [30]. The participants of both the groups produced valid and reliable answers. In order to confirm the presence of these two dimensions towards counterfeiting, validity and reliability tests were used. The author concluded that consumers who have experienced different luxury items hold different perceptions towards buying of luxury products [30]. The findings showed that everyone agrees on the devaluation effect of fake products; but those holding experience of counterfeit luxury brands, have varied attitudes on EDU and those who have never experienced the imitated products disagree on this effect [30].

Luxury brand counterfeiting is illegal. Forged items capitalize on the brand's symbolic value and goodwill. Its high-volume production leads to an extensive damage to the reputation of luxury brands. In 2006, a manuscript published showcased a review on consumer behavior towards purchasing counterfeit products [11].

Both perceived quality and expected drawbacks behind purchase of imitated products might have an impact on one's buying decision [2]. For luxury products to be effective, to be successful, they must develop a strong association with the clients and educate them with the brand values consistently. This will reduce the impact of counterfeits on luxury brands and the potential customers will be able to distinguish the quality amongst the authentic products and the fake items.

Maran aimed at identifying the factors influencing Indian consumer buying behavior towards an Indian brand [22]. The data helped in gaining the perception and satisfaction level of users of branded apparel.

The primary data was collected by doing survey through the use of questionnaires known as Quantitative method of research [28]. The results indicated that UK and Thai participants do not buy products for social class; however, some respondents from China have purchased luxury items just as a status symbol. There is almost no relationship amongst gender and purchase of luxury items and quality is of utmost importance to luxury consumers. The results [28] concluded that luxury brand companies should target young Indian customers as they are the main power of consumption. They need to understand consumers' perception and their buying behavior. It thus helps them to know how people with different demographic variables respond to luxury products with regard to its quality, exclusivity and societal worth.

Expressive statistics used to indicate that customers are more inclined towards purchase of forged than makeups or smart phones as counterfeit s are available in better quality and wide choice in Morocco [15]. The attitude towards purchase of imitated cosmetics and s are highly positively correlated to income as proved by Logistic Regression. Further, consumer demographics was built and proved that consumers with low income tend to buy counterfeits. Highly qualified women have less chances to buy imitated goods than men. In parallel, ANOVA test implicate, there is no association between family size and family income while income and the feeling of embarrassment are highly correlated.

The study has identified several reasons as to why customers are more inclined towards luxury fashion counterfeit items. As per the determinants recognized in earlier research work, this research paper uses Price Consciousness [1]; Perceived Uniqueness [10] [9]; Novelty Seeking [24]; Fashion Consciousness [6]; Prestige renamed as Social Status [3] (as represented in Figure 1 below).

3.1 Conceptual Research Model

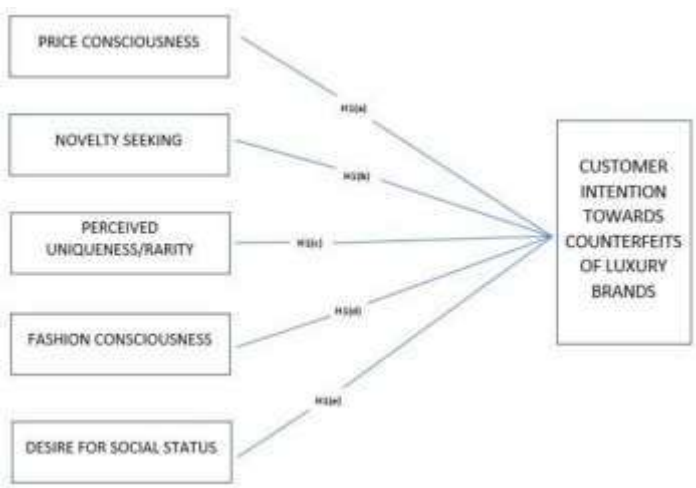

Figure 1: Research Model

4. Hypothesis Development

H1: There is a noteworthy impact of motivational factors on customers' intention in counterfeit products' trade.

Price Consciousness

Price has a significant impact on customer buying patterns. Individuals who make decisions primarily based on price are referred to as 'price conscious.' Such people know how much things cost and avoids buying things that are considered too expensive. It is crucial in the purchase of counterfeit goods. People buy counterfeits to gain prestige without having to pay for it [5].

H1 (a) - Price Consciousness is significantly related to consumer intention towards buying of counterfeit luxury brands.

Novelty seeking

Novelty seeking is a personality trait that states a tendency to pursue new experiences with intense emotional sensations. It is the keenness of the people to search for assortment and change [16] [29]. A client with this trait tends to try something new each time. Such clients are mostly inclined towards counterfeit goods with low buying risk.

H1 (b) - Novelty Seeking is significantly related to consumer intention towards buying of counterfeit luxury brands.

Perceived Uniqueness/Rarity

Perceived Uniqueness means more than simply inaccessibility. When people are looking for something which is hard to obtain, they express a "need for uniqueness". Quality and exclusivity are amongst the vital characteristics of a luxury product that are required to be combined with rarity [19]. The customers who desire for a product which is rarely available are more likely to look for exclusive and unique items.

H1(c) - Perceived Uniqueness is significantly related to consumer intention towards buying of counterfeit luxury brands.

Fashion consciousness

An individual's level of participation with styles or fashion is referred to as their level of fashion consciousness. Products associated with a recognized brand are more likely to be counterfeited [5]. Fashion participation defines the significance of fashion in one's life and this participation itself persuades the clients to buy fashion counterfeit products [23]. Since fashion articles are short lived, majority of the customers doesn't feel like spending their money on them as fashion trends keep changing very frequently.

H1 (d) - Fashion Consciousness is significantly related to consumer intention towards buying of counterfeit luxury brands

Desire for Social Status/ Prestige

Social status is that level of social worth an individual is taken into account to hold. It is determined by the possession of varied characteristics which, depending on the culture, point to superiority or inferiority. Luxury consumption trend is reflected by social product value, i.e., by prestige and conspicuousness [28]. Whereas, product value is represented by personal values such as self-identity, hedonism, etc.

H1 (e) - Social Status/Prestige is significantly related to consumer intention towards buying of counterfeit luxury brands

5. Research Methodology

The study is designed to recognize the magnitude of impact luxury brands have over the Indian customers in contrast to the duplicates of Luxury Brands in the Industry. This research gives an insight as to how the brand strategies should be devised in order to reach out to the consumer effectively.

6. Data Collection

A structured questionnaire has been designed that would focus on understanding of consumer preferences for luxury fashion brands and its counterfeits available. The information was gathered from both primary and secondary sources. For data analysis, the SPSS software was used. The questionnaire's descriptive statistics were computed using SPSS after the data was entered into the software.

The survey is conducted amongst various students and professionals at Design Institutes and Colleges wherein the respondents are fashion conscious. The study covers the age group of 18-40 years, who belong to different income level category (as different income level group will select different level of Design Institute or College as per their affordability). The Quantitative data will include a sample of 183 people in Delhi, a metropolitan city and a big fashion hub as geographical survey will not be possible. The sampling involves use of convenient methods to examine the brands in real world setting.

The survey is proposed to be distributed through social platforms like LinkedIn, Face book, Twitter, so as to approach the young respondents of India

Table 1: Respondent Profile

Basis	Category	Frequency	Percent
GENDER	Male	70	38.3
	Female	113	61.7
	Total	183	100
QUALIFICATION	High School	16	8.7
	Undergraduate	27	14.8
	Graduate	39	21.3
	Post Graduate	43	23.5
	Doctorate	58	31.7
	Total	183	100
AGE	18-23 years	42	23
	23-28 years	60	32.8
	28-33 years	45	24.6
	33-40 years	36	19.7
	Total	183	100

(Continue)Table 1: Respondent Profile

Basis Category		Frequency	Percent
MONTHLY INCOME	Under 50,000	28	15.3
	50,000-1,00,000	64	35
	1,00,000-1,50,000	23	12.6
	1,50,000 – 2,00,000	22	12
	Above 2,00,000	46	25.1
	Total	183	100

Males account for 38% of the responders, while females account for 62%. Around 55 percent of responders are under the age of 28, and 45 percent are between the ages of 28 and 40. Nearly 50% of the respondents earn below 1,00,000 per month, around 13% are earning between 1,00,000-1,50,000 per month and around 37% above 1,50,000. Around 45% of the respondents are Graduates or undergraduates, 55% are Post Graduates or Doctorate (as per Table 1).

A total of 21 items were included under five dimensions (i.e., Price Consciousness, Novelty Seeking, Perceived Uniqueness, Fashion Consciousness, Desire for Social Status) to measure the customer intention. All 21 statements were rated on a five-point Likert scale ranging from 1 to 5, with 1 indicating strong disagreement and 5 indicating strong agreement. The first four questions are about age, gender, monthly income, and qualification, which are all demographic characteristics.

7. Data Analysis

Correlation Analysis

The independent factors were "Price Consciousness, Novelty Seeking, Perceived Uniqueness, Fashion Consciousness, and Desire for Social Status," whereas the dependent variable was "Customer Intention.". In any study with multiple variables, after computing the means and standard deviations of the dependent and independent variables, researchers are keen to learn how one variable is related to another [26]. The direction, nature, and importance of the bivariate association of the variables used in the study are revealed through inter correlation analysis. The link between dependent and independent factors is examined in this study. To determine the link between the dependent and independent variables, the Pearson correlation was used. There could be a perfect positive correlation between two variables, which is represented by 1.0 (plus1), or a perfect negative correlation, which is represented by -1.0. (Minus 1). The study was done to see if any correlation observed between two variables was significant or not, and the correlation might range from -1.0 to +1.0. (Is it occurred by chance or is it there is a probability of its actual existence). In social science research, p=0.05 is the commonly acknowledged standard level of significance. This means that 95 times out of 100, the researcher can be confident that there is a substantial association between the variables, with just a 5% possibility that the relationship does not exist. Tables 2 and 3 below demonstrates the R-value derived from intercorrelation analysis using the rules of thumb.

Table 2: Explanation of R Value

R Value	Relationship
Above 0.70	Very strong association
0.50-0.69	Strong association
0.30-0.49	Moderate association
0.10-0.29	Low association
0.01-0.09	Very low association

Table 3: Correlation Matrix

		C_INT	PC	NS	PU	FC	DSS
C_INT	Pearson Correlation	1	.719**	.710**	.600**	.683**	.481**
	Sig. (2-tailed)		<.001	<.001	<.001	<.001	<.001
	N	183	183	183	183	183	183
PC	Pearson Correlation	.719**	1	.799**	.707**	.586**	.474**
	Sig. (2-tailed)	<.001		<.001	<.001	<.001	<.001
	N	183	183	183	183	183	183
NS	Pearson Correlation	.710**	.799**	1	.608**	.639**	.516**
	Sig. (2-tailed)	<.001	<.001		<.001	<.001	<.001
	N	183	183	183	183	183	183
PU	Pearson Correlation	.600**	.707**	.608**	1	.519**	.514**
	Sig. (2-tailed)	<.001	<.001	<.001		<.001	<.001
	N	183	183	183	183	183	183
FC	Pearson Correlation	.683**	.586**	.639**	.519**	1	.535**
	Sig. (2-tailed)	<.001	<.001	<.001	<.001		<.001
	N	183	183	183	183	183	183
DSS	Pearson Correlation	.481**	.474**	.516**	.514**	.535**	1
	Sig. (2-tailed)	<.001	<.001	<.001	<.001	<.001	
	N	183	183	183	183	183	183

**Correlation is significant at the 0.01 level (2-tailed).

Correlation Table

It is carried out in order to establish a link between constructs. "Correlation coefficients vary from -1 to +1, with -1 indicating perfect negative correlation and +1 indicating perfect positive correlation." According to the correlation table's findings, the majority of the factors have a strong association with the dependent variable, customer intention. Price Consciousness was correlated with a value of R=0.719, while Novelty Seeking was correlated with a value of R=0.710, Perceived Uniqueness was correlated with a value of 0.600, Fashion Consciousness was correlated with a value of 0.683, and Desire for Social Status was correlated with a value of 0.481. According to the correlation analysis, the strongest correlation was revealed with Price Consciousness, while the lowest correlation was found with Desire for Social Status. It is hypothesized that all five characteristics have a substantial association with customer intent. So, this is a good hint that linear regression should be used.

Regression Analysis

C_INT has been chosen as the study's dependent variable. As seen in the preceding model, the dependent variable in the summary table that predicts consumer intention is C_INT, whereas the independent variables are PC, NS, PU, FC, and DSS.

It shows "R value of 0.800, R square value as 0.640 and Adjusted R square value of 0.630". He suggests that the independent variables PC (Price Consciousness), NS (Novelty Seeking), PU (Perceived Uniqueness), FC (Fashion Consciousness), and DSS (Desire for Social Status) can be forecasted using C_INT's 63% variance. Despite the fact that it is mentioned that a decent fit will be able to anticipate a variation of the dependent variable of not less than 60%, this model is ideal because the results of this regression fall within the minimal rate.

Testing of Hypothesis between customer intention and Antecedent Variable

Table 4: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.800a	0.64	0.63	0.52773

a. Predictors: (Constant), DSS, PC, FC, NS, PU
b. Dependent Variable: C_INT

Table 5: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	87.746	5	17.549	63.014	<.001b
	Residual	49.294	177	0.278		
	Total	137.039	182			

a. Dependent Variable: C_INT
b. Predictors: (Constant), DSS, PC, FC, NS, PU

Table 6: Regression Analysis between Customer Satisfaction and Antecedent Variable

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.063	0.239		-0.264	0.792
	PC	0.328	0.095	0.293	3.452	<.001
	NS	0.208	0.083	0.204	2.517	0.013
	PU	0.103	0.075	0.092	1.371	0.172
	FC	0.347	0.067	0.325	5.212	<.001
	DSS	0.015	0.055	0.016	0.28	0.78

a. Dependent Variable: C_INT

Table 7: Hypothesis Testing and Validation

Decisions on Hypothesis	Beta Coefficient	P-Value	Decisions
H1(a)- "PC have a significant relationship with C_INT"	0.328	<0.001	Accepted
H1(b)- "NS have a significant relationship with C_INT"	*0.208*	*0.013*	Accepted
H1(c)- "PU have a significant relationship with C_INT"	*0.103*	*0.172*	Rejected
H1(d)- "FC have a significant relationship with C_INT"	*0.347*	<0.001	Accepted
H1(e)- "DSS have a significant relationship with C_INT"	*0.015*	*0.78*	Rejected

Note: *p<0.05. PC: Price Consciousness, NS: Novelty Seeking,
PU: Perceived Uniqueness,
FC: Fashion Consciousness, DSS: Desire for Social Status

As the antecedent factor customer intention, Price Consciousness, Novelty Seeking, Perceived Uniqueness, Fashion Consciousness, Desire for Social Status were built, and then linear regression analysis was used to examine the effect on consumer intention. Tables 4-6 provide the results of the significance analysis for specific variables. Each b coefficient was (0.103) Perceived Uniqueness, (0.328) Price Consciousness, (0.208) Novelty Seeking, (0.347) Fashion Consciousness, (0.015) Desire for social status.

The significance of the regression coefficient was represented by the standardized regression coefficient (b) (0.092) Perceived Uniqueness, (0.293) Price Consciousness, (0.204) Novelty Seeking, (0.325) Fashion Consciousness, (0.016) Desire for social status.

8. Results & Discussions

As per Table 7, Hypothesis 1: Price Consciousness is significantly related to customer intention. The regression analysis of the association reveals that PC significantly predicted C_INT, F (5,177) = 63.014, $p<0.001$, which indicates that the PC can play a significant role in shaping C_INT ($b=0.328$, $p< 0.001$). These results clearly direct the positive affect of the PC. As a result, the hypothesis is accepted.

Hypothesis 2: Novelty Seeking is significantly related to customer intention. The association between the variables was investigated using regression analysis, which revealed that NS significantly predicted C_INT, F (5,177) = 63.014, $p<0.001$. This indicates that NS can play a significant role in shaping C_INT ($b= 0.208$, $p< 0.05$), i.e., the results clearly direct the positive effect of the NS. As a result, the hypothesis is accepted.

Hypothesis 3: Perceived Uniqueness is significantly related to customer intention. The variable, PU did not significantly predict C_INT, F (5,177) = 63.014, $p<0.001$, which indicates that the PU could not play a significant role in shaping C_INT ($b=0.103$, $p< 0.$). As a result, the hypothesis is rejected.

Hypothesis 4: Fashion Consciousness is significantly related to customer intention. We may conclude from regression analysis that FC significantly predicted C_INT, F (5,177) = 63.014, $p<0.001$, which indicates that the FC can play a significant role in shaping C_INT ($b=0.347$, $p< 0.001$). As a result, hypothesis is accepted.

Hypothesis 5: Desire for Social Status is significantly related to customer intention. The variable DSS did not significantly predict C_INT, F (5,177) = 63.014, $p<0.001$, which indicates that the DSS could not play a significant role in shaping C_INT ($b=0.015$, $p< 0$). As a result, hypothesis is rejected.

9. Limitations and scope of the study

The scope for this kind of research is infinite. No doubt, a lot of research has been done in this area, however, there are still some challenges and areas of improvement present that need to be dealt with. As observed, data in the past research papers has been extracted from a limited population and all the surveys and questionnaires have been mostly designed to evaluate the consumer preferences. Therefore, further studies need to be done with a bigger sample size and in distant parts of South Asia so as to achieve a better understanding of consumer perception and attitude towards Luxury Brands.

Additionally, it would be worthwhile if similar surveys are conducted with manufacturers and producers of luxury brands, as they could help build a better image in India and unite their base in the country by concentrating on the wants and desires of the clients and further by offering them luxury products at alternative price range affordable to all.

Further studies could also incorporate more significant factors including inspiration, motivation in order to acquire adequate information about the client's conduct and their purchasing patterns in this specific market segment. Furthermore, Companies should attempt to make it less complex for the buyers so that they are able to differentiate between the original and duplicate merchandise. The promotional correspondence of luxury items should also concentrate on its exclusiveness so as to reach out to new clients and maintain quality so that the existing clients are not switching to duplicate items. Efforts should be taken to generate awareness amongst customers on refraining them to purchase any counterfeit product that would adversely affect the original brand and world economy.

10. Conclusion

The Research aims to carry out an examination of Luxury Fashion Brands in Delhi region of India, considering why Indian consumers are inclined more towards counterfeits of Luxury items. The aim of this study is also to examine the key aspects that play a crucial role in persuading people to buy duplicates of luxury goods which may additionally be valuable for branding, promotion and marketing strategies. Counterfeits are advertised in such a way that people are lured to buy them. Due to lack of education, the common man is not able to differentiate between original and forged items.

The main idea behind this study is to focus on the gap amongst those who can, and those who can't afford luxury brands. This research study will investigate about the need of luxury brands in India as more than half of the population is below the poverty line. People of India have very low purchasing power, they can't afford luxury brands. India has been a developing nation where people need better education, better transport facilities, and safety for women. The Indian customer is unreliable, grasps luxury yet needs appropriate luxury brand information. This study will also help the luxury brands understand that in order to be successful and to develop a better image in India, they should focus on to the needs and requirements of customers by offering them the products with a wider price range affordable to all.

Due to the tremendous use of fake duplicates available, it has become essential for worldwide advertisers of Luxury brands to differentiate among the market sections and categorize the areas with the most potential. Brands may be analysed through present brand assessment parameters or factors which are significant in order to comprehend Indian buyer inclinations, their shopping behaviours, their buying purchase patterns and perceptions towards the luxury brands and will consider different variables to know whether this inflow of such a large number of luxury brands would really benefit the individuals of India??

Although a lot of research has been done in this area, there are still certain issues to be researched. The study concludes that 'Affordability' is the strongest driving factor in Indians while purchasing luxury counterfeits, and which overpowers all the variables.

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FASHION

Adaptive Clothing Brands in Mainstream Fashion

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Abstract:

Living with any kind of disability is not easy in terms of performing daily activities and moving out in public and socialising. Clothing has always played an instrumental role in making a person a better social being, since comfortable and aesthetically appealing clothing has the ability to imbibe a feeling of social belongingness and instils higher self-esteem. People with disability, people with less mobility and ageing population are forms a significant portion of total population both at national and global level. However, the fashion market is mainly flooded with clothing styles for mainstream society and differently abled people often complain about lack of adequate functional and fashionable style options available for them. Moreover, the available product range is limited with not so aesthetically appealing designs.

Hence, in this paper, an attempt has been made to comprehend and discuss the term disability, problems and clothing needs of such people. The brands that are offering exclusive adaptive clothing lines with their important features both at national and global level are given. This paper would motivate its readers to empathise with people with disabilities, conduct research into adaptive clothing and design suitable adaptive clothing.

Keywords : *Adaptive clothing, brands, disability, functional clothing, research*

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1. Introduction

To live with dignity is every human being's right. At large, society does not only constitute people with all abilities, but a major portion is also represented by differently-abled people. Physical limitations of anyone should not deter them from dreaming and doing anything they wish to do. Along with fulfilling the physiological needs of people, clothing also serves to satisfy the urge for social belongingness. Many times, the clothing industry boasts of new innovations taking place in its various segments and is known for creating new fashion trends every now and then. However, at the same time, it fails to fully accommodate people with special needs because of its fewer clothing options available for them.

As quoted by Fashion United, 'The fashion world, a $3 trillion global industry, has rarely paid attention to the needs of people with disabilities, even though the U.S. Census reports that they make up 19 percent of the population'. And according to a survey report by the National Statistical Office, India in 2018, the overall percentage of persons with disabilities in India is at 2.2 per cent of the total population, which is huge in number [1]. As per the Adaptive Clothing Market Analysis study published in 2018, the global inclusive fashion market is expected to be worth upwards of $390 billion in 2026 [2]. Hence, a need arises to study and research in detail what adaptive clothing is, how it helps the end user to live a dignified life. Also, what all the fashion brands are there which are putting their efforts into designing functional and fashionable adaptive clothing and tapping this less tapped market. Before designing clothing for special needs, it's important to understand their needs and to empathise with problems faced by the end user in executing various functions.

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1.1 Disability

People with special needs, differently abled people, and people with disabilities are various terms used synonymously to describe the set of people who have a deformity in one or more part of their body. As per the World Bank's data, over 15% of the world's population have some form of disability [3]. There can be different kinds of disabilities, like locomotor disability, blindness, autism spectrum disorder, Parkinson's disease etc [4]. Various clothing needs arise due to different kinds of disabilities which need to be studied individually with the utmost empathy and dealt with very sensitively while designing clothing for each disability.

2. Problems faced by people with disabilities

As per reported studies, people with disabilities have increased

Dependence on caregiver for dressing and undressing, they want to appear normal and same as other people of their age. They also feel discomfort with clothing and medical equipment [5, 6]. Apart from that, they may also face problems like skin irritation, rashes, bed sores etc while using the garment, due to poor fabric quality or poor garment design. Table 1 demonstrates various clothing issues faced by the people affected by various disabilities [7].

Table 1, Disabilities and their clothing issues

Disability	Clothing issues
Amputees	· Disfigurement is always visible and this can have varying psychological effects on the individual.
Arthritis	· Have difficulty in getting dressed a nd undressed · Fastenings on shoes and stockings cause difficulty

Disability	Clothing issues
Spinal Injuries	· Unable to dress by themselves · Need to be kept warm · Non-absorbent, synthetic fibres must be avoided. · Seams must be carefully positioned to avoid pressure sores.
Spina Bifida	· Fastenings may cause a problem for some people. · Need to be kept warm · Safety is a primary requirement for clothing. · Difficulties in shape and proportion · Easy access need for incontinence pads and appliances
Dwarfing disease	· Figures can be small but in proportion or have short arms and legs in relation to body size. · Have difficulty in finding clothing to suit their age
Cerebral palsy	· Unable to dress by themselves · Shape problems can arise from the rigid limbs of the spastic and floppy posture of the athetoid.
Strokes	· Dressing is slow and frustrating process. · Fastenings cause difficulty. · Fabric should be easy to care for to assist independence
Scoliosis and Kyphosis	· Need to be kept warm. · Fit garment to a brace rather than to a person. · Detract the eye away from the appliance because the main clothing problem is to get garments to hang properly. · Wear and tear problems

3. Adaptive clothing

People with disability like to wear garments that adequately hide their disability to increase their likelihood of getting accepted by others and leading to increased engagement in social activities [5, 8].

Adaptive clothing, garments and footwear are specially designed for people with physical disabilities and post-surgery patients who may have difficulties dressing themselves due to the inability to manipulate closures such as buttons, zippers, or due to a lack of a full range of motion required for self-dressing [8]. In other words, adaptive clothing is a term used for clothing for people with various needs and is especially designed to cater to the needs of disabled people and significantly reduces their dependency on others. The well-designed adaptive clothing can reduce the risk of pressure ulcers in bedridden patients and can prevent back and shoulder injuries and skin irritation [9].

Moreover, adaptive clothing also refers to clothing designed for people facing difficulty wearing usual clothing due to lack of mobility or ageing [10]. As per studies, for those managing health conditions, adaptive clothing can make a significant and appreciated difference in quality of life simply by making dressing less difficult.

3.1 Features of adaptive clothing

The major problems arise out of using normal clothing are soreness, dress being too long and hanging near the wheels or brakes of a wheelchair. The use of regular clothing could bring several disadvantages to a disabled individual as per Langtree [8].

Adaptive clothing can be designed by suitably incorporating one or more features into the clothing. Some of the commonly used features based on review of literature are listed below:

- Replacing buttons with zippers, velcro, magnetic button
- Opening in centre back for ease of wearing
- Flat seams to prevent skin irritation to facilitate incontinence aids
- Longer length in the back to accommodate people sitting in wheelchairs,
- a stretchy waist for added comfort and safety
- special seams, fabrics and closures [11]

Adaptive clothing should be designed with specialized garment pattern, seams and closures, easy to operate fastners and trims and appropriately accommodate mechanism [5].

Examples of adaptive clothing include open back shirts, easy snap pants and wrap-around skirts and dresses for women, extra wide slippers and shoes etc.

The currently available adaptive clothing is majorly functional with less attention on fashion style and the garment provides a casual look [12]. It was found that people did not wear adaptive clothing if they were not hiding physical disability or not stylish enough [13]. Well-designed adaptive clothing that is fashionable can boost self-esteem; it should show off the good points and conceal the disability without having to compromise with the fashion quotient of the wearer. The adaptive clothing should be adequately durable to resist wear and tear and affordable to all affected people. Moreover, it should be convenient to put on and take off with long openings and minimum fasteners [14]. Various factors to consider while designing adaptive clothing could be aesthetic, comfort, protection, ease of movement, easy access, quality, fit, wear and tear, shopping facilities etc [15].

3.2 Global brands in adaptive clothing

There are some brands globally that are striving to offer functional adaptive clothing lines. They design classical styles ensuring a life of comfort for people with disabilities for a more inclusive society. The major brands making a mark in the market for adaptive clothing are mentioned below:

3.2.1 Tommy Hilfiger: It is the first fashion brand to have an adaptive clothing line for children, men and women. The major feature of Tommy Hilfiger is that it designs inclusive clothing for people with special needs, having minimalistic designs and maintaining Tommy Hilfiger stripes and logos. It incorporates velcro fastenings, wrist loops for easier pull-on and wear, pants with larger leg openings to accommodate braces and orthotics, seams that open to accommodate prosthetics, and magnetic zippers that can be fastened with one hand. Various clothing styles designed include jackets, dresses, shirts, t-shirts, pants etc [16].

3.2.2 Target: Use of extra-soft cotton fabrics, flat seams, no-tags, high-rise fleece pants in larger sizes to hide diapers, and hidden openings for abdominal access are important features of Target kids' clothing line. Styles like jackets with zip-off sleeves, footless pajamas with snap-tops, soft tees and tops with trendy graphics, diaper-accessible leggings are available for differently-abled children [17].
There are even wheelchair-friendly open-in-the-back jackets, which will make getting dressed so much easier for affected kids.

3.2.3 Silvert's: Silverts has launched adaptive clothing for seniors, elderly and people with disabilities. The clothing line includes aesthetically pleasing mobility-friendly blouses and sweaters and wheelchair-friendly pants and footwear [18].

3.2.4 Reboundwear: The brand reboundwear is known for its super soft, easy to take on and off features, and addresses everything from wound sites to surgical ports due to its multi-zipper designs.

3.2.5 Slick Chicks: It is amongst innovative adaptive clothing brands. They offer inner clothing in a variety of styles and the essential colors of black, beige, and white having side-fitting features. Slick Chicks is a patented adaptive underwear that is designed to empower people with a disability or physical challenge. They feature hook-and-eye fasteners at the waistband, so anyone can seamlessly transition in and out of their clothing, regardless of their physical situation.

Other adaptive clothing brands for men, women and children are Optivus, Bealies Adaptive Wear, Unhidden, Able2wear etc [19]. Table 2 explains some adaptive clothing items with their features from different brands' websites.

Table 2 Adaptive products with their features by various brands

Product Image	Product Features
	• Regular Fit adapted for seated wear. • VELCRO® brand closure at wearer's right side seam [16]
	• Stretchy pant waistband for ease of dressing and comfort • Easy touch openings at the lower leg accommodate casts, boots and reduced mobility • Easy grip loops, 1 on each outer side of the waistband for easy pull on and off • Pants zip off below the knee • Handy pockets to store belonging [17]
	• Women's Snap Front Closure Bra • Easy front closure design with plastic snaps, • Elastic bottom band • Light and breathable polyester spandex fabric [17]
	• Secured with Snaps at Shoulders • No Pressure Points - Strategically Placed Shoulder Snaps Eliminate Pressure Points • Complete Dignity - Full Back Overlap [17]
	• Three strategically placed 2-way zipper openings at the shoulders and center front. • Helpful for those with limited mobility. • Great for shoulder surgery recovery. • Provides easy access for heart monitors, ports, and infusions.
	• Drop front access trouser • Don't have zips or buttons • With a standard higher back and shaped seat style comfortable • Velcro fastening are easy to manage

3.3 Indian brands in Adaptive clothing

Adaptive clothing has a huge scope in the Indian market as there are very few brands catering to a few disabilities at present and adaptive wear is hardly available in physical stores. Even the existing brands are at a very nascent stage, often inspired by the disability of some family member or someone closely related. Some brands dedicated to producing adaptive clothing are given below:

3.3.1 Suvastra Designs: Suvastra Designs, founded by Shalini Visakan, from Chennai, designs inclusive clothing for both persons with and without disabilities. She has designed shirts with magnetic buttons and pants with Velcro for wheelchair bound people, a one-piece saree for ageing and wheelchair bound women ladies. It designs especially long crotches to accommodate adult diapers and attaches bigger loops to zippers for ease with fingers. She has used cotton and linen fabric for designing her indo-western collection.

Some other Indian brands catering to elderly and people with special abilities are Aaraam Se by Ashima Bhan, Move Ability by Joe Ikareth and Zyenka etc [2].

4. Conclusion

Adaptive clothing not only eliminates the discomfort associated with wearing normal clothing but also makes the differently abled people an integral part of mainstream society. At the same time, functional and fashionable adaptive clothing enables people to live with dignity and confidence. There is still huge scope and potential for the adaptive clothing market as there are few players available in this segment. The designers first need to study the wide range of problems arising in carrying out the different activities by people affected with specific disability. Moreover, the user-friendly adaptive clothing needs to be designed and manufactured in various styles, colours and breathable fabrics etc to promote inclusivity in fashion industry. This study was conducted to suggest the various research opportunities available in this important clothing segment.

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APPAREL

Apparel Store Patronage: Effect of Bargain Behaviour, Complaint Behaviour and in-Store Vulnerability of Consumers

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Abstract

Background: Store choice and patronage patterns are based on consumer's perceptions, images, and attitudes formed from experiences, information, and need. Furthermore, patronage behaviour involves a decision process related to where consumers shop, how they shop, and what they purchase. This decision process is often initiated by patronage motives, which determine why consumers shop and make purchases at certain retail stores. The personal behaviour of consumers like bargain behaviour, complaint behaviour and in-store vulnerability will have impact on the purchase process and its related apparel store patronage behaviour.

Methods: This paper focuses on the effect of bargain, behaviour, complaint behaviour and in-store vulnerability behaviour of consumers on apparel store patronage behaviour. Data was collected from the sample of 220 respondents using a structured questionnaire.

Result & Conclusion: The regression analysis shows that bargain behaviour and complaint behaviour has significant negative effect on the apparel store patronage where as in-store vulnerability has no significant effect on the apparel store patronage. Based on the findings managerial implications for the apparel retailers have been discussed.

Keywords: *Apparel, bargain behaviour, complaint behaviour, consumers, in-store vulnerability behaviour, store patronage*

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1. Introduction

The Indian retailing industry is moving towards the phase of organized retailing from the phase of unorganized retailing over the past two decades [1]. The Indian apparel industry has undergone a major overhaul because of the emergence of organized retailing which has brought a change in the shopping behaviour of many people and it is now more appealing to young consumers [2]. Moreover, the economic status of the consumers is growing consistently time to time which lead to the increase in needs, desires and demands. At the same time, the competition is also growing within the industry because of the large number of players entering the markets both from national and international levels [3]. These changes in the business environment directly influence the overall lifestyle and behaviour of the people during their purchase process and its related decisions like store selection, store patronage etc.

Store choice and patronage patterns are based on consumer's perceptions, images, and attitudes formed from experiences, information, and need. Furthermore, patronage behaviour involves a decision process related to where consumers shop, how they shop, and what they purchase [4]. This decision process is often initiated by patronage motives, which determine why consumers shop and make purchases at certain retail stores [5]. The personal behaviour of consumers like bargain behaviour, complaint behaviour and in-store vulnerability will have impact on the purchase process and its related apparel store patronage behaviour.

With the presence of many players in the field of apparel retailing, the retailers want to know the growth prospects of the market so that they can be able to make their long-term strategic plan, based on apparel store patronage of consumers. The bargain behaviour, complaint behaviour and in-store vulnerability are the personal behaviour of the consumers and these behaviours will have an impact on the buying behaviour of the consumers. Particularly in case of apparel buying, most of the consumers are very much involved and spent considerable amount of time and money to purchase apparel products. During this process consumers tend to bargain for the price, complain if there is any problem with the product or service and vulnerable if there is any delay etc. These behaviours will have impact on the buying behaviour and also the degree of patronage towards the apparel store. So it is intended to study the effect of bargain behaviour, complaint behaviour and in-store vulnerability of the consumers on apparel store patronage.

2. Materials and Methods

2.1 Consumer Behaviour

Consumer behaviour which was earlier termed as 'overt behaviour' is a continuous consumption process related to pre-purchase, purchase and post purchase issues. According to [6] consumer behaviour is the study of human or consumer responses to products, services, and the marketing of products and services. Consumer behaviour is dynamic because the thinking, feelings and action of individual consumers, targeted consumer groups and society at large are constantly changing [7]. For example the Internet has

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changed the way people search for information about products and services. The fact, consumers and their environments are constantly changing highlights the importance of ongoing consumer research and analysis by marketers to keep abreast of important trends. The dynamic nature of consumer behaviour makes development of marketing strategies an exciting and yet difficult task. Strategies that work at one time or in one market may fail miserably at other times or in other markets [6]. During the purchase process consumers exhibit certain kind of behaviours which includes bargain behaviour, complaint behaviour, in-store vulnerability behaviour etc., which have significant impact on the purchase decision, store selection and store patronage behaviour.

2.2 Bargain Behaviour

Bargaining is often an indispensable way to secure a deal during within-destination shopping. Negotiating a fair price, as a casual interpersonal interaction, is an important element of many tourists' transactions such as when purchasing souvenirs and local specialty products and services [8]. This is especially true in many less-developed destinations with loose market regulations [9]; thus, price negotiation has become the dominant means of price setting for tourists. The process generally begins with the seller asking a preposterous price, followed by the buyer trying his/her best to lower it until a compromise is reached. China's cultural environment and less-regulated market have conditioned consumers to exhibit high bargaining intention when purchasing from vendors [10].

Negotiation is a frequently invoked mechanism for resolving conflicts between individuals or representative of groups and buyer-seller negotiation tasks are used with integrative potentials to examine the influence of conflict management styles on negotiation behaviour and on subsequent outcomes [11]. The result shows that negotiation behaviour has a positive influence on outcome. Few authors in their study on female apparel consumers discussed that the apparel shopper will involve in extensive bargaining [4]. Some authors also used bargain – consciousness variable in her study on apparel shopping behaviour [12]. Compared to mainstream tourism shopping research, some scholars have paid special attention to tourists' bargaining behaviour in particular [9, 13]. In the context of tourism, bargaining over price is a traditional form and social protocol of shopping in many African, Middle Eastern, and Asian destinations, where the rules of economic structure are not well established [9].

2.3 Complaint Behaviour

There are many suggestions of why customers complain, but a common understanding is that CCB occurs when the customer is dissatisfied [14]. Some studies brief that if a consumer is not happy with a product or service, he/she could make three different courses of action – i) the consumer can complain directly to the retailer for refund or exchange by either speaking or writing to the store manager, ii) the consumer can express dissatisfaction about the store or product to friends or others and/or boycott the store, iii) the consumer can take legal action against the store [15].

Shoppers who get their problems resolved feel even better about the store than if nothing had gone wrong [16]. If the consumer does not believe that the store will respond well to a complaint, the person will be more likely to simply switch than fight [17]. People more likely spread the word about unresolved negative experiences to their friends than they are to boast about positive occurrences.

Complaints do not always occur from dissatisfaction [18]. In addition, individuals may deal with dissatisfaction differently and the choice of action is depending on the cost and benefit factors, which are further discussed. Few studies further clarify that a customer may choose to complain when an acquired product or service is defective or contains a deficiency [19]. Previous studies also stress that the likelihood for a customer to complain is dependent on the situation such as the constructs of ease of complaining [20, 21] including chances of success in complaining and complaint self-efficacy [22, 23].

2.4 In-Store Vulnerability

Many marketing and consumer behaviour scholars desire to make consumer behaviour research relevant to public policy by exploring consumer vulnerability. Such an approach is generally consistent with the court vulnerability [24]. Several scholars find that the courts generally define vulnerable consumers as those whose distinctive sensitiveness have contributed to their product–related injuries [25]. A consumer-situation typology of vulnerable consumers is includes four consumer groups that are physical sensitivity, physical competency, mental competency and sophistication level and five situational alternatives (material environment, decision maker, consumption interval, usage definition, and temporary condition). This typology illustrates that consumer vulnerability arises from the interaction of a person and all of his or her personal characteristics with a consumption situation.

Vulnerability is a state of powerlessness that arises from an imbalance in market place interactions or from the consumptions of marketing messages and products [24]. It occurs when control is not in an individual's hands creating a dependence on external factors (e.g., marketers) to create fairness in market place. The actual vulnerability arises from the interactions of individual states, individual characteristics, and external conditions within a context where consumption goals may be hindered and the experiences affects personal and social perceptions of self. Looking across studies provides evidence that both internal and external factors contribute to consumer vulnerability. Internal factors that contribute to vulnerability are fear, patterns of contact, disability, addiction, race/ethnicity, persuasion attempts, perception of appearance, mood, stress etc. External conditions that contribute to vulnerability are social problem, stigmatization, and repression, discrimination, and resource distribution [24].

2.5 Apparel Store Patronage

Haynes et al., (1994) define patronage as how individuals choose an outlet for shopping. Store choice and patronage patterns are based on consumer's perceptions, images, and

attitudes formed from experiences, information, and need [26]. Furthermore, patronage behaviour involves a decision process related to where consumers shop, how they shop, and what they purchase. This decision process is often initiated by patronage motives, which determine why consumers shop and make purchases at certain retail stores [27]. Store patronage involves the consumer's choice for a particular retail store [28]. Few studies suggested that consumers form a set of beliefs about a store, on the basis of which they decide whether it is the type of shopping environment that appeals to them, creating store patronage intention [29].

The retail patronage behaviour concept includes the possibility of buying at the store, revisiting the store and recommending it to others [23, 30]. Few studies proposed that value perceptions, which influence consumer purchasing decisions, are based on perceptions of product quality (what consumers get) and price (the monetary and non-monetary aspects) [31]. One study proposed a model in which store environmental dimensions (social, design, ambient factors) influence consumer perceptions of store choice criteria (interpersonal service quality, merchandise quality, monetary price, time/effort cost and psychic cost) which affect store patronage intentions [24]. Some scholars tested a model in which store attributes (product-related, service quality-related, and store-related attributes) are significantly related to consumer satisfaction, which in turn influences retail patronage behaviour [32]. To identify the antecedents of retail patronage, few researchers conducted a meta-analysis, showing that retail patronage is determined by assortment and quality of merchandise, services, store atmosphere, low price level, fast check-out, shop opening hours, friendliness of store personnel, parking facilities and store convenience [30].

2.6 Methods

2.6.1 Research Model

The research model is depicted in Figure 3.1. The three independent variables of the study were: bargain behaviour, complaint behaviour and in-store vulnerability. The dependent variable of the research was apparel store patronage. The purpose of this study was to examine the relationship among the independent variables and also the effect of between independent variables on the dependent variable.

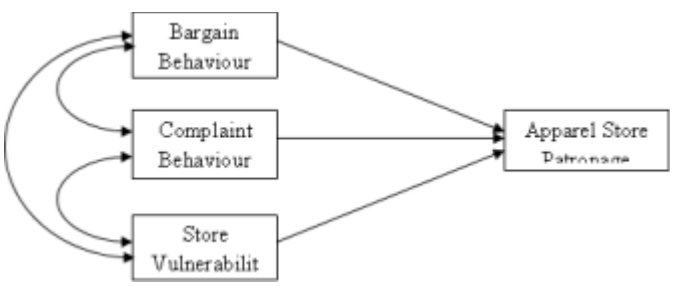

Figure 1 - Research Model

2.6.2 Research Questions

Based on the discussions in the literature review the research questions of this study are as follows:

1. What is the correlation between bargain behaviour, complaint behaviour and in-store vulnerability?
2. What is the effect of bargain behaviour on the apparel store patronage?
3. What is the effect of complaint behaviour on the apparel store patronage?
4. What is the effect of in-store vulnerability on the apparel store patronage?

2.6.3 Research Hypotheses

Based on the research questions the following hypotheses were framed for this study:

H1: The bargain behaviour of the consumers has positive correlation with complaint behaviour.

H2: The bargain behaviour of the consumers has negative correlation with vulnerability behaviour.

H3: The complaint behaviour of the consumers has negative correlation with vulnerability behaviour.

H4: The bargain behaviour of the consumers is negatively related to the apparel store patronage of the consumers

H5: The complaint behaviour of the consumers is negatively related to the apparel store patronage of the consumers

H6: The vulnerability behaviour of the consumers is negatively related to the apparel store patronage of the consumers

2.6.4 Sampling Methods

The research design selected for this study is both descriptive and exploratory study. Non- random sampling and convenience sampling method was adopted for the study. The study was conducted major cities in the state of Kerala, India. They were Kannur, Ernakulam, Kollam, Kottayam, Kozhikode, and Thiruvananthapuram. These cities cover the major population of the consumers, which represents the population of Kerala. The respondents were the customers of apparel and the respondents were selected on the basis of non random sampling and convenience sampling which means that the customers who were willing to respond to the questionnaire were selected. The sample of this study was 220. From each city 40 sample respondents were selected and a total of 240 questionnaires were collected. Out of 240 questionnaires, 20 questionnaires were incomplete and only 220 questionnaires can be usable. So the sample size was arrived to 220.

2.6.5 Questionnaire Development

A structured questionnaire was designed to collect data for this research. There were three parts of the questionnaire in this study. Part I of the questionnaire covered respondents' demographic factors of age, gender, education, occupation,

marital status, and amount spent for apparel purchase per year. Part II of the questionnaire covered independent variables bargain behaviour, complaint behaviour, and In-store vulnerability. The variable bargain behaviour was measured using 2 items; the variable complaint behaviour was measured using 2 items and the variable in-store vulnerability was measured using 3 items. Part III of the questionnaire covered dependent variable Apparel Store Patronage which was measured using 3 items. All the 10 items in the questionnaire were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

3. Data analysis and interpretation

3.1 Demographic Descriptive

The demographics of this study reveals that the predominant consumer respondents from the sample of 220 respondents were female (n= 139, 62.2%), and age group up to 25 years (n = 178, 80.9%). There were undergraduates (n = 109, 42.9%) and students (n = 122, 55.5%). 181 respondents (82.3%) were single, unmarried. About 95 (43.2%) respondents were reported that their average amount spent for apparel purchase per year was between Rs. 2001 – 4000.

Table 1: Demographic Descriptive

S. No.		No. of Respondents	Percentage of Respondents
Gender	Male	81	36.8
	Female	139	63.2
	Total	**220**	**100**
Age	Upto 25 yrs	178	80.9
	26 - 35 yrs	28	12.7
	36 - 45 yrs	11	5
	Above 46 yrs	3	1.4
	Total	**220**	**100**
Education	Upto HSC	1	0.5
	Diploma	17	7.7
	UG	109	49.5
	PG	80	36.4
	Above PG	13	5.9
	Total	**220**	**100**
Occupation	Student	122	55.5
	Business	12	5.5
	Employee	75	34.1
	Others	11	5
	Total	**220**	**100**
Marital Status	Single	181	82.3
	Married	39	17.7
	Total	**220**	**100**
Amount Spent on Apparel Purchase	Up to 2000	49	22.3
	2001 - 4000	95	43.2
	Above 4000	76	34.5
	Total	**220**	**100**

Source: Primary Data

3.2 Correlation Analysis

Table 2: Correlation between Bargain Behaviour, Complaint Behaviour and In-store Vulnerability

S. No	Variable	1	2	3
1	Bargain Behaviour	1		
2	Complaint Behaviour	.076*	1	
3	In-store vulnerability	.04	.189**	1

Source: Primary Data; ** Pearson Correlation is significant at the p < 0.01 level

Table 2 presents correlations among the Bargain Behaviour, Complaint Behaviour and In-store Vulnerability. The variable 'Bargain Behaviour' has significant positive relationship at 5% level with variables Complaint Behaviour ($r = .076$, $p < .05$). This findings are supports hypothesis 1 i.e. bargain behaviour of the consumers has positive correlation with complaint behaviour. So, hypothesis H1 is supported.

Bargain Behaviour has no correlation with the variable In-store vulnerability ($r = .04$, $p > .01$). This finding do not support hypothesis 2 i.e. bargain behaviour of the consumers has positive correlation with vulnerability behaviour. So hypothesis H2 is not supported. The variable 'Complaint Behaviour' has significant positive relationship at 1% level with the variable In-store vulnerability ($r = .189$, $p < .01$). This finding support hypothesis 3 i.e. complaint behaviour of the consumers has positive correlation with vulnerability behaviour. So, hypothesis H3 is supported.

3.3 Regression Analysis

3.3.1 Simple Regression: Independent variables and Apparel Store Patronage

The simple linear regression analysis was conducted to examine the hypotheses, H4: The bargain behaviour of the consumers is negatively related to the apparel store patronage of the consumers; H5: The complaint behaviour of the consumers is negatively related to the apparel store patronage of the consumers and H6: The In-store vulnerability behaviour of the consumers is negatively related to the apparel store patronage of the consumers in the research model.

Table 3: Simple Regression- Independent Variables Vs Apparel Store Patronage

S.	Variables	B	β	t	Sig.
1	Bargain Behaviour > Apparel Store Patronage	-0.114	-0.116	-1.238	0.042
2	Complaint Behaviour > Apparel Store Patronage	-0.148	-0.161	-1.903	0.017
3	In-store vulnerability > Apparel Store Patronage	0.01	0.009	0.138	0.89

Source: Primary Data

The Table 3 presents the results of the simple linear regression analysis. When looking at the bargain behaviour, the result shows that the bargain behaviour had a significant negative effect (β= -0.116, t = -1.238, p < .05) on apparel store patronage. This evidence gave support for the hypothesis H4, The bargain behaviour of the consumers is negatively related to the apparel store patronage of the consumers. So, hypothesis H4 is supported.

The results for complaint behaviour shows the complaint behaviour had a significant negative effect (β= -0.161, t = -1.903, p < .05) on apparel store patronage. This evidence gave support for the hypothesis H5 i.e. The complaint behaviour of the consumers is negatively related to the apparel store patronage of the consumers. So, hypothesis H5 is supported.

The results for in-store vulnerability shows the in-store vulnerability had no significant effect (β= 0.009, t = .138, p > .05) on apparel store patronage. This evidence did not support hypothesis H6 i.e. The In-store vulnerability behaviour of the consumers is negatively related to the apparel store patronage of the consumers. So, hypothesis H6 is not supported.

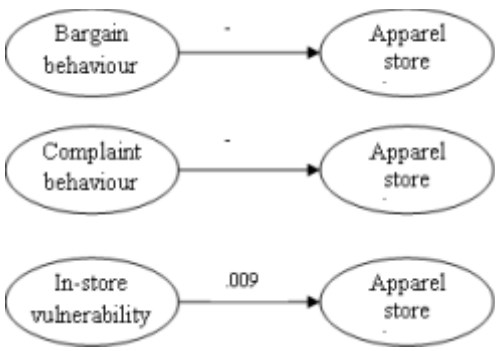

Figure 2: Simple Regression - Independent Variables Vs Apparel Store Patronage

3.3.2 Multiple Regression: Dependent Variable: Apparel Store Patronage

Table 4: Multiple Regression- Apparel Store Patronage

S. No	Variables	B	β	t	Sig.
1	Bargain Behaviour	-0.118	-0.122	-1.29	0.042
2	Complaint Behaviour	-0.149	-0.161	-1.904	0.027
3	In-store vulnerability	.0007	0.000	.001	0.999
4	Constant	3.256		8.964	.000

The multiple linear regression analysis was conducted to examine the combined effect of independent variables on the apparel store patronage and test the hypotheses, H4: The bargain behaviour of the consumers is negatively related to the apparel store patronage of the consumers; H5: The complaint behaviour of the consumers is negatively related to the apparel store patronage of the consumers and H6: The In-store vulnerability behaviour of the consumers is negatively related to the apparel store patronage of the consumers in the research model.

The Table 4 presents the results of the multiple linear regression analysis. When looking at the bargain behaviour, the result shows that the bargain behaviour had a significant negative effect (β= -0.122, t = -1.29, p < .05) on apparel store patronage. This evidence gave support for the hypothesis H4, The bargain behaviour of the consumers is negatively related to the apparel store patronage of the consumers. So, hypothesis H4 is supported.

The results for complaint behaviour shows the complaint behaviour had a significant negative effect (β= -0.161, t = -1.904, p < .05) on apparel store patronage. This evidence gave support for the hypothesis H5 i.e. The complaint behaviour of the consumers is negatively related to the apparel store patronage of the consumers. So, hypothesis H5 is supported.

The results for in-store vulnerability shows the in-store vulnerability had no significant effect (β= 0.000, t = .001, p > .05) on apparel store patronage. This evidence did not support hypothesis H6 i.e. The In-store vulnerability behaviour of the consumers is negatively related to the apparel store patronage of the consumers. So, hypothesis H6 is not supported.

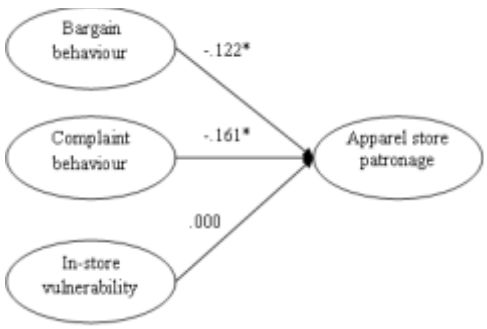

Figure 3: Multiple Regression- Independent Variables Vs Apparel Store Patronage

4. Discussions and implications

The purpose of this study was to examine the effect of bargain behaviour, complaint behaviour, in-store vulnerability on the apparel store patronage of the consumers. This chapter summarises demographics and hypotheses findings, discusses implications of findings and poses scope of future research.

The findings of bargain behaviour reveal that the majority of the consumers are very much interested in bargaining while purchasing apparel. This is an interesting finding that the apparel retailers should make note. The apparel retailers particularly organised retailers who sell apparel at fixed price should provide some bargaining component or section in their sales strategy or in their store. Moreover, the bargain behaviour has positive correlation with complaint behaviour which means that the consumers who have higher bargain behaviour tend to complain more in that way if the retail store gives some good bargaining offers to consumers then the chances of complaints from the consumers may be reduced. Also, as the bargain behaviour has negative impact on the apparel store patronage which means that the consumers who

are not satisfied with the bargaining do not develop store patronage. So if the apparel store provides some bargaining component in their sales strategy then the chances of developing the apparel store patronage among the consumers are more.

The findings of complaint behaviour reveal that the majority of the consumers have complaint behaviour if there is a problem while purchasing apparel. So the apparel retailers should take care that both the apparel products what they sell and the service what they provide should satisfy the consumers. The complaint behaviour has a positive correlation with the in-store vulnerability which means that if there is a delay in service or too much persuasion from the sales persons, then the consumers to become vulnerable and this will increase the complaint behaviour. The complaint behaviour has negative effect on the apparel store patronage, which means that the higher the complaint behaviour then there will be a decrease in the degree of the apparel store patronage. So the apparel retail stores should take enough steps to satisfy the consumers through various customer relationship strategies so that the complaints of the consumers can be reduced.

The findings for in-store vulnerability reveal that the majority of the consumers have in-store vulnerability behaviour which means that if there is delay in service or too much sales persuasion then the consumers become vulnerable. So the apparel retail stores should ensure the prompt services and also to instruct their sales people not to persuade the consumers too much.

The findings for apparel store patronage reveal that the consumers are having patronage behaviour towards the apparel stores. This is a good opportunity for the apparel retailers to come up with various strategies to make the consumers to have a very good patronage with their stores. Besides the other factors, if the apparel retail stores can take care of the bargain interest, complaint nature and in-store vulnerability of the consumers then there will be higher chances of increased store patronage by the consumers.

5. Conclusion

The present research work has led the researcher to have a good understanding on the effect of bargain behaviour, complaint behaviour, and in-store vulnerability on the apparel store patronage of the consumers. The various facts of the study have been presented in this report in appropriate places. The outcome of this research would provide the apparel retailers about the changing dynamics in the apparel store patronage of the consumers in the near future, with respect to their bargain behaviour, complaint behaviour, and in-store vulnerability and other related factors. These would further act as guidelines for the retailing strategies such as product differentiation, quality enhancement, value for money, and promotional mix. The finding of this study indicates that the proposed model worked well for the apparel retailing. The proposed model can be used to test the store patronage for other retail products. Such future studies on testing the model in various retail products may increase the robustness of the model explaining storage patronage behaviour in various retail environments. In this study the focus is given on the store patronage of the apparel retail store, in future this model can be tested for store patronage in online and other retail formats. The ethnicity of the consumers may have substantial impact on the apparel store patronage, so in future this model may be tested toward different ethnicities.

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Journal of the TEXTILE Association

DYEING

Effect of Comparative Study on Chiffon and Crinkled Woven Materials using Selected Natural Dyes

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Abstract

Natural dyes are biodegradable, non-toxic and non-allergenic. They are processed in a way that avoids the use of harmful chemicals during the dyeing and finishing process. They have a much lower environmental impact than synthetic dyes. As of natural origin, natural dyes are not harmful to the environment. This makes it very appealing to the consumers. Natural dyestuffs produce rare colour ideas and are automatically harmonizing. This research was focused on to impart the selected natural dyes to Chiffon and Crinkled cotton woven materials. The shades obtained were effective and had good mechanical and colour fastness. When subjected to antimicrobial tests for antibacterial and antifungal had exhibited excellent zones of inhibition.

Keywords: *antibacterial, antifungal, chiffon, crinkled, natural dyes*

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1. Introduction

In nature, the fruit, flower and leaf of plants show various colour from red to purple and contain various natural dyes which can be extracted by simple procedure. Natural dyes can be barted into three categories: natural dyes obtained from plants, animals and minerals [1]. Natural dyes possess positive attributes such as soft and lustrous colours to the textile dyeing. Many of the plants used for dye extraction are classified as medicinal and some of these have recently been shown to possess remarkable antimicrobial activity [2]. It is possible to obtain a full range of colours using various mordants. That natural dyes, on the other hand are usually less intense and more prone to bleaching due to mechanical impact, washing or UV irradiation [3]. It is scientifically evaluated for anti-inflammatory, antipyretic, analgesic, larvicidal, insecticidal, antimicrobial, anxiolytic, antidepressant, hepatoprotective, tranquilizing and sedative property. Roots, seeds and leaves of C. ternatea are commonly used in the ayurvedic system of medicine extracts of this plant have been used as an ingredient in the "Ayurvedic Medhya Rasayana" as a rejuvenating recipe used for treatment of neurological disorders and are considered so enhance the intellect [4]. Tecoma Stans is a naturalized in tropical and subtropical areas of Africa, Asia and Oceanica. The entire palm possesses medicinal value and used for the treatment of various ailments. Its fast growth and propagation rates cause it to be regarded as an invasive tree like those in South Africa a Nambia [5]. Tea plant (Camellia sinensis L.) is a source of tea brew which is a very refreshing and popular drink in the world that is defined as the hot aqueous infusion of dried leaves. The flavones present in tea infusions, also called catechins, constitute as much as 20–30% of tea's dry matter. Terminalia chebula is called the 'King of Medicine' in Tibet and is always listed at the top of the list in Ayur-vedic Materia Medica due to its extraordinary power of healing [6].

It has enjoyed the prime place among medicinal herbs in India ancient times. T. Chebula (fruit) (myrobalan) is one of the most popular Persian herbs used to improve memory function and fruit of T. chebula contains antioxidant ingredients, including ascorbic acid and quercetin, which are effective against oxidative stress-induced neurodegeneration [7]. Antibacterial activity of Terminalia chebula extracts against severe bacterial strain is reported in extracts from different parts of diverse plant species of plants like roots, flower, leaves, seeds etc [8]. Eucalyptus is a fast-growing evergreen tree native to Australia an ingredient in many products, it is used to reduce symptoms of coughs, colds, and congestion. It also features in creams and ointments aimed at relieving muscle and joint pain. Almost every part of this plant has medicinal properties [9].

Cotton fiber is the most important natural fiber used in the textile industry. Cotton known as "The king of Fibres" continues to be the predominant fibre in the Indian textile decent, despite stiff competition from the man-made synthetic fibres [10]. The cotton fiber is made up of countless cellulose molecules. Cotton fibers are natural hollow fibers; they are soft and cool known as breathable and absorbent [11]. Chiffon has a lightweight texture and a semi-mesh weave which is what gives the fabric a chic transparent appearance, as well as making it slightly rough to the touch. Many sheer fabrics are fragile, thin, and delicate; thus, seam slippage is a frequent problem that occurs in the seam line of sewn garments [12]. Crinkle cotton is a soft and stretchy fabric that has been treated to have a lasting textured, wrinkly look. Crinkles in woven fabric as wrinkled from being a part of potential aesthetic interest to the fashion or mass-market garment industry, can be used as a detection and response mechanism in high performance garments [13].

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2. Methodology

The methodology of the project comprises the following steps:

2.1 Selection of Fabric

Chiffon fabric (CHº) is sheer, which means that it is light and semi-transparent with a simple weave warp and weft are the two basic components used in weaving to turn thread or yarn into fabric. It is made by passing each filling yarn, over and under each yarn, with each row alternating, producing a high number of intersections. It has the highest number of interlacing as compared with other weaves and therefore it produces the firmest fabrics or some of the most durable fabrics are made in this construction [14]. Crinkled fabric (CRº) is a multi-layer woven fabric consists of at least two layers, which are woven one above the other and stitched together. The investigator selected Chiffon cloth (CHº) and Crinkled cloth (CRº) for the study.

2.2 Selection of Dye and Mordant

Natural dyes and their use in dyeing is probably the most ancient art environmentally friendly substitute for synthetic, non-toxic and an alternative to synthetic dyes that are causing irreversible damage to the planets. A mordant is any substance which can be fixed to fabric and reacts with the dye to produce colours on fabric. So, Natural dye and Natural Mordants was selected for the study.

2.3 Selection of Natural Dyes

Clitoria ternatea L., the blue pea (Plate 1) flower has many functional properties like antidiabetic properties, anti-proliferative properties, antioxidant properties, antimicrobial properties and anticomplusive activity. Tecoma Stans (Plate 2) flowers showed anti-diabetic and anti-cancer activity while roots showed antibacterial activity. Camellia Sinensis (Fig.1) is produced by using young tea leaves and sold for consumption without fermentation after withering, steaming or pan firing, drying and grading. In addition, its content minerals and vitamins increase the anti-oxidant potential of this type of tea [15]. Hence Clitoria Ternatea (CT), Tecoma Stans (TS) and Camellia Sinensis (CS) were selected as natural dyes for study.

PLATE 1
CLITORIA TERNATEA

PLATE 2
TECOMA STANS

Fig. 1
CAMELLIA SINENSIS

PLATE 3
MYROBALAN

PLATE 4
EUCALYPTUS BARK

2.4 Selection of Natural Mordants

Myrobalan (M) (Plate 3) has chebulagic acid, tannic acid, corilangin, polyphenolic compounds, triterpenoids, and ascorbate, which found in the dried fruits can be ground into powder and used to produce a buttery yellow dye. Eucalyptus tree barks (Plate 4) fast-growing eucalyptus is one of the major promising cellulose feed stocks for ethanol production in the long term due to its high content of cellulose [16]. Myrobalan was dried in shade and powdered. Eucalyptus bark was taken, broken into pieces, powdered and kept ready for dyeing.

2.5 Selection of Dyeing Medium and Method of Dyeing

Aqueous medium and Fabric dyeing was selected for the study.

2.6 Pilot Study

A Pilot study was conducted for chiffon fabric (CHº) and crinkled cloth (CRº) using three natural dyes Ciltoria Ternatea, Tecoma Stans and Camellia Sinensis with two mordants Myrobalan and Eucalyptus bark.

2.6.1 Process and Dyeing Parameters for Pilot Study

In pilot study, two selected Chiffon cloth (CHº) and Crinkled cloth (CRº) woven fabrics were subjected to three selected Clitoria Ternatea (CT), Tecoma Stans (TS) and Camellia Sinensis (CS) 6% natural dyes with two Myrobalan (M) and Ecualyptus Bark (E) as natural mordants in selected 2%. The selected dyeing parameters for the pilot study of CTMCH, CTMCR, CTECH, CTECR, TSMCH, TSMCR , TSECH, TSECR, CSMCH, CSMCR, CSECH, and CSECR . This was subjected to natural dyeing using three mordanting techniques like pre, simultaneous and post mordanting which gave 18 samples CTMCHPR, CTMCHS, CTMCHPO, CTECHPR, CTECHS, CTECHPO, TSMCHPR, TSMCHS, TSMCHPO, TSECHPR, TSECHS, TSECHPO, CSMCHPR, CSMCHS, CSMCHPO, CSECHPR, CSECHS and CSECHPO in CHº and CTMCRPR, CTMCRS, CTMCRPO, CTECRPR, CTECRS, CTECRPO, TSMCRPR, TSMCRS, TSMCRPO, TSECRPR, TSECRS, TSECRPO, CSMCRPR, CSMCRS, CSMCRPO, CSECRPR, CSECRS and CSECRPO 18 samples in CRº which resulted in thirty six natural dyed samples for pilot study.

2.6.2 Selection of Natural Dyed Samples from Pilot Study

From pilot study two samples from natural dyed samples of TSM and two samples from CSE was selected based on the best shades of reproducibility as judged by 500 students from Chikkanna Government Arts College, Tiruppur by showing them the 36 natural dyed samples. The selected natural dyed samples for the study (Fig. 2) was from Post mordanting technique namely TSMCHPO, TSMCRPO, CSECHPO and CSECRPO for further study.

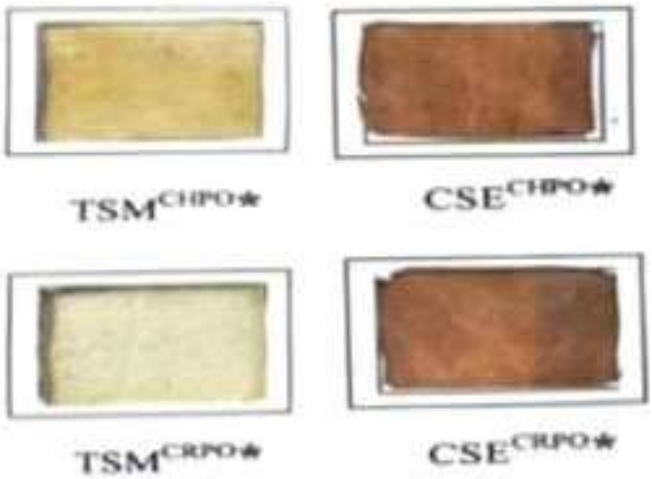


Figure 2: Selected samples for the Study

2.7 Preparation of Natural Dyes and Mordants

To dye CHº, CRº grey fabrics, with the selected post mordanting techniques for further study, desired grams of (6%) Tecoma Stans (TS) dye powder was taken and mixed with M:L ratio of 1:100 ml of water. This mixture was boiled for one and half-an-hour at 50ºC-60ºC temperature for extraction of the natural dye solution. The same process was followed to extract the Camellia Sinensis (CS) dye solution. When two Tecoma Stans and Camellia Sinensis natural dye solutions were ready, they were taken and kept in two separate baths for further process. For mordants preparation desired grams of Myrobalan (M) and Eucalyptus bark (E) powders of 2% each were taken and mixed in M:L ratio of 1:50 ml of water. This mordant mixture was boiled for half-an-hour at 50ºC-60ºC temperature for the extraction of mordant solution. The mordant solution is kept ready for further dyeing process. Thus, two Natural Dye baths of Tecoma Stans (TS) and Camellia Sinensis (CS) and two mordant baths of Myrobalan (M) and Eucalyptus bark (E) for post mordanting were kept ready for natural dyeing.

2.8 Natural Dyeing of CHo and CRo

The natural dye solutions 6% of Tecoma Stans (TS) and Camellia Sinensis (CS) were taken separately in two baths in M:L ratio of 1:50 for both Chiffon cloth (CHº) and Crinkled cloth (CRº) woven materials. The Chiffon cloth (CHº) and Crinkled cloth (CRº) woven materials which were pre-soaked in water for good absorbency were squeezed out, for excess water and steeped into the respective natural dye baths Tecoma Stans (TS) and Camellia Sinensis (CS), boiled for half-an-hour at 50ºC-60ºC temperature. After the desired time, the natural dyed CHº and CRº with Tecoma Stans (TS) and Camellia Sinensis (CS) were removed and partially dried.

Now, for the mordant baths, for post mordanting, 2% natural mordants Myrobalan (M) and Eucalyptus bark (E) bath solutions which are kept ready, to which each of the natural dyed CHº and CRº fabrics were steeped inside into the respective mordant baths and boiled for 30 minutes at 50ºC-65ºC temperature for natural post mordanting process in two separate dye baths. After the described time of post mordanting the dyed chiffon cloth and crinkled cloth materials were taken, rinsed in cold water and dried in shade. Thus four dyed fabrics TSMCHPO, TSMCRPO, CSECHPO and CSECRPO were obtained.

2.9 Evaluation

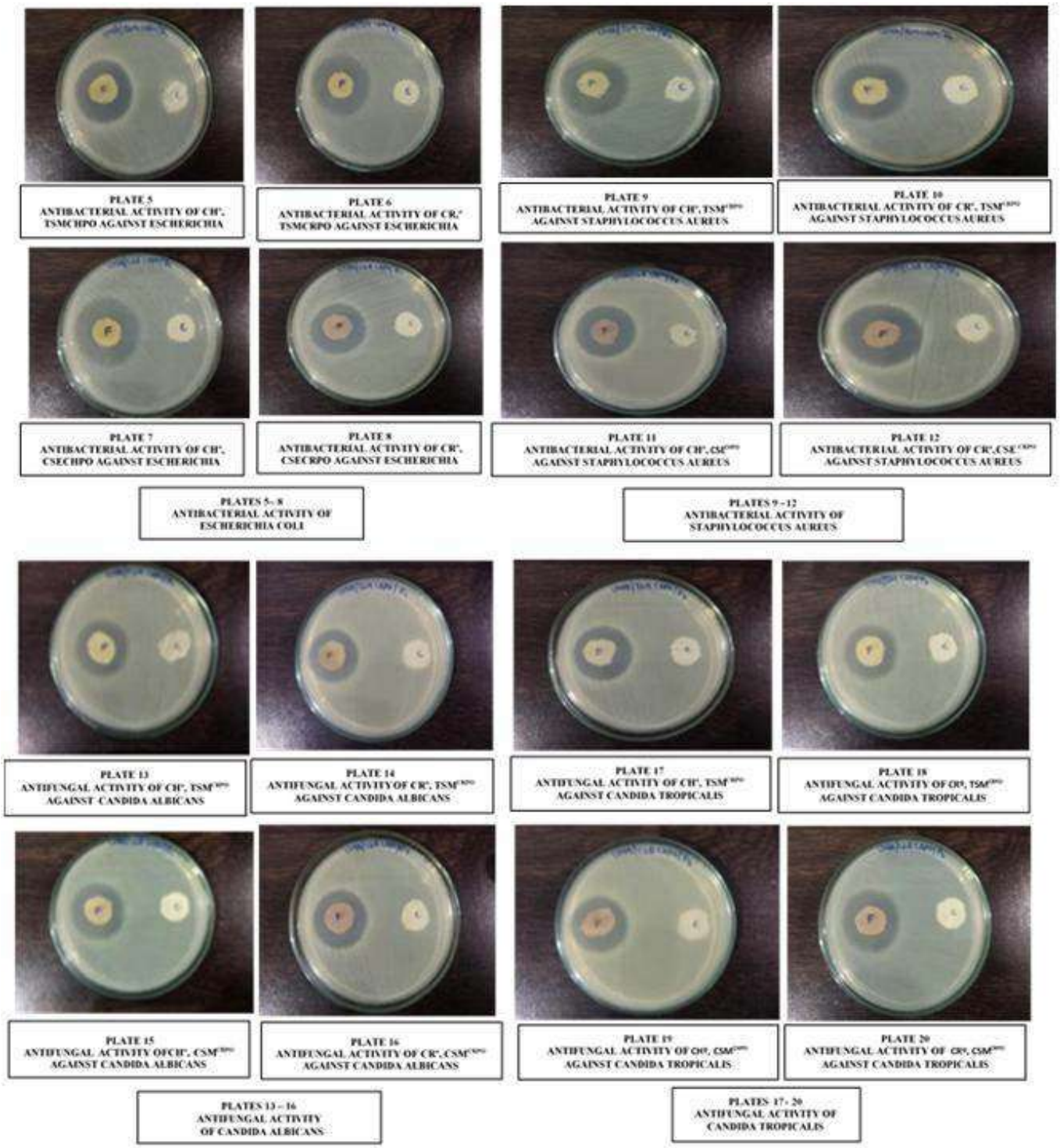
Evaluation was carried out both subjectively and objectively.

2.10 Fabric Tests

The fabric tests are subjected to the original chiffon cloth (CHº) and Crinkled (CRº) woven fabrics and natural dyed TSMCHPO, TSMCRPO, CSECHPO and CSECHPO fabrics for the following Fabric Weight, Fabric Thickness, Tensile Strength and Elongation, Stiffness, Crease recovery, Drape, Abrasion Resistance, Shrinkage, Water Absorbency such as Drop Test, Colour Fastness Tests to Sunlight, Washing, Crocking and Perspiration was done. Anti- Microbial tests such as Anti-Bacterial test and Anti-Fungal test was also carried out.

2.11 Anti-Microbial Tests

The four natural dyed TSMCHPO, TSMCRPO, CSECHPO and CSECHPO fabrics were subjected to Antibacterial and Antifungal Tests. Antimicrobial activity can be defined as a collective term for all active principles (agents) that inhibit the growth of bacteria, fungi prevent the formation of microbial colonies, and may destroy microorganisms [17]. The test plates for antibacterial were examined for the clear zone of inhibition around each control and dyed samples separately for Escherichia coli (Plates 5 - 8) and Staphylococcus aureus (Plates 9 - 12) respectively. The test plates for antifungal were examined for the clear zone of inhibition around each control and dyed samples separately for Candida albicans (Plates 13 - 16) and Candida tropicalis (Plates 17 - 20) respectively.



2.12 Construction of Apparel

Four T-shirts were constructed for a seven year girl of 28-size using Tie and dye techniques. The cotton woven dyed Chiffon cloth TSMCHPO and CSECHPO material were converted to T-shirt using sunburst of marble tie and dye technique (Plates 21, 22). The cotton woven dyed Crinkled cloth TSMCRPO and CSECRPO material was converted using stripes and circles tie and dye techniques (Plates 23, 24).

PLATE 21
NATURAL DYED
TSM^{CHPO}SUNBURSTTIE AND DYE T-SHIRT

PLATE 22
NATURAL DYED
TSM^{CRPO} STRIPES TIEAND DYE T-SHIRT

PLATE 23
NATURAL DYED
CSE^{CHPO} MARBLE TIEAND DYE T-SHIRT

PLATE 24
NATURAL DYED
CSE^{CRPO} CIRCLESTIE AND DYE T-SHIRT

3. Results and Discussion

The results and discussion for the study is given below

3.1 Visual Evaluation of Natural Dyed Samples

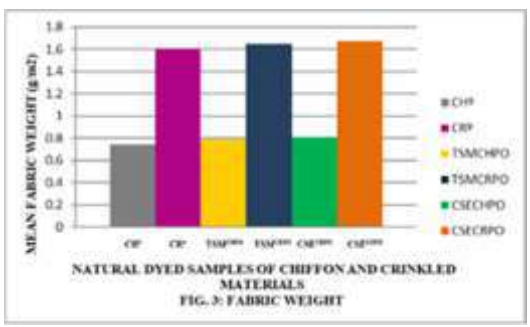
The visual evaluation results show the response percent for all the natural dyed samples. The natural dyed sample CSECRPO was preferred by 62 % of respondents, TSMCRPO was preferred by 54 % of respondents. CSECHPO was preferred by 50 % of respondents and TSMCHPO was preferred by 41 % of respondents as received by Chikkanna Government Arts College Tiruppur students. As, these four post mordanting CSECRPO, TSMCRPO, CSECHPO and TSMCHPO natural dyed samples exhibited highest rating were selected for the study.

3.2 Analysis of Mechanical Tests

The average Fabric weight, Thickness, Tensile Strength and Elongation, Stiffness, Crease recovery, Drape, Abrasion resistance, Drop Test and Shrinkage. Colour Fastness tests to Sunlight, Washing, Crocking and Perspiration was done. Anti-Microbial Tests such as CSECRPO, TSMCRPO, CSECHPO and TSMCHPO Anti-Bacterial Test and Anti-Fungal Test was also carried out. The results for Original and Dyed Chiffon cloth and Crinkled materials is shown in Tables 1,2,3,4,5,6,7,8,9,10 and Figures 3, 4, 5, 6, 7, 8, 9, 10, 11, 12)., 13, 14.

Table 1: Fabric Weight

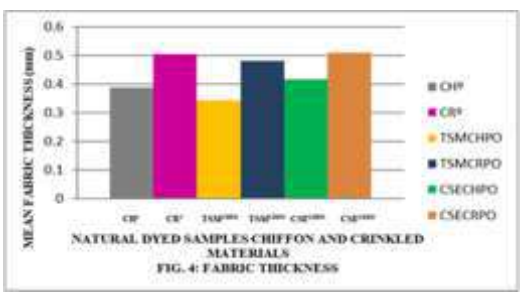
SAMPLES	MEAN FABRIC WEIGHT (g/m^2)	SD	CV %	% LOSS OR GAIN OVER ORIGINAL
CH^o	0.744	0.047	6.31	-
CR^o	1.6	0.014	0.87	-
TSM^{CHPO}	0.786	0.028	3.56	5.64
TSM^{CRPO}	1.65	0.021	1.27	3.12
CSE^{CHPO}	0.807	0.029	3.59	8.46
CSE^{CRPO}	1.676	0.019	1.13	4.75



NATURAL DYED SAMPLES OF CHIFFON AND CRINKLED MATERIALS
FIG. 3: FABRIC WEIGHT

Table 2: Thickness

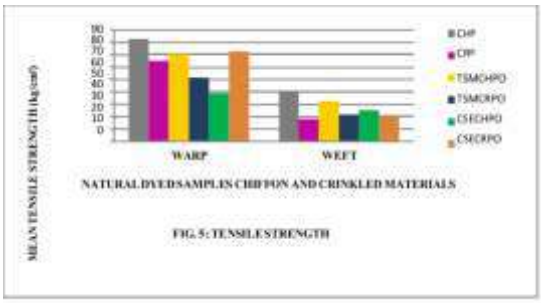
SAMPLES	MEAN FABRIC THICKNESS (mm)	SD	CV %	% LOSS OR GAINOVER ORIGINAL
CH^o	0.388	0.106	27.31	-
CR^o	0.506	0.880	17.39	-
TSM^{CHPO}	0.343	0.050	686	-11.59
TSM^{CRPO}	0.482	0.055	876.3	-4.74
CSE^{CHPO}	0.416	0.030	13.86	7.21
CSE^{CRPO}	0.510	0.014	2.74	0.78



NATURAL DYED SAMPLES CHIFFON AND CRINKLED MATERIALS
FIG. 4: FABRIC THICKNESS

Table 3: Tensile Strength

SAMPLES	MEAN TENSILE STRENGTH (Kg/cm^2)		SD		CV %		% LOSS ORGAIN OVER ORIGINAL	
	WARP	WEFT	WARP	WEFT	WARP	WEFT	WARP	WEFT
CH^o	82.6	40.36	127.25	4.920	154.05	12.19	-	-
CR^o	65.24	18.22	11.147	18.22	17.08	21.99	-	-
TSM^{CHPO}	70.32	32.48	7.097	4.197	10.09	12.92	-14.86	-19.52
TSM^{CRPO}	51.52	21.92	21.660	7.313	42.04	33.36	-21.03	20.30
CSE^{CHPO}	38.76	25.34	5.073	6.080	13.08	23.99	-53.07	-37.21
CSE^{CRPO}	72.44	20.35	8.986	1.045	12.40	5.13	11.03	11.69

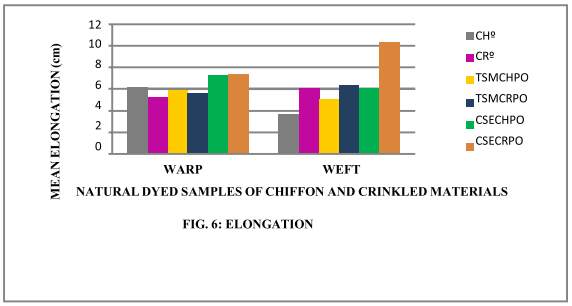


NATURAL DYED SAMPLES CHIFFON AND CRINKLED MATERIALS

FIG. 5: TENSILE STRENGTH

Table 4: Elongation

SAMPLES	MEAN ELONGATION (cm)		SD		CV %		% LOSS OR GAINOVER ORIGINAL	
	WARP	WEFT	WARP	WEFT	WARP	WEFT	WARP	WEFT
CHº	6.186	3.642	2.628	1.184	42.48	32.50	-	-
CRº	5.226	6.056	1.276	2.501	24.41	41.29	-	-
TSM^{CHPO}	5.933	5.048	1.115	2.223	18.79	44.08	-4.089	39.55
TSM^{CRPO}	5.556	6.334	2.033	2.562	36.59	40.44	6.314	4.59
CSE^{CHPO}	7.282	6.024	2.670	1.966	36.6	32.63	17.71	65.40
CSE^{CRPO}	7.362	10.341	1.488	4.928	20.21	47.65	40.87	70.75

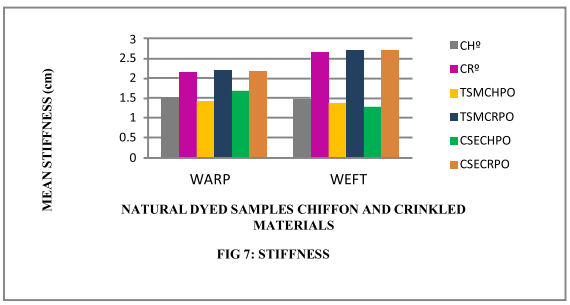


NATURAL DYED SAMPLES OF CHIFFON AND CRINKLED MATERIALS

FIG. 6: ELONGATION

Table 5: Stiffness

SAMPLES	MEAN STIFFNESS (cm)		SD		CV %		% LOSS ORGAIN OVER ORIGINAL	
	WARP	WEFT	WARP	WEFT	WARP	WEFT	WARP	WEFT
CHº	1.52	1.47	0.225	0.231	14.80	15.71	-	-
CRº	2.14	2.66	0.107	0.195	5	13.64	-	-
TSM^{CHPO}	1.43	1.38	0.211	0.305	14.75	22.10	-5.92	-6.12
TSM^{CRPO}	2.2	2.7	0.149	0.149	6.77	5.5	2.803	1.503
CSE^{CHPO}	1.68	1.27	0.139	0.194	8.27	15.27	10.52	-13.60
CSE^{CRPO}	2.18	2.7	0.122	0.188	0.55	6.96	1.86	1.503

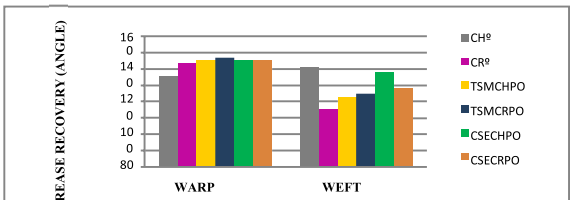


NATURAL DYED SAMPLES CHIFFON AND CRINKLED MATERIALS

FIG 7: STIFFNESS

Table 6: Crease Recovery

SAMPLES	MEAN CREASE RECOVERY(ANGLE)		SD		CV %		% LOSS ORGAIN OVERORIGINAL	
	WARP	WEFT	WARP	WEFT	WARP	WEFT	WARP	WEFT
CHº	111	122.6	3.829	3.373	3.44	2.75	-	-
CRº	127	70.2	4.422	13.62	3.48	19.40	-	-
TSM^{CHPO}	131.4	85.4	2.458	11.08	1.87	12.98	18.37	-30.34
TSM^{CRPO}	134.5	90	6.883	11.785	5.11	13.09	5.90	28.20
CSE^{CHPO}	131.6	115.2	1.955	19.634	1.48	17.04	18.55	-6.03
CSE^{CRPO}	130.4	96.4	5.440	21.649	4.17	22.44	2.67	37.32

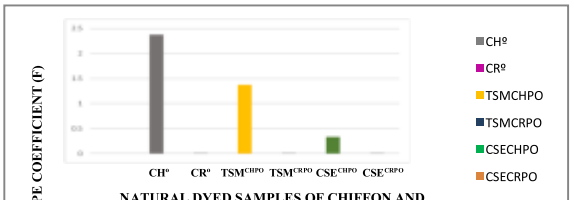


NATURAL DYED SAMPLES OF CHIFFON AND CRINKLED MATERIALS

FIG. 8: CREASE RECOVERY

Table 7: Drape Coefficient

SAMPLES	MEAN DRAPE COEFFICIENT(F)	SD	CV %	% LOSS OR GAIN OVER ORIGINAL
CHº	2.375	0.0109	0.46	-
CRº	0.011	0.0415	71.30	-
TSM^{CHPO}	1.376	0.0187	1.38	- 42.06
TSM^{CRPO}	0.010	0.0397	70.89	-9.09
CSE^{CHPO}	0.33	0.0149	4.80	-86.10
CSE^{CRPO}	0.010	0.0388	97	-9.09

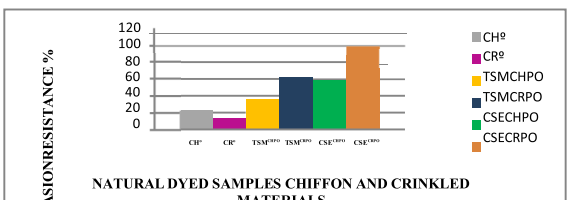


NATURAL DYED SAMPLES OF CHIFFON AND CRINKLEDMATERIALS

FIG. 9: DRAPE

Table 8: Abrasion resistance

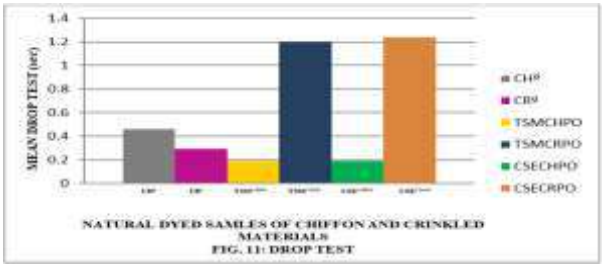
SAMPLES	MEAN BEFORE ABRASION (mg)	MEAN AFTER ABRASION (mg)	WEIGHT LOSS	ABRASION VALUE	MEAN ABRASION RESISTANCE %	% LOSS OR GAIN ORIGINAL
CHº	13.3	10.31	2.99	0.224	22.5	-
CRº	23.5	20.26	3.24	0.137	13.8	-
TSM^{CHPO}	12.6	11.52	1.08	0.361	36.12	60.53
TSM^{CRPO}	10.63	21.62	2.01	0.620	62.03	349.49
CSE^{CHPO}	20.71	10.94	1.77	0.591	59.2	163.11
CSE^{CRPO}	24.5	21.29	3.21	0.990	99.1	618.11



NATURAL DYED SAMPLES CHIFFON AND CRINKLED MATERIALS

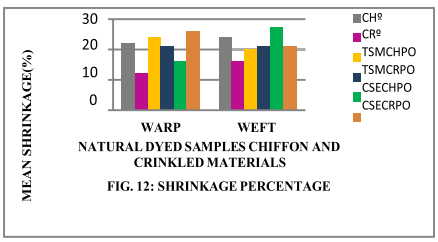
FIG. 10: ABRASION RESISTANCE

Table 9: Drop Test	
SAMPLES	MEAN DROP TEST (sec)
CH°	0.46 sec
CR°	0.29 sec
TSM^{CHPO}	19 sec
TSM^{CRPO}	1 min 20 sec
CSE^{CHPO}	19 sec
CSE^{CRPO}	1 min 24 sec

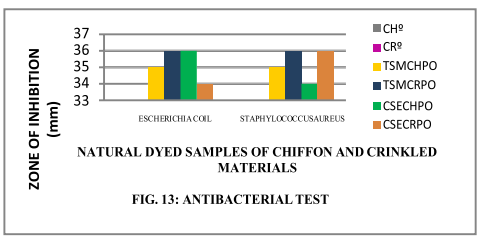


NATURAL DYED SAMLES OF CHIFFON AND CRINKLED MATERIALS
FIG. 11: DROP TEST

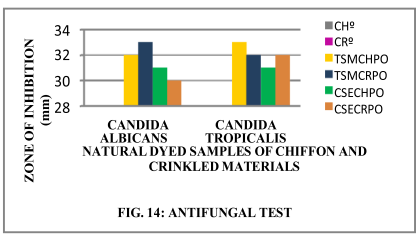
Table 10: Shrinkage										
SAMPLES	MEAN SHIRNKAGETEST (cm)		MEAN SHRINKAGE %		SD		CV %		% LOSS OR GAINOVER ORIGINAL	
	WARP (L=1cm)	WEFT (L=1cm)	WARP	WEFT	WARP	WEFT	WARP	WEFT	WARP	WEFT
CH°	0.78	0.76	22	24	0.078	0.117	10	15.39	-	-
CR°	0.88	0.84	12	16	0.042	0.051	4.77	6.07	-	-
TSM^{CHPO}	0.76	0.80	24	20	0.107	0.066	14.07	8.25	-2.56	-89.47
TSM^{CRPO}	0.79	0.79	21	21	0.110	0.083	13.92	10.50	-10.22	-5.95
CSE^{CHPO}	0.84	0.73	16	27	0.072	0.133	8.57	18.21	7.69	-3.94
CSE^{CRPO}	0.74	0.79	26	21	0.117	0.087	15.81	11.01	-15.90	-5.95



NATURAL DYED SAMPLES CHIFFON AND CRINKLED MATERIALS
FIG. 12: SHRINKAGE PERCENTAGE



NATURAL DYED SAMPLES OF CHIFFON AND CRINKLED MATERIALS
FIG. 13: ANTIBACTERIAL TEST



NATURAL DYED SAMPLES OF CHIFFON AND CRINKLED MATERIALS
FIG. 14: ANTIFUNGAL TEST

From Table 1 and Fig. 3 it shows that when means were compared between original fabrics, CR° revealed higher fabric weight by 1.6 g/m² whereas CH° had 0.744 g/m². When compared within means of natural dyed four samples CSECRPO showed highest fabric weight of 1.676 g/m² followed by TSMCRPO 1.65 g/m² and CSECHPO 0.807 g/m². The least fabric weight was seen in TSMCHPO of 0.786 g/m². When dyed samples were noted for percent loss or gain over original, all four natural dyed samples showed a gain in fabric weight. The highest percent gain was noted in CSECHPO by 8.46 % and the least percent gain of 3.12% was noted in TSMCRPO.

From Table 2 and Fig. 4 it shows that when means were compared between original fabrics, CR° revealed higher fabric thickness by 0.506 mm whereas CH° had 0.388 mm. When compared within means of natural dyed four samples CSECRPO showed highest fabric thickness of 0.510 mm. The least fabric thickness was seen in TSMCHPO of 0.343 mm. Whereas TSMCRPO and CSECHPO had moderate thickness. When dyed samples were noted for percent loss or gain over original, the highest thickness percent gain was noted in CSECHPO by 7.21 % and the least percent gain of 0.78 % was noted in CSECRPO.

From Table 3 and Fig. 5 for warp tensile strength when means were compared between original fabrics, CH° had the highest 82.6 kg/cm2 followed by CR° having 65.24 kg/cm2 as warp tensile strength. When compared between means of four natural dyed samples, CSECRPO showed highest warp tensile strength as 72.44 kg/cm2. The least warp tensile strength was seen in CSECHPO having 38.76 kg/cm². Whereas TSMCHPO and TSMCRPO showed 70.32 kg/cm2 and 51.52 kg/cm2 warp tensile strength in fabrics. When dyed samples were noted for warp tensile strength percent loss or gain over original, the warp tensile strength 11.03 percent gain was noted in CSECRPO.

From Table 4 and Fig. 6 for warp elongation when means were compared between original fabrics, CR° had the best 5.226 cm warp elongation followed by CH° having 6.186 cm warp elongation. When compared between means of four natural dyed samples, TSMCRPO showed 5.556 cm as best warp elongation among the other three dyed samples. For weft elongation when means were compared between original fabrics, CH° had the best 3.642 cm weft elongation followed by CR° having 6.056 cm weft elongation. When compared between means of four natural dyed samples, TSMCHPO showed 5.048 cm as best weft elongation among the other three dyed samples. When dyed samples were noted for warp elongation percent loss or gain over original, the best warp elongation of 6.314 percent gain was noted in TSMCRPO. When dyed samples were noted for weft

elongation percent loss or gain over original, all the four natural dyed samples exhibited a gain in weft elongation. The best weft elongation of 4.59 percent gain was noted in TSMCRPO.

From Table 5 and Fig. 7 for warp stiffness when compared between means of original fabrics, CRº had the highest 2.14 cm warp stiffness followed by CHº having 1.52 cm warp stiffness. When compared between means of four natural dyed samples, CSECRPO having 2.18 cm as highest warp stiffness and the least warp stiffness of 1.43 cm was seen in TSMCHPO. For weft stiffness when compared between means of original fabrics, CRº had the highest 2.66 cm weft stiffness followed by CH° having 1.47 cm weft stiffness. When compared between means of four natural dyed samples, TSMCRPO and CSECRPO had shared equally the highest 2.7 cm weft stiffness and the CSECHPO having 1.27 cm as least weft stiffness. When dyed samples were noted for warp stiffness percent loss or gain over original, the highest percent gain was noted in CSECHPO which had 10.52 % and the least 1.83 percent gain was noted in CSECRPO. When dyed samples were noted for weft stiffness percent loss or gain over original, percent gain was equally shared between TSMCRPO and CSECRPO.

From Table 6 and Fig. 8 for warp crease recovery when compared between means of original fabrics, CHº had the fastest crease recovery by 111º followed by CRº having 127º. Amongst the four natural dyed materials best crease recovery was seen in CSECRPO by 130.4º and followed by TSMCHPO and CSECHPO having 131.4º, 131.6º crease recovery. For weft crease recovery when compared within original samples. CRº had the fastest recovery by 70.2°. Between four natural dyed materials best crease recovery was noted in TSMCHPO having 85.4º followed by TSMCRPO and CSECRPO having 90º, 96.4º crease recovery. When compared for percent loss or gain over original for four natural dyed samples, all the samples exhibited a gain in warp crease recovery. The best warp crease recovery percent was seen in CSECRPO and TSMCRPO had the best weft percent crease recovery.

From Table 7 and Fig. 9 it shows that when means were compared between original fabrics, the drape was found to be higher in CHº by 2.375 F followed by CRº having 0.011 F. Within four natural dyed samples the drape was higher in TSMCHPO of 1.376 F. The four samples had a loss percent in drape.

From Table 8 and Fig. 10 it shows that when abrasion resistance percent was compared between original fabrics, CR° revealed higher fabric abrasion resistance by 13.8 % whereas CH° had 22.5 %. When compared within abrasion resistance percent of natural dyed four samples TSMCHPO showed highest abrasion resistance of 36.12 %. The least fabric abrasion resistance of 59.2 percent was seen in CSECHPO. When dyed samples were noted for percent loss or gain over original, all the four natural dyed samples exhibited a gain in abrasion resistance. The highest percent gain was noted as 618.11% by CSECRPO and the least percent gain of 60.53% was noted in TSMCHPO.

From Table 9 and Fig. 11 it shows that when means were compared between original fabrics, CRº has the highest absorbency nature by 0.29 sec whereas CH° wetted the fabric by 0.46 sec. When compared between means of four natural dyed samples, TSMCHPO and CSECHPO both showed good absorbency by 19 sec respectively.

From Table 10 and Fig. 12 for warp shrinkage when compared between means of original fabrics, CHº had less 0.78 cm followed by CRº having 0.88 cm warp shrinkage. When compared between means of four natural dyed samples, CSECRPO having 0.74 cm as least warp shrinkage and the highest warp shrinkage of 0.79 cm was seen in TSMCRPO. For weft shrinkage when compared between means of original fabrics, CHº had less 0.76 cm followed by CR° having 0.84 cm weft shrinkage. When compared between means of four natural dyed samples, CSMCHPO having 0.73 cm as least weft shrinkage followed by TSMCRPO and CSECRPO which shared equally of 0.79 cm weft shrinkage and the TSMCRPO having 0.79 cm as highest weft shrinkage. When dyed samples were noted for percent loss or gain over original, the percent loss or gain in warp shrinkage was noted in CSECHPO which had 7.69 %.

3.3 Analysis of Colour Fastness Tests

The result obtained for colour fastness to sunlight shows that the colour change when analyzed for the four natural dyed TSMCHPO, TSMCRPO, CSECHPO and CSECRPO materials, reveal that all the four natural dyed samples had slight change in colour. When checked for colour fastness to washing all the four natural dyed fabrics showed no colour change. With regard to colour staining TSMCHPO had slight colour staining compared to the other three TSMCRPO, CSECHPO and CSECRPO natural dyed samples. With regard to wet crocking, all the four natural dyed samples showed no colour change and slight colour staining was noted in TSMCHPO whereas all the other three had no colour staining. In dry crocking, all the samples exhibited no colour change and colour staining. For the effect of acid and alkali perspiration, all the four natural dyed TSMCHPO, TSMCRPO, CSECHPO and CSECRPO samples exhibited noticeable slight colour change and staining.

3.4 Analysis of Anti-Microbial Tests

Anitimicrobial Tests of Antibacterial and Antifungal Tests were carried out on original and dyed Chiffon and Crinkled fabrics.

From Fig. 13, Original control CHº, CRº fabric samples did not show any inhibitory zones indicating the absence of antibacterial surface finishing. TSMCRPO, CSECHPO showed 36 mm inhibitory zones each respectively and TSMCHPO, CSECRPO showed 35 mm and 34 mm inhibitory zones against test bacteria Escherichia coli. Whereas TSMCRPO, CSECRPO had 36 mm each respectively and TSMCHPO had 35 mm, CSECHPO had 34

mm inhibition zones were found in Staphylococcus aureus. All the four natural dyed samples had good inhibitory zones against bacteria.

From Fig. 14, original control CHº, CR° fabric samples did not show any inhibitory zones indicating the absence of antifungal surface finishing. TSMCRPO, TSMCHPO, CSECHPO and CSECRPO had 33 mm, 32 mm, 31 mm and 30 mm inhibitory zones against test fungi Candida Albicans. Candida Tropicalis showed TSMCHPO, TSMCRPO, CSECRPO, CSECHPO had 33 mm, 32 mm, 32 mm and 31 mm inhibitory zones. All the four natural dyed samples had good inhibitory zones against fungi.

4. Summary and Conclusion

Environmentally safe products are gaining popularity in recent years, so it has become extremely important for textile chemists and colourists to find eco-friendly ways of producing colours for textiles [18]. The four natural dyed TSMCHPO, TSMCRPO, CSECHPO and CSECRPO samples exhibited good shades. The mechanical tests conducted on these natural dyed fabrics revealed that they had good strength and drape, best abrasion resistance, crease recovery and stiffness. The natural dyed samples showed good water absorbency in drop test and shrinkage test. The natural dyed samples showed best colour fastness to sunlight, washing, wet crocking. dry crocking and perspiration. The antibacterial and antifungal test results of natural dyed

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Effect of Finishing Treatment on Micro Polyester for Chemical Resistant Work Wear

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Abstract
In India there are many Industries using or processing various chemicals. One such industry where chemicals are utilized is Electroplating Industry. This industry mostly comprises of small-scale units where workers employed do not wear any kind of Protective Clothing and handle Chemicals wearing normal clothing. In fact, it is a well-known fact that in most of the chemical industries, workers are in direct contact with chemicals. Electroplating Industry is one such industry where workers handle hazardous chemicals. The basic electroplating employs a plating bath filled with water containing a small amount of acid or alkali added to improve its conductivity . A wide variety of chemicals and substances are used, depending on the surface properties of the objects to be electroplated. All textiles serve various needs such as modesty, functional and aesthetics. The need of protection is of utmost importance. Textiles protect the body from various hazardous conditions in which man has to work. A chemical accident is the unintentional refuse or spill of one or more hazardous substances which can harm human health or the environment. Personal Protective Equipment, or PPE, is designed to provide protection from serious injuries or illnesses radiological, physical, electrical, mechanical, or other hazards resulting from contact with chemicals. Considering this Protective need in work environment the present study was conducted. The objective is to study the effect of finishes on the micro polyester fabric. The fabric with good comfort property using various weave structures and finishes treatments so that it can block penetration and permeation of abrasive sulphuric acid and sodium hydroxide used in chemical industry.

Keywords: *Ramie, Silk, Epoxy, OMMT Nanoclay, Mechanical properties, and SEM*

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1. Introduction

The term "finishing" in textile manufacturing refers to a set of procedures that transform woven or knitted cloth into a finished material. This process includes any actions that take place after dyeing the fabric or yarn with the purpose of enhancing the appearance, quality, or texture of the finished product, whether it be textile or clothing .

The application of fluorocarbon finishes on textiles results in the formation of a consistent polymer film from the dispersion. The water and oil repellency of polyester/cotton blend is observed to be superior to that of cotton. The protective clothing should possess excellent water, oil, and pesticide repellency . Fluorocarbons contain perfluoroalkyl residue in which hydrogen atoms are exchanged by fluorine. They have very high thermal stability. Nano finishes being developed for textile substrates are in their nascent stage. Some of the finishes have been commercialised. These finishes impart additional functions to the material. The commercially available variants are Nano Care TM, Lotus Effect TM, NanosphereTM and Ag Fresh.3.

Replacement of fluorocarbons in the field of repellents of liquids, mainly in waterproof and oleo phobic textile materials, became the crucial issue in attempts to find eco-friendly and efficient barrier systems ensuring both high protective effects and physiological parameters (wearing comfort). Except the hydro- and oleo phobic effects, multi-barrier properties (protection against heat and flame, heat stress and heat stroke protection, soil-release) and relevant physiological parameters (breathability, thermo regulating/insulating properties) and wearing comfort without the movement restriction are required for protective clothing. These properties achieved by customized yarn and fabric construction in combination with textile fiber selection, followed by special textile finishing and garment design (cut, multi-layered structures) . They must comply with cost effectiveness and prolonged service life under the harsh conditions of use and maintenance cycles. Innovative approaches are demonstrated in examples of commercial solutions .

The performance of hybrid laminated composites was evaluated for their potential use in protective clothing. Nine types of woven fabrics were utilized, woven with polyester fibers as the warp yarns and three types of weft materials. Three types of weaving structures were employed, with 10 ends/cm and 15 picks/cm. A nonwoven glass fiber mat was selected for use due to its superior performance and cost-effectiveness in the realm of fiber-reinforced composites. It was discovered that the HLC (hybrid laminated composite) fabricated from (polyester/glass) fabric, combined with satin and nonwoven glass fiber mat, displayed the best functional performance. The reinforcement material, structure, and

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resin properties all played a significant role in the thickness, puncture resistance, and UV transmittance of the produced HLC. The fiber/matrix interface was a crucial factor in influencing the interlaminar fracture toughness of the laminated composites. The HLC fabricated from (polyester/glass) fabrics with satin and glass fiber mat was the most effective in achieving functional performance. This multifunctional HLC was recommended for use in protective clothing as a headwear due to its high puncture resistance and improvement in UV transmittance, as well as its low weight and thickness, which provided comfort .

2. Materials and Methods

There is a need of Chemical protective clothing, so the micro polyester yarn was used to develop fabrics. The effect of Finishes was studied on the 6 samples developed in two weaves with 60, 72 and 84 PPI. The fabrics were developed on a power loom in two weave structures i.e., plain and rip stop. Then the samples were finished with two types of finishes Alkyl Urethane (F1) and Fluorocarbon (F2) procured from two manufacturers. These finishes were used to impart oil and water resistance. The recipe used was as prescribed by manufacturer. These finishes were applied with pad-dry-cure method as represented in Plate No. The finish pick up with 20% was given to each sample. All the samples were tested for chemical resistance as per specification of ISO6530.

Plate No.1: Padding Machine

Plate 2: Fabric Ready for Padding

Table 2: Coding for Finishing

Type of Finish	Code	Chemical Name
Finish 1	F1	Alkyl Urethane (Huntsman)
Finish 2	F2	Fluorocarbon (Resil)
Before Finish	BF	-

3. Results and Discussions

3.1 Effect of Finishes on Comfort Properties

3.1.1 Air Permeability

It was observed that application of Finish 1 lead to increased Air Permeability in some cases. It was also observed that when comparing Plain and Rip Stop weaves, Rip Stop weave with 60 picks allowed more Air Permeability than Plain Weave as shown in Table 3 and Figure 1. The below graph is shows that as the pick increases the Air Permeability decreases. In filament fineness 0.53 dtex, the fabric with 60 picks has Air Permeability of 6.7 cm3/cm2/s is before finish but after the application of Finish1 it increased to 9.1cm3/cm2/s. Thus, the finishing treatment has resulted in increase of Air Permeability.

Table 3: Effect of Finishes on Air Permeability

Filament Fineness	Weave	Ends	Picks	GSM	Air Permeability Before Finish	Air Permeability Finish F1	Air Permeability Finish F2
0.53	Ripstop	102	62	148	6.69	9.1	8.00
0.53	Ripstop	104	78	151.25	2.495	1.2	1.20
0.53	Ripstop	104	86	160.4	1.5	0.8	0.51
0.53	Plain	104	62	146.9	4.357	3.51	2.93
0.53	Plain	102	74	152.7	2.368	1.202	0.92
0.53	Plain	96	86	154.95	0.55	0.631	0.58

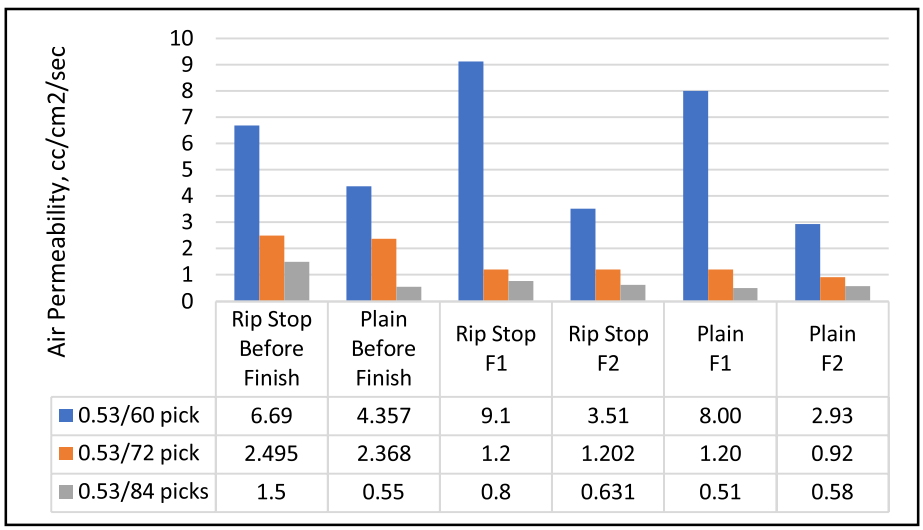

Figure 1: Air Permeability Before and After Finish

3.1.2 Water Permeability

It was observed that water vapor transmission has decreased with the application of finishes. As represented in Table 4 and Figure 2. It was observed that in Micro Yarn with PPI 60 in Plain weave water permeability increases when finish 1 and finish 2 is applied, whereas with PPI 72 and 84 the Water Permeability decreases when finish is applied. Thus, the finishing treatment has resulted in increase of water permeability only with lower PPI. The purpose of water permeable fabric is to make it comfortable to the wearer .

Table 4: Effect of Finishes on Water Permeability

Filament Fineness	Weave	Ends	Picks	GSM	Water Permeability Before Finish	Water Permeability Finish F1	Water Permeability Finish F2
0.53	Ripstop	102	62	148	9.83	6.5	9.76
0.53	Ripstop	104	78	151.25	8.4	5.4	8.19
0.53	Ripstop	104	86	160.4	8.34	6.13	7.9
0.53	Plain	104	62	146.9	5.68	7.75	8.48
0.53	Plain	102	74	152.7	9.04	6.06	6.83
0.53	Plain	96	86	154.95	8.42	8.3	6.68

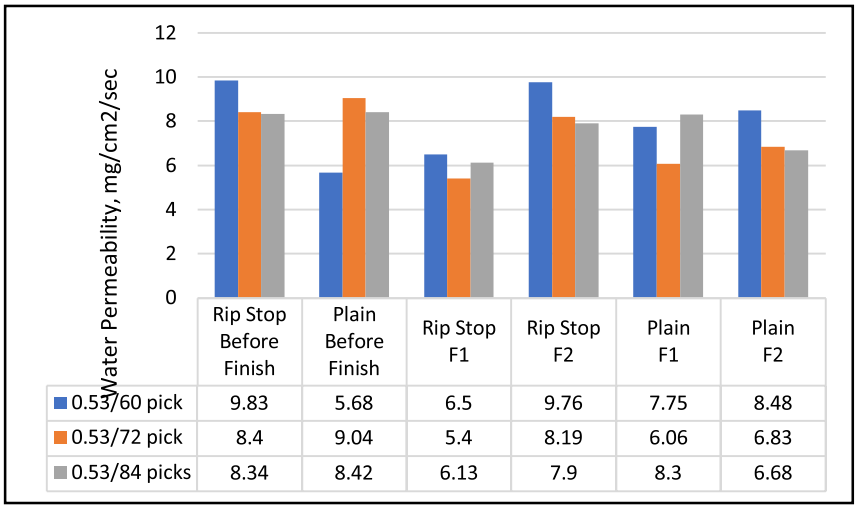

Figure 2: Water Permeability Before and After Finish

4. Effect of Finishes on Durability

4.1 Tensile Strength

As represented in Table 5, the Micro Yarn in Ripstop weave with 84 picks has the maximum Tensile Strength. Figure 3 shows that after the application of Finish 2 the Tensile Strength increased in Plain Weave. The results showed in Table 5 and Figure 3 that application of finish lead to increase in Tensile Strength. Thus, the Finish 2 resulted in increasing the tensile strength of fabrics woven with micro yarn.

Table 5: Effect of Finishes on Tensile Strength

Filament Fineness	Weave	Ends	Picks	GSM	Tensile Strength Warp and Weft (Before Finish)		Tensile Strength Warp and Weft (F1)		Tensile Strength Warp and Weft (F2)	
0.53	Ripstop	98	64	142.7	1148.5	779.1	1175.5	701.9	1238	698
0.53	Ripstop	102	78	152.65	1127	873.4	1176	979.25	1205.5	927.4
0.53	Ripstop	100	90	156.2	1131.5	1058	1229.5	1047	1230	1107.5
0.53	Plain	104	62	146.9	1144.5	822.25	1107	800.55	1068.5	803.3
0.53	Plain	102	74	152.7	1160.5	918.1	1150	876.3	1150	900.3
0.53	Plain	96	86	154.95	1057.5	971.1	1132	1064	1120.5	1058.5

Figure 3: Tensile Strength before and after finish

4.2 Tearing Strength

It was observed that the Tearing Strength increased after the application of finish. Application of Finish1 resulted in higher increase in Tearing Strength of both warp and weft yarns as compared to Finish 2. Table 6 represents the warp and weft Tearing Strength. It can be observed from Figure 4 that Tearing Strength increased with Finish 1 in all the Picks. Also, the 60 picks showed more Tearing Strength as compared to others. The GSM also increased with the increase in pick. It was observed that the 60 picks with filament fineness 0.53 in Ripstop weave have the maximum Tearing Strength. The ISO recommends tearing strength as 15 N for the protective clothing.

Table 6: Effect of Finishes on Tearing Strength

Filament Fineness	Weave	Ends	Picks	GSM	Tearing Strength Warp and weft		Tearing Strength Warp and weft(F1)		Tearing Strength Warp and weft (F2)	
0.53	Ripstop	102	62	148	35.6	27.5	99.3	75.4	80.2	65.9
0.53	Ripstop	104	78	151.25	43	33.7	82.3	69.7	50.7	48.4
0.53	Ripstop	104	86	160.4	31.4	27.8	62.2	51.5	50.7	35.9
0.53	Plain	104	62	146.9	39.8	27.8	57.4	41.9	44.6	33.7
0.53	Plain	102	74	152.7	32.2	25.2	40	32.6	33.9	29.5
0.53	Plain	96	86	154.95	28.4	21.5	38.1	28.1	31.2	25.5

Figure 4: Tearing Strength Before and After Finish

4.3 Effect of Finishes on Chemical Resistance

All fabric samples of micro polyester woven in Ripstop and Plain Weave treated with F1 and F2 finish shows 100% chemical resistance and 0% chemical penetration.

It was also observed that when Finish F1 was applied then water permeability was not affected thus making F1 finish more apt for the said end use in this study. The comfort and chemical resistance are desired characteristics for the development of this fabric.

5. Conclusion

All fabric treated with F1 and F2 finish showed 100% chemical resistance and 0% chemical penetration. It was also observed that the air permeability decreased with the increase in picks. It was observed that application of Finish 1 lead to increased air permeability in some cases. It was also observed that when comparing Plain and Rip Stop weaves, Rip Stop weave with 60 picks allowed more air permeability than Plain weave. In filament fineness 0.53 dtex, the fabric with 60 picks showed air permeability of 6.7 cc/cm2/s before finish but after the application of finish 1 it increased to 9.1cc/cm2/sThus, the filament fineness 0.53 dtex and Finish 1 has resulted in increase of air permeability. It was observed that water permeability has decreased with finish application.

Water vapour transmission of micro yarn was best with PPI 72. The results show that application of finish made the samples chemical resistant. Samples woven in 84 picks Micro Yarn showed increase in Tensile Strength with application of finish 2. After the application of finish F1 the tearing Strength increased considerably in samples woven in 60 picks. The results showed that both the finishes resisted the penetration of chemicals tested in Rip Stop Weave. The micro yarn with 84 picks showed the maximum tensile strength. Figure 3 shows that after the application of Finish 2 the tensile strength increased in plain weave. Tearing strength increased with Finish 1 in all the Picks. Also, the 60 picks showed more Tearing Strength as compared to others.

The mass in g/m2 increased with the increase in pick. It was observed that the 60 picks with filament fineness 0.53 had the maximum tearing strength of 57.5 N in plain weave. The ISO recommends tearing strength as 15 N for the protective clothing. Here, F1 finish with 60 picks and 0.53 dtex filament fineness had maximum tearing strength. The tearing strength was lowest i.e. 28.4 N in case of filament fineness 0.53 dtex with 84 picks without the application of any finish. The tearing strength increased after the application of finish. Application of Finish 1 resulted in higher increase in tearing strength of both warp and weft yarns as compared to Finish 2. The sample woven in 60 picks with micro yarn and rip stop weave with Finish 1 was best for developing work wear.

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Journal of the TEXTILE Association

GARMENT

Alternative Methodology for Designing and Sizing Uniforms for Women in Security Forces

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Abstract:

Background : While size charts of readymade garments aim at fitting them to maximum possible persons in the targeted population, security force uniforms must not only maximize the fit for every wearer but also minimize the performance losses without sacrificing the identity and pride attached to these. These uniforms should help avoid the musculoskeletal stress that ill-fitted uniforms can cause, and also conveniently accommodate the accessories and equipment used in combat or ceremonies. Security forces uniform design has so far been male oriented and the increasing induction of women into security forces demands a newer approach.

Methods :Unlike the standard practice of using a single primary linear parameter like the chest or waist girth for creating the first level classification and then accommodating the body types thereunder, this study adopts the body types as the primary classification criteria and then accommodates linear measurements within each body-type. This study proposes the use of both linear and nonlinear anthropometric measures to segment the body types.

Results :The results of the factor analysis and factor score based cluster analysis and the uniforms stitched and tested based on these favor the use of body types as the primary basis for designing women or unisex security uniforms.

Conclusion :This study confirms the need for using body types as the primary parameter in designing women or unisex security uniforms and using nonlinear anthropometric measures also for segmenting body types.

Keywords: *Anthropometric body-types, Alternative uniforms design method, Body-type based size-charts, Women uniforms, Unisex security uniforms*

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1. Introduction

Size charts are the industry standard for mass producing garments according to predefined linear measurements that suit the body dimensions of the identifiable subgroups within a target population. Garments are usually sized based on a primary girth measurement around the chest for the upper and the waist for lower garments. However, lack of fit continues to be a major reason for the rejection of readymade garments by consumers. The current sizing systems yield a good fit for only 20% of the target population [1]. According to a McKinsey report, poor fit and style accounted for 70% of the apparel ecommerce returns globally [2]. The growing mismatch between the standard size charts and the wearing comfort and fit is attributed to the traditional systems of anthropometric data collection, interpretation and application [3].

Security force uniforms belong to a distinct category of clothing as these must fit everyone in the target population. The target group does not have the option to reject the uniforms based on poor fit. Uniforms are designed as a single ensemble from head to toe – making it necessary to design them with the objective of providing easy arm, elbow, legs and knee movements. Besides providing proper fit, these must also integrate well with a wide range of accessories and equipment, and offer maximized mobility [4]. Apart from these, security forces also look for versatility to suit varied climates, safety against hazards, durability, easy storage, maintainability, cost, tradition, recognition, contemporary military appearance, compatibility with other uniforms and comfort as key requirements in the design of their uniforms [5].

In the new millennium, several instances of changes in the design of security force uniforms have been reported in the media and research studies. The US Army introduced a unisex combat uniform in 2013 [6]. It has also launched a regular green uniform in 2021 [7], which will become mandatory by 2028. The Indian Army has also got its traditional green uniform redesigned by NIFT in 2022 [8]. Some countries have also redesigned their police uniforms. Most of these changes are, however, focused on improving comfort and camouflage. Only the unisex combat uniform of the US Army addresses the differences in male and female body types. However, the security forces uniform design process still involves the same standard industry process of creating size charts based on linear anthropometric measurements. In recent times, however, 3D scanning is being widely used for taking accurate and multiple measurements to improve the fit [9]. New research is also

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focusing on 4D data collection by including body motions as the fourth dimension [10]. Researchers have also developed linear programming methods [11] and clustering algorithms [12] to improve the fit-efficiency of the size charts. One research which takes into account the body type, however, relies on the theoretical types such as the hourglass, rectangular, pear or apple shapes rather than identifying the body types based on relevant anthropometric data [13].

Therefore, the present study aims at first identifying the body types by analyzing the anthropometric data, both linear and non-linear, of the target population and then preparing the standard size charts separately for each of the body type groups. In this research, uniforms were also designed, stitched and evaluated.

2. Materials and Methods

The data used in this paper was generated in an unpublished interdisciplinary research project done in the Department of Home Science (Fabric and Apparel Science), Bhagini Nivedita College, University of Delhi during 2016 over a period of 12 months.

A total of 50 female NCC cadets were selected from 4 different Delhi University colleges based on stratified random sampling using height as the classifier. The equipment used for collecting anthropometric data included: TANITA Body Composition Monitor (BCM), Digital Stadiometer, anthropometric rods, standard measuring tapes and a weighing machine. In all, 26 anthropometric parameters were selected for data collection (Table 2). Since the primary objective of the data collection process was to segment the sample by body type, the measurements taken included heights, lengths, circumferences, weights, as well as body composition related indices and percentages. The 10 Student Researchers associated with the project were specially trained to take these measurements accurately. Since BCM could not generate the required data, the sample size was reduced to 48.

SPSS version 13 was used to test the suitability of the data for further statistical analysis such as Factor Analysis (FA) and Cluster Analysis (CA). Apart from performing the Kaiser-Meyer-Olkin (KMO) measure of Sampling Adequacy and Bartlett's test of Sphericity, the communality measure of each variable was also checked to confirm its suitability for inclusion in FA. KMO ranges between 0 to 1 for any set of data and values closer to 1 are better with a value greater than .5 is the cut-off. If the value of Bartlett's test of Sphericity is significant (less than 0.05), it confirms that the correlation matrix was not an identity matrix and the data is good enough for FA.

Keeping in view the fact that FA was only an intermediate step towards segmenting sample into body type groups using CA, Principal Component Analysis (PCA) procedure of FA was used to extract the component factors (Table 2 & 3). Case wise factor scores based on these components were also generated as these provide the only logical way to use the output of FA in CA [14]. Varimax rotation with Kaiser Normalization were applied in the PCA procedure. Since the factor scores generated are standardized, these can be used as such in cluster analysis without having to identify variables requiring standardization and deciding on the appropriate procedure for standardization [15]. Since the original data included both quantitative and qualitative variables, the Two Step Cluster Analysis (TSCA) was performed to identify the body type clusters and their respective members (Table 4). Log-likelihood was used as the distance measure.

Since the objective of TSCA was not only to segment the sample population but also to gain in depth knowledge of the defining characteristics of each cluster, the TSCA procedure was also used to plot 1) the within cluster variations of the 5 extracted factors (Fig, 1) and 2) the variable wise importance within each cluster (Fig. 2).

Development of Standard Size Chart was done by importing the case wise cluster membership data generated by the cluster analysis process into a spreadsheet containing the original measurements and sorting the sample population based on the cluster membership of the cases. Cluster means were used as the basis for designing medium size garments. Cluster means were also compared with the overall means and the maximum and minimum values of each cluster was used for deciding on other sizing requirements.

Paper patterns were prepared based on the mean measurements of different clusters. Using these patterns, two sets of khaki uniform shirts and trousers were stitched. One set was for the standard medium size. Another was for large or small as per the requirements of different clusters. The stitched uniforms were tested on two cadets of each identified cluster to validate the results of the cluster analysis and size chart developed using the mean measurements of each cluster.

3. Results and Discussion

Statistical analysis was performed separately for the body type segmentation for shirt and trousers. This paper includes the results relating to the shirts only. The outputs for the trousers were similar.

The data was tested for Sampling Adequacy using the KMO and for Sphericity using Bartlett's Test. KMO test returned a value of 846 - well above the minimum required value of .5 and above .8, which is considered meritorious. Similarly Bartlett's test was significant with a value of .000, - well below the cut-off of .05. Both confirmed the suitability of the data for FA.

Figure 7: Matena Village, Almora

S. No.	Measurement	Mean	Std. Deviation (SD)	Communalities
1	Body Height (Cm)	155.73	6.427	.948
2	Chest Circumference (Cm)	80.58	5.852	.913
3	Upper Waist Circumference (Cm)	64.92	5.812	.865
4	Abdomen Circumference (Cm)	72.00	8.440	.865
5	Biacromial Breadth (Cm)	30.04	3.294	.812
6	Upper arm Circumference (Cm)	28.80	3.089	.748
7	Arm Length (Cm)	52.33	3.454	.754
8	Forearm Length (Cm)	31.31	3.340	.800
9	Mid-upper Arm (Cm)	23.08	3.319	.663
10	Arm hole Depth (Cm)	35.65	2.950	.749
11	Wrist Circumference (Cm)	14.00	1.130	.767
12	Neck Circumference (Cm)	32.88	2.772	.611
13	Lower Waist Circumference (Cm)	69.33	8.777	.887
14	Biceps (Cm)	8.81	3.444	.828
15	Triceps (Cm)	11.23	4.449	.812
16	Suprailiac (Cm)	10.54	4.068	.710
17	Subscapular (Cm)	11.33	3.083	.701
18	Weight (kg)	47.71	7.754	.981
19	Fat (%)	25.12	5.786	.702
20	Fat Mass (kg)	12.42	4.481	.952
21	Fat Free Mass - FFM (kg)	35.25	3.906	.971
22	Muscle Mass (kg)	33.44	3.590	.959
23	Bone Mass (kg)	2.02	.385	.558
24	BM Index	19.79	2.705	.955
25	Deviation from Ideal Weight (kg)	5.37	6.702	.964
26	Obesity (%)	-9.91	12.279	.969

While higher values of SD indicates the wide divergences in the body characteristics of the sample population, higher communalities confirm their eminent suitability for inclusion in the FA. All variables had values above the .5 cut-off.

Table 2: Principal Components Extracted by Factor Analysis

Component	Extracted Solution		Rotated Solution	
	% Variation	Cumulative %	% Variation	Cumulative %
1	50.868	50.868	39.904	39.904
2	14.429	65.297	20.608	60.512
3	8.693	73.990	10.161	70.673
4	4.501	78.491	6.203	76.876
5	3.976	82.467	5.591	82.467

The Scree plot was also cross checked to confirm that these five factors positively contributed to the variance in the underlying data. That these factors explained nearly 82.5% of the variation also proves that these factors are suitable for further analysis. Since Varimax rotation ensured that each of these factors were uncorrelated with each other, it allows us to treat them as independent variables.

As per the recommended practice, a cut-off of .4 was applied for variables loading on any factor. The factor names are based on the variables with dominant loading.

What PCA (Table 3) brings out is that among the five components, the last 3 relate primarily to the arms and their connecting muscles, while the first two relate to the whole body or the upper body. What is important to note is that the last 3 factors pinpoint the need for paying attention to the differences in the arm related measurements in the design of uniforms, since standard size charts do not pay the necessary attention to the arm related differences. PCA also confirms the relevance of body composition parameters to the easy identification and understanding of the body types.

Two step cluster analysis was carried out on the case wise factor scores generated by FA in the previous step. Automatic clustering, however, resulted in a single cluster. Since the objective of this project is to group the cases based on the factors extracted in the previous process, it became necessary to specify the number of clusters to be created. In the first step, clustering was done for 3 to 5 clusters on an experimental basis keeping in mind the five factors extracted by FA. Variable wise importance plots were checked for clustering that were based on variable importance meeting the critical value criteria. After analyzing the output of the experimental runs, results were finally obtained for a 4 cluster solution

Table 3: Principal Component Factors and their Constituent Variables

Variable	Loading	Variable	Loading
***Factor 1**:* Heavy body build/obese		***Factor 2**:* Tall, bony/muscular (Continued)	
BM Index	0.953	Arm Length (Cm)	0.705
Obesity (%)	0.951	Bone Mass (kg)	0.665
Chest Circumference (Cm)	0.904	Biacromial Breadth (Cm)	0.664
Fat Mass (kg)	0.894	Weight (kg)	0.616
Upper Waist Circumference (Cm)	0.886	Lower Waist Circumference (Cm)	0.526
Fat (%)	0.805	Abdomen Circumference (Cm)	0.440
Abdomen Circumference (Cm)	0.796	Neck Circumference (Cm)	0.409
Weight (kg)	0.759		
Mid -upper Arm (Cm)	0.711	***Factor 3**:* Heavy upper arm and wrist	
Arm hole Depth (Cm)	0.641	Wrist Circumference (Cm)	0.671
Subscapular (Cm)	0.630	Triceps (Cm)	0.670
Upper arm Circumference (Cm)	0.512	Upper arm Circumference (Cm)	0.535
Triceps (Cm)	0.506	Arm Length (Cm)	0.473
Suprailiac (Cm)	0.493	Arm hole Depth (Cm)	0.438
Muscle Mass (kg)	0.484		
Neck Circumference (Cm)	0.479	***Factor 4**:* Short, slender and muscular	
FFM (kg)	0.478	Biceps (Cm)	0.801
Lower Waist Circumference (Cm)	0.466	Supra-iliac (Cm)	0.534
		Subscapular (Cm)	0.461
***Factor 5**:* Tall, bony/muscular			
Body Height (Cm)	0.951	***Factor 6**:* Long forearm	
FFM (kg)	0.855	Forearm Length (Cm)	0.856
Muscle Mass (kg)	0.845		

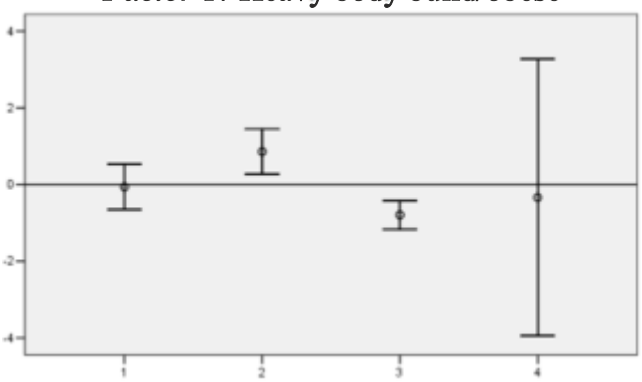
Table 4: Cluster sizes and membership (Log-likelihood was used as the distance measure)

Cluster	Members	% of total	Cluster	Members	% of total
1	18	37.5%	3	12	25.0%
2	14	29.2%	4	4	8.3%

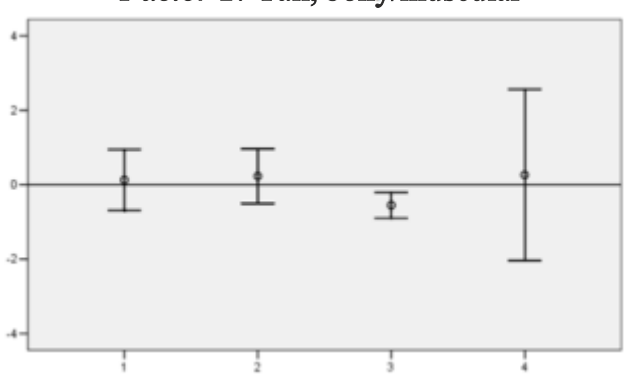
The TSCA output in Table 4 shows that the first three clusters had more than 25% of the sample population, while the last cluster had only 4 members representing less than 10% of the sample. It appeared to be cluster of outliers. The naming of the clusters was done for the sake of convenient referencing, based on the plots of within cluster variation among the factors and the variable-wise importance in the 4 clusters. These plots were also necessary to understand the defining characteristics of the members of the different clusters.

What is observed in Figure 1: Within Cluster Variation of the extracted factors is that in the case of Factor 1 (heavy obese), the mean score of the factor coincides with the mean of Cluster 1, whereas the mean of Cluster 2 is a little away from the Factor Mean on the positive side and the mean of Cluster 3 is a little away from the Factor Mean on the negative side.

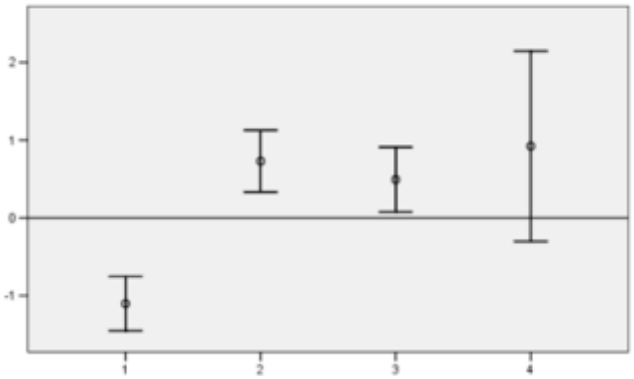
Factor 1: Heavy body build/obese



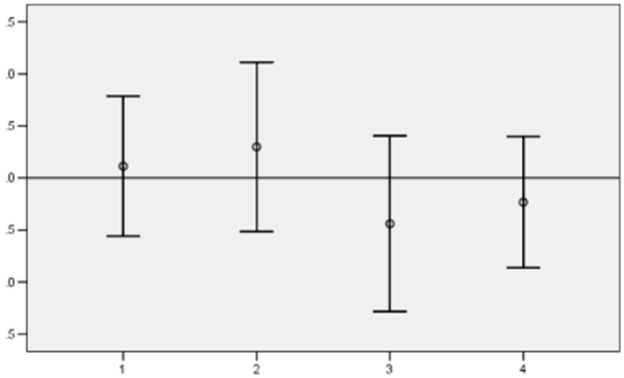
Factor 2: Tall, bony/muscular



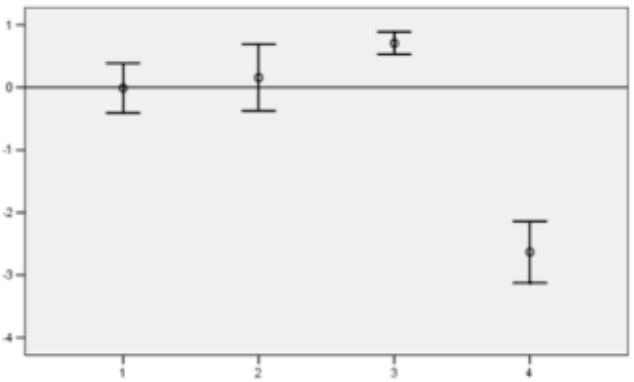
Factor 3: Heavy upper arm and wrist



Factor 4: Short, slender and muscular



Factor 5: Long forearm



Legend

X axis indicates clusters by their number
Y axis represents regression factor scores in -3 to +3 Z Score format with 0 in the middle indicating the mean score.

The horizontal line from the factor score mean 0.0 helps understand how far or close the clusters are to the mean of the concerned factor score

Figure 1 - Within Cluster Variation of the 5 extracted factors

Although the mean of Cluster 4 is also close to the Factor Mean on the negative side, there is a high degree of within cluster dispersion of this factor. In the case of Factor 2 (tall muscular bony), the mean of Cluster 1 coincides with the Factor Mean while the Cluster 2 mean is very close to it on the positive side and the mean of Cluster 1 is a little away on the negative side. Though the Cluster 4 mean is also close, it's within cluster dispersion is noticeable. In the case of Factor 3 (heavy arm and wrist), the mean of Cluster 1 is away from the Factor Mean on the negative side while the means of Cluster 2 and 3 are somewhat close to it on the positive side and the mean of Cluster 4 is a little away on the positive side with a high dispersion. In the case of Factor 4 (short, slender, muscular), all the clusters show wide dispersion with the means of Clusters 1 and 2 on the positive side and 3 and 4 on the negative side. In the case of Factor 5 (long fore arm), the mean of cluster 4 is distinctively away on the negative side while that of Cluster 1 coincides with the Factor Mean and those of Clusters 2 and 3 are on the positive side.

Figure 2: shows the variable-wise importance in the 4 Clusters. Although the ultimate goal of the cluster analysis is to segment the target population into body type groups and use only the cluster means of the linear measurements relevant to uniforms design for the concerned cluster, understanding the variable wise importance in cluster helps in identifying the key measurements which the designer must keep in mind while preparing the patterns. Cluster 1 distinguishes itself by the extreme negative association with the heavy upper arm and wrist factor indicating that this cluster needs slim sleeves. Cluster 2 has distinct positive association with heavy upper arm and wrist as well as the heavy build and obese factor implying thereby that this cluster will need extra fullness in the bodice and sleeve patterns. Cluster 3 distinguishes itself by its positive association with the short, lean and long forearm and the heavy upper arm and wrist factors indicating that this cluster requires a sloped sleeve with a slim bodice. As pointed out earlier Cluster 4 appears to be an outlier cluster having insignificant association with four factors and a strong negative association with the short, lean and long forearms factor. The names assigned to the clusters is primarily for easy referencing only.

The feedback on the stitched uniforms were obtained, on a 5 point scale with 5 indicating 'Very Good' and 1 meaning very bad, The average of the scores received from the female Cadets who tried out the sample garments were as shown in Table 6.

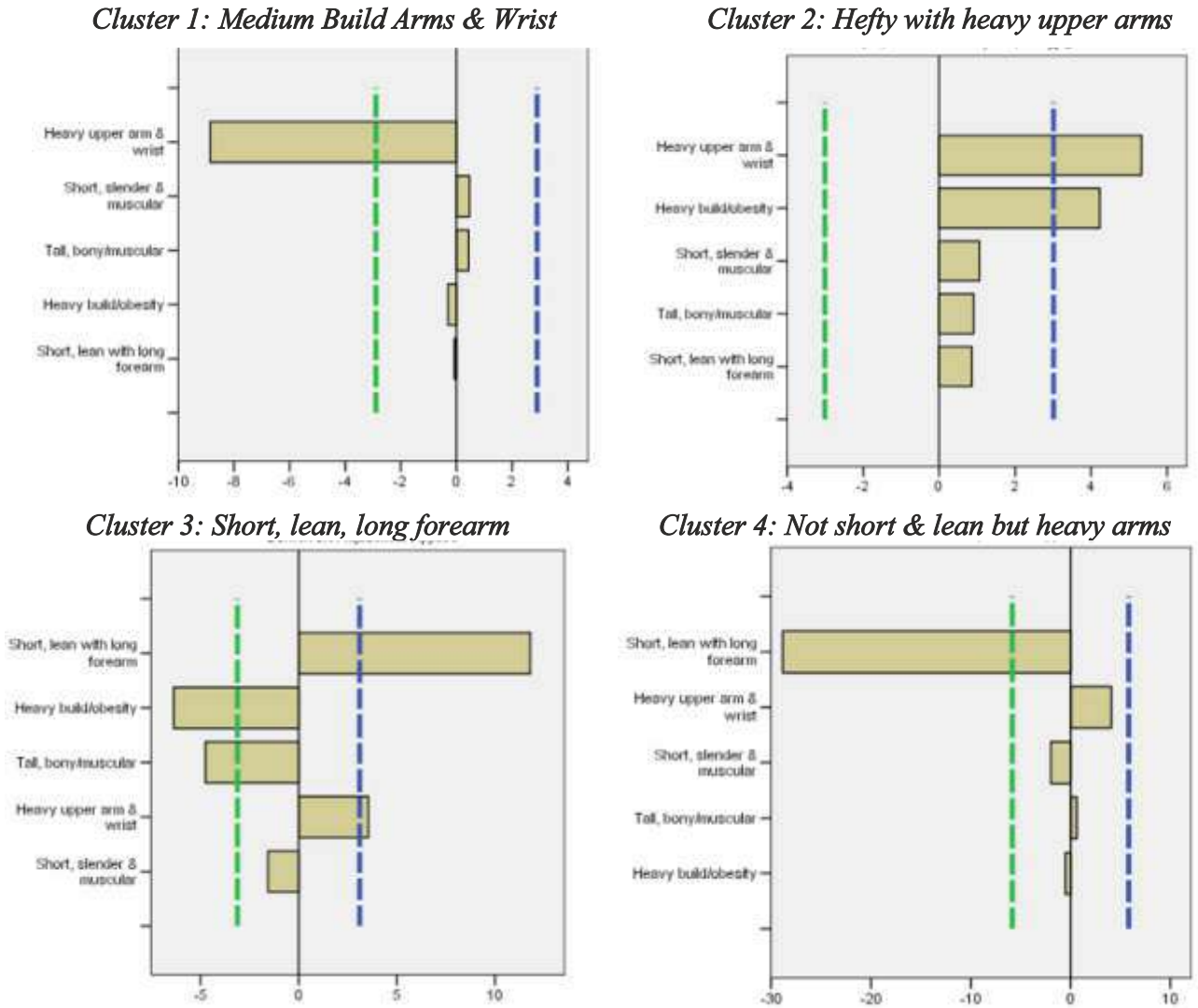


Figure 2: Variable-wise Importance in the 4 Clusters

Table 6: Criteria wise Average Feedback Scores on Uniforms

Criteria	Average Score	Criteria	Average Score
Look and Feel	4.5	Comfort	3.9
Ease of Movement	4.25	Fit	3.8

The scores on fit and comfort could have been better with finer grained sizing. As mentioned earlier, trial uniforms were stitched only for the medium size and one size smaller or larger.

4. Conclusions

The results of the research reveal that better looking uniforms can be designed by first segmenting the target population into body type clusters using the methodology described in this paper. The degree of fit and comfort could also be enhanced by adopting the standard sizing methodology for each cluster separately. This method appears to be more suitable for designing uniforms for adult girls and women. This method may also be preferred for sizing women's uniforms or garments as it does not involve the hassles of 3D scanner based data collection. Since the body composition data provides useful health information, it may be easier to motivate women to volunteer to provide the data. Possibly, this methodology could be extended, especially to designing plus size garments for women. It must be noted that this study is based on a sample population of only 48. A far larger sample may be needed for more accurate body type segmentation and size charting.

5. Acknowledgments

The author gratefully acknowledges the funding support received for this research through the Delhi University and Department of Science & Technology Innovation Project. The author is also grateful to Prof. Satwanti Kapoor, Department of Anthropometry, Delhi University for mentoring the project.

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Journal of the TEXTILE Association

Effect of Process Variables on Properties of MVS Yarns

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Abstract:

This paper examines the influence of various process variables, including nozzle air pressure, yarn delivery speed, and card cylinder speed, on the characteristics of MVS yarns produced using Murata vortex spinning (Vortex III 870 system). The findings reveal that nozzle air pressure and yarn delivery speed exert significant influence on yarn evenness, imperfections, hairiness, and tensile properties. Raising the nozzle air pressure in vortex spinning has the effect of enhancing yarn tenacity and unevenness in the yarn structure. Conversely, this increase in air pressure tends to reduce the level of hairiness in the resulting spun yarn. Overall, the analysis demonstrates that higher card cylinder speeds tend to enhance properties such as unevenness and hairiness of the yarn.

Keywords: *MVS yarn, Process variable, Viscose yarn, Vortex spinning, Yarn properties*

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1. Introduction :

Meeting the stringent quality standards for knitted fabrics, especially concerning their appearance and comfort, remains a significant challenge. Traditional air-jet spun yarns have limited applicability in knitting due to their adverse impact on fabric hand, finding primary use in woven products like table cloths, bed sheets etc. To address these limitations and cater to the regular wear and casual markets, Murata Machinery Ltd. developed the Vortex III 870 spinning system. This innovative yarn production method, characteristic of vortex-spun yarns, has successfully mitigated several drawbacks associated with air-jet spun yarns, especially for specific end-use applications. The performance of fabrics prepared from vortex-spun yarns is not solely influenced by fabric structure but also by the unique structure and properties of these yarns [1-3].

Various process parameters employed in vortex spinning can induce structural and property changes in vortex-spun yarns, encompassing factors such as fiber alignment categories, spatial configuration within the yarn, fiber packing density of the yarn cross-section, yarn tensile properties, evenness, and hairiness [4-7]. These alterations subsequently impact the characteristics of fabrics manufactured using vortex-spun yarns.

While prior research has primarily focused on comparing the performance of fabrics constructed from different yarn types, including ring-spun, compact-spun, rotor-spun, and vortex-spun yarns [8-11], there has been a notable scarcity of studies exploring the relationship between process parameters and the properties of MVS yarns particularly spun on Vortex III 870 spinning system. Some limited investigations have examined specific aspects, such as the low-stress and thermal comfort characteristics of woven fabrics made from polyester-cotton MVS yarns in relation to twisting jet pressure, delivery speed, and nozzle distance [1]. Similarly, others have delved into the impact of process parameters, such as nozzle pressure, yarn delivery speed, and yarn count, on the properties of viscose knitted fabrics [3].

This dearth of comprehensive literature addressing the intricate interplay between yarn process parameters and fabric characteristics leaves spinners in a state of uncertainty when determining the ideal process parameters for achieving specific fabric characteristics. Consequently, there is a pressing need for research that can aid yarn manufacturers in optimizing MVS process parameters, thereby expanding the potential applications of MVS yarns in the production of knitted garments. The focus of this study revolves around examining the impact of key process parameters, specifically nozzle air pressure, yarn delivery speed in MVS, and carding machine cylinder speed, on the properties of MVS yarns used in the manufacturing of knitted garments.

2. Materials and Methods

2.1 Samples

To conduct this study, 100% viscose fibers with a length of 38 mm and a fineness of 1.2D have been used. Yarn samples of 40s Ne were meticulously prepared on Murata vortex spinning (using Vortex III 870 spinning system), in accordance with an experimental plan designed using the Box and Behnken methodology [12]. The specific details of the experimental plan, as well as the actual values of the three variables corresponding to the coded levels, are presented in Table 1 and Table 2.

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Table 1: Experimental plan for MVS machine variables used for yarn samples

Combination No.	Nozzle pressure MPa (x_1)	Yarn delivery speed m/min (x_2)	Card cylinder speed rpm (x_3)
1.	-1	-1	0
2.	1	-1	0
3.	-1	1	0
4.	1	1	0
5.	-1	0	-1
6.	1	0	-1
7.	-1	0	1
8.	1	0	1
9.	0	-1	-1
10.	0	1	-1
11.	0	-1	1
12.	0	1	1
13.	0	0	0
14.	0	0	0
15.	0	0	0

Table 2: Actual values corresponding to coded levels

Coded level	Actual value		
	Nozzle air pressure MPa (x_1)	Yarn delivery speed m/min (x_2)	Card cylinder speed Rpm (x_3)
-1	0.50	380	440
0	0.52	410	500
1	0.54	440	560

2.1 Test Methods

Prior to testing, all yarn samples underwent a conditioning period lasting 48 hours under standardized test conditions, maintaining a temperature of 27±2 ºC and relative humidity at 65±2%.

Yarn tensile properties were assessed using the Uster Tensorapid 4 instrument, with a gauge length of 500 mm, a test speed of 5000 mm/min, and a pre-tension of 0.5cN/tex. The yarn tenacity value was determined as the average of 30 individual tests.

To evaluate yarn evenness and hairiness (H values), we employed the Uster Tester 5-S800, operating at a yarn speed of 800 m/min and a testing duration of 0.5 minutes. The evenness and hairiness values for each yarn sample were computed as the mean of 10 test results.

3. Results and Discussion

3.1 Statistical Analysis

To derive meaningful insights from our experimental data concerning the properties of various MVS yarns, we employed the SYSTAT 13 computer statistical tool program. This enabled us to formulate response surface equations that encapsulate the intricate relationships within the data. The response surface equations, along with the squared multiple correlation coefficients of the yarns, are comprehensively presented in Table 3.

In interpreting these equations, it is essential to consider the sign of the coefficients. A negative coefficient in a response surface equation signifies that a particular characteristic decreases as the corresponding variable increases, while a positive coefficient indicates that the characteristic increases with an increase in the variable. It is crucial to recognize that the trend is influenced not only by the sign but also by the magnitude of the coefficients associated with squared and interaction terms. Visual representations of these relationships can be observed in the spatial diagrams (Figs 1-4).

Table 3: Response surface equations for characteristics of yarn

Characteristic	Response surface equation	Squared multiple regression coefficient (R^2)
Tenacity (gf/tex)	$14.210+0.484\ X_1- 0.149\ X_2- 0.128\ X_1^2 - 0.055\ X_3^2 – 0.125\ X_1*X_2$	0.998
Elongation-at-break,%	$6.837+ 0.100\ X_2 + 0.614\ X_1^2 -0.061\ X_3^2 -0.055\ X_1*X_2$	0.997
Unevenness, %	$10.707 +0.233\ X_1 +0.063\ X_2 +0.107X_1^2$	0.973
Hairiness (H values)	$3.580- 0.339\ X_1- 0.051\ X_2+ 0.018\ X_3+ 0.019\ X_1^2$	0.996

3.2 Tenacity

Table 3 and Figure 1 illustrate the variations in yarn tenacity resulting from different processing parameters. Notably, all three parameters wield a substantial influence on the tenacity of MVS yarns, with nozzle air pressure exerting the most significant effect, followed by yarn delivery speed and card cylinder speed.

Increasing the nozzle air pressure leads to enhanced yarn tenacity. This effect can be attributed to two opposing factors: the increased tight wrappings and reduced proportion of unwrapped sections, both contribute to improved tenacity while decrease in number of core fibres reduces the tenacity. However, the dominance of the former factor results in an overall enhancement of yarn tenacity.

Conversely, higher delivery speeds result in reduced MVS yarn tenacity. This phenomenon can be explained by the role of yarn delivery speed in determining the residence time of fibers within the yarn formation zone. As the fiber bundle experiences prolonged exposure to the whirling force, it accumulates a greater amount of twist, ultimately enhancing the tenacity of MVS yarns.

Furthermore, the impact of card cylinder speed on yarn tenacity follows a nuanced pattern. Initially, increasing cylinder speed leads to higher yarn tenacity, likely due to improved fiber orientation. However, as cylinder speed continues to rise, the increase in short fiber content within the carding zone becomes a limiting factor, ultimately reducing yarn tenacity.

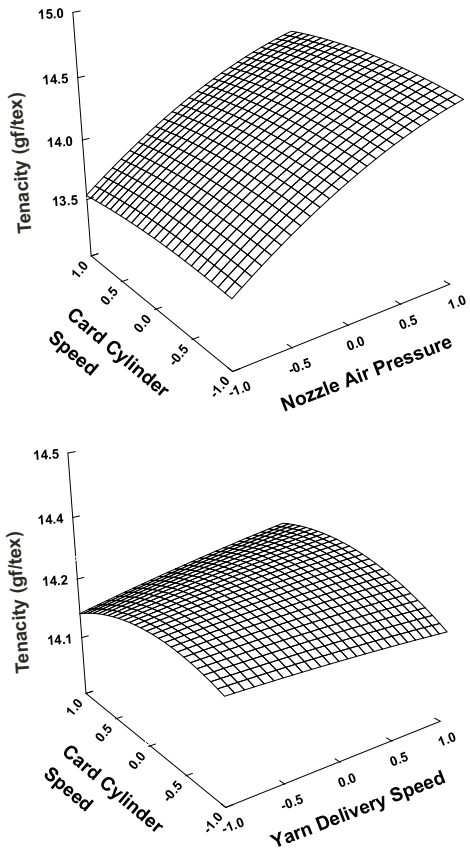

Figure 1: Response surface plots for the effect of process variables on yarn tenacity

3.3 Breaking Elongation

Regarding breaking elongation, our observations reveal intriguing patterns influenced by the manipulation of Process variables. An increase in nozzle air pressure initially leads to a reduction in breaking elongation due to the presence of increased tight wrappings. However, as nozzle air pressure continues to rise, changes in the yarn structure counter intuitively cause an increase in breaking elongation. This phenomenon underscores the complex interplay between the tightening effect of increased pressure and the structural adjustments within the yarn.

At lower delivery speeds, a smaller yarn diameter is attained, primarily because the fiber bundle experiences an extended exposure to the whirling force, resulting in a higher twist imparted to the yarn. This elevated twist, accompanied by tighter regular wrappings, correlates with a reduction in breaking elongation as yarn delivery speed decreases.

In contrast, variations in card cylinder speed do not yield a significant change in elongation. This implies that altering the card cylinder speed has a relatively minimal impact on the breaking elongation of MVS yarns.

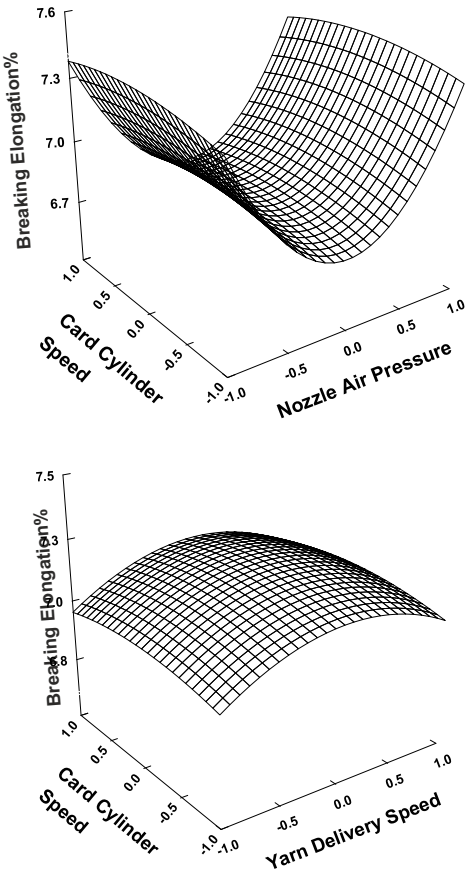

Figure 2: Response surface plots for the effect of process variables on yarn breaking elongation

3.4 Unevenness

The impact of process variables on yarn evenness and imperfections is a critical aspect of our study. Notably, nozzle air pressure plays a significant role in shaping these characteristics. As the nozzle air pressure increases, yarn evenness experiences a decline, accompanied by a noticeable increase in the number of thin places, thick places, and neps. This adverse effect can be primarily attributed to the heightened fiber loss experienced at higher pressure settings.

Similarly, when yarn delivery speed is increased, deterioration in yarn evenness was observed and an increase in the occurrence of thin and thick places. This trend highlights a clear relationship between higher delivery speeds and compromised yarn physical properties, including evenness and the presence of imperfections. Conversely, lower delivery speeds contribute to superior yarn properties, emphasizing the importance of controlling this parameter for optimal results.

Additionally, as the speed of the cylinder rises, there is a gradual increase in the U% (unevenness percentage). This

increase can be attributed to fiber rupture or damage, a phenomenon that becomes more pronounced with higher cylinder speeds. This finding sheds light on the intricate dynamics between cylinder speed and yarn unevenness.

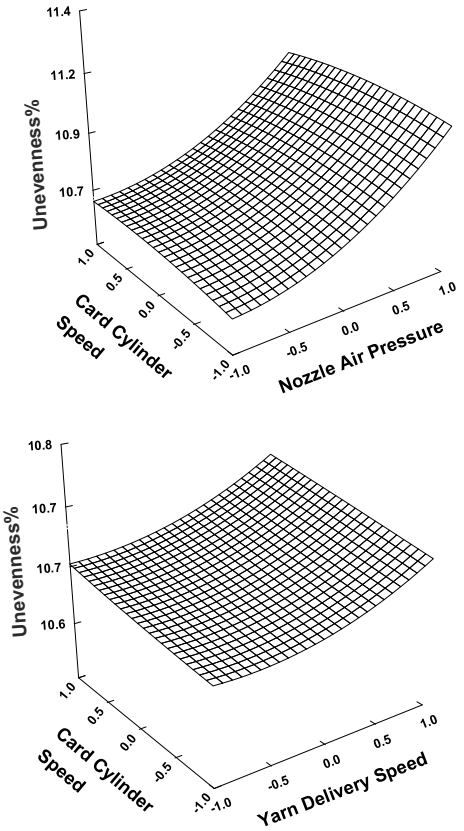

Figure 3: Response surface plots for the effect of process variables on yarn unevenness %

3.5 Hairiness

An increase in nozzle air pressure leads to a reduction in the hairiness (H values) of vortex-spun yarns. This phenomenon can be attributed to the heightened nozzle air pressure, which results in an increased whirling force of the air stream. This, in turn, leads to more effective fiber wrapping, contributing to the decrease in yarn hairiness.

Furthermore, it has been noted that lower delivery speeds yield smaller yarn diameters. This is because the fiber bundle remains exposed to the whirling force for a longer duration, allowing for a greater amount of twist to be imparted. Consequently, the higher twist and more tightly wound regular wrappings contribute to a reduction in yarn hairiness (H values) as the yarn delivery speed decreases.

Hairiness experiences an increase as the card cylinder speed rises, primarily because of the heightened fiber rupture and the generation of short fibers within the yarn.

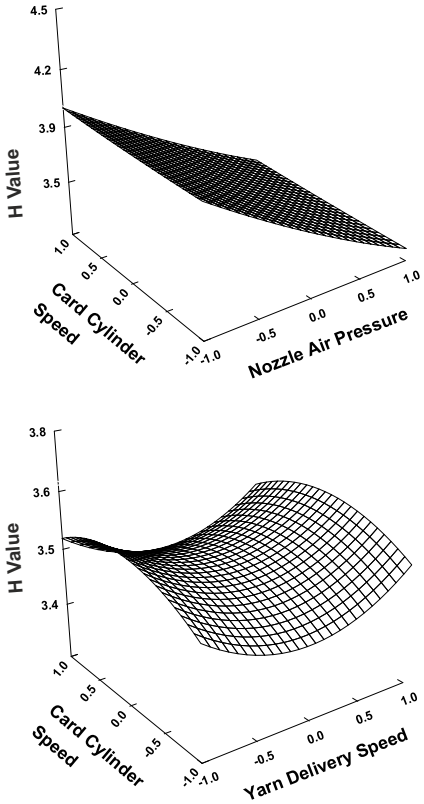

Figure 4: Response surface plots for the effect of process variables on yarn hairiness

4. Conclusions

This investigation underscores the substantial influence of nozzle air pressure, yarn delivery speed, and card cylinder speed on the characteristics of vortex yarns. Notably, nozzle pressure emerged as a pivotal factor profoundly affecting vortex yarn properties. Lower nozzle pressure settings yielded improvements in yarn evenness and reduced imperfections. The results unequivocally demonstrate the positive impact of increased nozzle pressure on the hairiness and tensile properties of MVS yarns, attributed to enhanced yarn wrappings.

Key findings reveal a direct relationship between delivery speed and yarn tensile properties, with an increase in delivery speed corresponding to a decline in these properties. Moreover, elevated delivery speeds contributed to heightened yarn hairiness.

In summary, this study highlights the significance of carefully selecting and optimizing delivery speed, nozzle pressure, and card cylinder speed to achieve desired properties in vortex yarns. Much like the optimization of spinning conditions in traditional ring and rotor spinning technologies, the process parameters in MVS spinning can be fine-tuned to meet specific end-use requirements. This understanding opens up avenues for enhancing the versatility and adaptability of vortex yarns in various applications.

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Journal of the TEXTILE Association

Green Process for Degumming of Tussar Silk by Sapindus Extract

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Abstract:

Tussar is a variety of wild silk that has an inherent natural colour and lustre. Conventionally, Tussar is degummed with Marseilles soap and sodium bicarbonate at 100°C for 1 hour, followed by a hot wash and neutralisation. This method consumes a large amount of water and energy. This research aims to develop a process of extracting natural soap from Sapindus (Soapnut) and utilising it for degumming of Tussar silk under milder treatment conditions to achieve the desired effect. The process is scientifically optimized using the advanced statistical tool of response surface methodology (RSM). With 12 g/l of Sapindus extract at 84 °C, complete degumming was accomplished in 34 minutes. Microscopic analysis showed that the sericin deposits from the fibre got removed, and the fibre surface became clear and smooth (hand-feel rating of 5), with adequate water absorbency (5 sec), dye uptake and shine, with little loss in tensile strength (11.86 kgf), and elongation (29.10%). The Fourier-transform infrared spectroscopy (FTIR) analysis indicated that the functional groups of Tussar silk remained unaffected.

Keywords: *Degumming, Natural surfactant, Sericin, Sapindus Soapnut, Tussar silk*

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1. Introduction :

Silk is a fibre developed by nature in a continuous filament form and which is widely imitated by manmade fibres - be it regenerated (Viscose, Lyocell) or synthetic (Polyester, Nylon) [1]. Removing the outer non-fibrous protective layer from silk is essential for imparting functional performance regarding moisture regain, lustre, comfort wear and aesthetic appeal. The conventional process of degumming involves using harsh synthetic chemicals, which affects the inherent properties of raw silk in terms of strength and impacts the environment [2].

Mulberry, tropical Tussar, oak Tussar, Eri, and Muga are the five commercially available types of silk, and only India produces them all. About 9.9% of all non-mulberry silk variants are made up of Indian tropical Tussar silk [3]. With a market share of around 1%, it only makes up a small portion of the overall silk production, at about 2% [4]. The Tussar silk fiber's structural protein is fibroin, and its adhesive is sericin, a proteinaceous substance. Tussar silk has a low sericin content (5–12%) since most of it is lost during the cooking, bruising, and reeling of cocoons. Sericin comprises serine, aspartic acid, glycine, and a large portion of threonine, whereas fibroin contains glycine, alanine, and serine.[5]. Sericin, which is mainly amorphous and serves as a binder to maintain the structural integrity of the cocoon, makes the silk thread seem harsh and rigid while also masking its brilliant lustre and whiteness [6].

Degumming is essential because it hinders the homogeneous penetration of chemicals and dyes during wet processing [7].

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The peptide bonds in sericin are broken during degumming by hydrolysis, traditionally done using alkalis, acids, enzymes, or even water under pressure at a high temperature [8]. The soap-soda process is traditionally used for degumming silk, which provides effective sericin removal but also affects its strength.

Using synthetic surfactants typically increases the toxic load and the extent of the impact of Chemical Oxygen Demand (COD) on the ecosystem [9]. In addition, synthetic surfactants may not be readily biodegradable compared to naturally derived surfactants [10]. Biological sources have gained popularity as a way to create surfactants that are less expensive and less harmful to the environment than synthetic surfactants [11]. Sapindus mukorossi, Sapindus laurifolia, and Acacia auriculiform known as Soap-nut in India, have been widely explored for various applications. Considered to have originated from China and southern India, the soap-nut tree has spread globally. Saponin comprises four chemical substances —triterpenoid, sesquiterpene glucoside, protein, and fatty oil. It is a non-ionic bio-surfactant that reduces surface tension and provides potent detergency. Unlike synthetic compounds, natural molecules like soapnut saponin don't harm the environment. Saponins are organic chemical substances that naturally foam or lather in water, much like soap [12]. The glycosides with their aglycones that are connected to sterols are called saponins. These sterols include triterpines composed of hedaragenin, oleanolic acid, antigogenin, gitogenin, digitogenin, and sarsasapogenin [13-14].

In this study, degumming of Tussar silk was attempted using a natural soapnut extract. Furthermore, a response surface statistical method was used to optimize the natural soap degumming parameters and to determine optimal degumming conditions.

2. Materials and Methods

2.1 Materials

The fabric is 100% plain-woven Tussar silk weighing 70 g/m2 (GSM) and was purchased from Nilima Silks in Bangalore, Karnataka. The soapnuts, or Sapindus, were purchased at a Mumbai market. Atul Ltd provided the acid dye (Tulacid Red Brown SNBL, C.I. Acid Red 117). Rossari Biotech Ltd. provided the nonionic surfactant (Commercial soap) (Kleenox WLF Liq), and other laboratory-grade reagents were bought from SD Fine Chemical Ltd in Mumbai.

2.2 Method

2.2.1 Saponin extraction

The Sapindus was crushed and ground into powder form after being dried at 50 °C for 24 hours. A Soxhlet aqueous extraction technique was used to extract saponin from Sapindus [15]. Before adding it to the Soxhlet equipment, 25 g of the powdered soapnut was placed in a thimble holder. A round-bottom flask was filled with 250 ml of distilled water to start the extraction procedure at 100 °C for 8 hours. After that, the apparatus was turned off, and to obtain 100 ml of extract, it was further concentrated by evaporating water.

2.2.2 Degumming of tasar silk

A 20x20 cm piece of Tussar silk fabric was cut, conditioned at 65% RH and 27°C for 24 hours, and then degummed using a 10 g/l Sapindus extract for 40 minutes at 100°C. The material-to-liquor ratio and pH were kept at 1:10 and 5-7, respectively. After the degumming process, the samples were thoroughly washed with hot water, cold water, and dried. Initial experiments revealed that Sapindus extract might successfully degum Tussar silk. The Design of Expert (DoE) program was applied to optimize the parameters. 17 trials were performed to determine the optimal Sapindus extract concentration, treatment duration, and temperature.

Tussar silk fabric was soap degummed for 60 minutes at 90 °C using 1 g/l of commercially available non-ionic detergent. The material-to-liquor ratio and pH was maintained at 1:10 and 9-10, respectively. At the end of the degumming process, the degummed samples were thoroughly washed with hot water and then cold water and then dried. Alkali degumming was performed at 90 °C for 60 minutes using 2 g/l soda ash and 1 g/l non-ionic soap. The ratio of materials to liquor was 1:20. After the degumming process, the samples were thoroughly washed with hot water and then cold water, then dried.

2.2.3 Dyeing

Dyeing was carried out to assess the dyeing properties of degummed silk fabric. Tussar silk fabric was dyed using a recipe that included 2% (on the weight of the fabric) acid dye, and the pH of the dye bath was kept at 5 by adding acetic acid. The dyeing was carried out for 45 minutes at 90 °C. The ratio of materials to liquor was kept at 1:20. After dyeing, the fabric underwent an after-treatment of a hot wash, a cold wash, and drying.

3. Performance evaluation and characterizations

3.1 Sapindus (Soapnut) extract

(i) The emulsification index (E24 test) was measured using a standard procedure [16] by using Equation 1.

$$Emulsification\ Index\ (E-24) = \frac{Height\ of\ emulsified\ layer}{Total\ height\ of\ the\ solution} \times 100 \quad (1)$$

(ii) Surface tension (Equation 2) was calculated by using TensioCAD semi-automatic Du Noüy Ring and Wilhelmy Plate Tensiometers.

$$Surface\ tension(\sigma) = \frac{Fmax}{(L \times cos\theta)} \quad (2)$$

Where, Fmax is the maximum force applied to the platinum ring, L is the ring's characteristic length, and θ is the contact angle between the platinum ring and the solution.

(iii) Foaming behaviour was measured by ASTM Test Method D1173-53[17].

(iv) The pH of the extract was determined using a laboratory pH meter

3.2 Fabric evaluation

(v) Weight loss (Equation 3) was measured by the gravimetric method as per ISO: 1383–1977 (BIS, 1982).

$$Weight\ loss\ (\%) = \frac{W_a - W_b}{W_a} \times 100 \quad (3)$$

Where, Wa and Wb are the weight of fabric before the process and the weight of fabric after the process, respectively.

(vi) Absorbency of the Tussar silk was evaluated by AATCC 39-1980 Test Method.

(vii) Tensile and elongation properties were tested using a Universal Tensile Tester (Tinius Olsen, H5K-S UTM, USA) using ASTM D 5035 (Strip method).

(vii) The dyeing characteristics, in terms of K/S values of dyed Tussar silk fabric, was measured by the Spectrascan-5100+ (Datacolor International, USA) computerized color-matching system. The illuminant was D65 at 100 standard observers, and the K/S was calculated by Kubelka Munk (Equation 4).

$$K/S = \frac{(1-R)^2}{2R} \quad (4)$$

Where, K, S and R stand for the absorption coefficient, scattering coefficient, and reflectance, respectively at complete opacity of the dyed sample.

(viii) The hand feel was tested by a subjective evaluation method, which is generally used in industries where experienced people from textile backgrounds give ratting.

(ix) The FTIR spectra of the fabric samples were assessed in the range of 4000–500 cm−1 by Shimadzu ATR spectrophotometer.

(x) Microscopic images were taken by Laser Image analyzer Optical microscope (OLS5100 laser microscope).

4. Results and Discussion

4.1 Characteristics of Sapindus extract

Table 1 lists the specific properties of Sapindus extract based on the parameters investigated and compares them to commercial soap used in the industry. Figure 1 is a picture of the height of the emulsified layer taken during the measurement of the emulsification index. Commercial soap and sapindus extract have the same characteristics except for surface tension. The brownish, mildly acidic sapindus extract, consisting of a chemical compound, namely saponin, exhibits good emulsification potential, which is necessary for emulsifying sericin during silk degumming, as indicated in Table 1. Sapindus extract helps to minimise hydrophobicity and quickly wet out the fabric surface for effective gum removal since it has a surface tension of roughly 41.75 dynes per cm, significantly lower than water surface tension (72.8 dynes per cm). The foaming tendency of Sapindus extract is within the industry-accepted tolerance limit of 170 mm [18].

Table1: Characteristics of commercial soap and Sapindus extract

Parameters	Commercial soap (10 g/l)	Sapindus extract (10 g/l)
Physical appearance	Cloudy liquid	Brownish liquid
Emulsification index(E24)	58	72
Surface tension (σ)	28.7	41.8
pH	10.2	5.3
Foam height (mm)	95	170

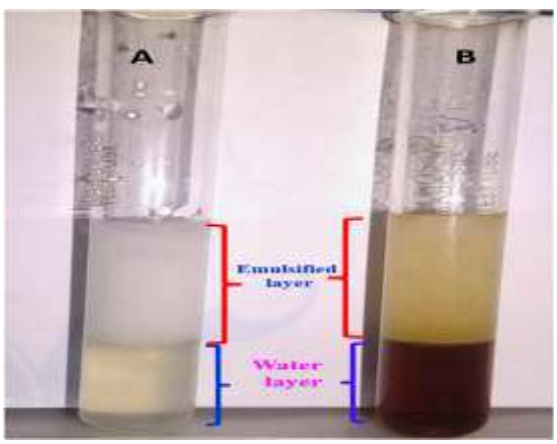

Figure 1: Emulsification index of Sapindus extract, A. Commercial Soap B. Sapindus extract

4.2 Optimization using response surface methodology (RSM)

4.2.1 Box-Behnken Design

The Box-Behnken Design (BBD) was used to optimize the process variables such as Sapindus extract concentration, degumming time, and temperature. The suitability of trials for the desired performance evaluation was assessed using a linear process model for the Analysis of Variance (ANOVA). Table 2 illustrates the lower and upper limits of the process conditions selected for degumming Tussar silk fabric.

Table2: Process conditions with range for Sapindus extract degumming of Tussar silk

Run	Sapindus Concentration (g/l)	Time (min)	Temperature (^{0}C)	Weight loss (%)
1	5	40	100	5.0
2	5	30	80	3.2
3	10	30	60	4.2
4	5	50	80	3.3
5	10	40	80	5.1
6	10	40	80	3.7
7	15	30	80	5.1
8	10	50	60	4.8
9	10	40	80	4.8
10	15	40	60	4.6
11	15	50	80	6.7
12	10	40	80	4.9
13	10	50	100	5.8
14	10	30	100	5.3
15	5	40	60	3.9
16	15	40	100	6.8
17	10	40	80	3.3

The parameters of Sapindus extracts degumming for Tussar silk were optimized using design expert software. 17 experiments were carried out to optimize the process conditions for degumming Sapindus extracts; the results are summarized in Table 3 and Table 4, respectively.

Table 3: Design matrix of Sapindus extract degumming of Tussar silk

Symbol	Name	Unit	Lower limit	Upper limit
A	Sapindus extract concentration	g/l	5	15
B	Temperature	^{0}C	60	100
C	Time	Minutes	30	50

Table 4: ANOVA model results of Sapindus extract degumming of Tussar silk

Source	Sum of squares	df	Mean sq.	F-value	P-value	
Model	12.11	3	4.04	8.29	0.0024	significant
A-Concentration	7.41	1	7.41	15.23	0.0018	
B-Time	1.05	1	1.05	2.16	0.1655	
C-Temperature	3.64	1	3.64	7.49	0.0170	
Residual	6.33	13	0.48			
Lack of Fit	3.74	9	0.41	0.64	0.73	not significant
Pure Error	2.59	4	0.64			
Cor Total	18.44	16				
R^2	0.65					
Adjusted R^2	0.57					
Predicted R^2	0.45					
Adeq Precision	9.67					

Abbreviation: ANOVA, analysis of variance

The results indicate that the model F-value of 8.29 indicates that the model is significant. An F-value of this magnitude is only 0.24% likely to arise due to noise. P-values less than 0.05 indicate that model terms are significant [19-20]. In this case, A and C are significant model terms. Values greater than 0.10 indicate that the model terms are not significant. The F-value of 0.64 indicates that the lack of fit is insignificant compared to the pure error. A significant lack of fit f-value has a 73.46% chance of occurring due to noise. The predicted R^2 of 0.45 is in reasonable agreement with the adjusted R^2 of 0.57; i.e., the difference is less than 0.2. Adequacy of Precision measures the signal-to-noise ratio. A ratio greater than 4 is desirable. A ratio of 9.67 indicates an adequate signal. Therefore, this model was used to navigate the design space.

4.2.2 Regression Analysis

Design expert implementation could be approximated using an equation (5). The weight loss of Sapindus extract and degummed Tussar silk fabric can be predicted using the coding equation given below for all process parameters, such as Sapindus extract concentration, temperature, and degumming time.

$$\text{Weight loss \%} = +4.73+0.9625*A+0.3625*B+06750*C \quad \textbf{(5)}$$

Where A, B and C stand for Sapindus extract concentration, temperature and time, respectively.

4.2.3 Response Surface Plot

The set of experiments as per the BBD was analysed by the Response Surface Methodology (RSM) and represented in Figures 2, 3 and 4.

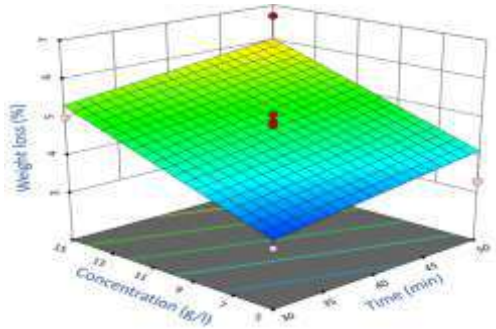

Figure 2: Optimization of Sapindus extract concentration and time

Figure 2 illustrates the relationship between Sapindus extract concentration and time on the weight loss of Tussar silk at a constant temperature. For the degumming, a fixed temperature of 80°C was chosen. The results show that longer treatment times and higher concentrations of Sapindus extract slightly improve the weight loss of degummed Tussar silk. Maximum weight loss on degummed silk was achieved in 35–45 minutes at 10–15 g/l Sapindus extract concentration.

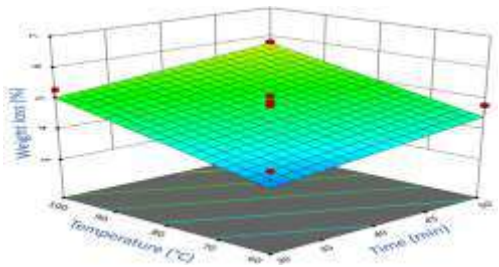

Figure 3: Optimization of temperature and time of degumming

Figure 3 then shows the effect of degumming duration and temperature on the weight loss of Tussar silk with a fixed concentration of Sapindus extract. According to the findings, degummed Tussar silk lost more weight as the temperature rose. The passage of time had little impact on it, though. The maximum weight loss was noticed between the temperature range of 80 to 100°C for the time of treatment in the range of 35 to 45 minutes.

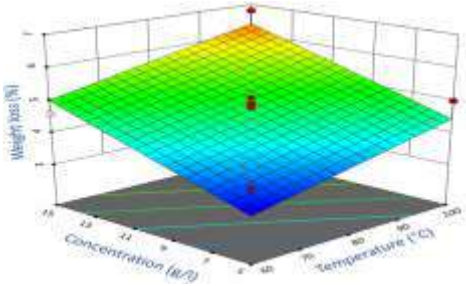

Figure 4: Optimization of Sapindus extract concentration and temperature

Figure 4 depicts how temperature and the concentration of Sapindus extract, used to degum Tussar silk, affect weight loss over a set time. The degumming time was set at 40 minutes, and it was found that when the temperature and Sapindus concentration rise, the weight loss of degummed Tussar silk increases. At 80-100°C and a Sapindus extract concentration of 10-15 g/l, maximum weight loss on degummed silk was achieved.

4.2.4 Optimization of Responses

The range of process parameters and their outputs (weight loss) is shown in Table 5. All process parameters and outputs were given the desired weightage to achieve the goal.

Table 5: Ranges of process parameters and their outputs

Name	Goal	Lower limit	Upper limit	Lower weight	Upper weight	Importance
A: Concentration (g/l)	Minimize	5	15	1	1	3
B: Time (min)	Minimize	30	50	1	1	3
C: Temperature (°C)	Minimize	60	100	1	1	3
Weight loss (%)	Is in range	5	6.5	1	1	3

The optimized recipe provided by Design of Experiments (DOE) for Sapindus extract degumming of Tussar silk is 12 g/l Sapindus extract at 830C for 34 min with 0.467 desirability.

4.3 Comparative assessment of Sapindus extract degumming and conventional degumming.

The parameters for evaluating Tussar silk using different methods of degumming are shown in Table 6.

Table 6: Comparative assessment

Parameter	Untreated	Alkaline degumming	Soap degumming	Sapindus extract degumming
Weight loss (%)	-	4.34	3.93	3.88
Absorbency (sec)	40	4	5	5
Tensile strength (Kgf)	15.34	9.83	11.26	11.86
Elongation (%)	28.36	33.83	30.67	29.10
K/S	2.72	3.79	3.33	3.77
Hand feel rating	1	4	5	5

In terms of weight loss, absorbency, tensile strength, elongation, and colour strength (K/S), Table 6 compares the performances of conventional methods, and the Sapindus extract degumming process. Tussar silk has had a more significant amount of gum reduction with alkali and shows more weight loss. The sericin coating on the silk filament makes it resistant to water penetration, but all degumming methods increase the silk's absorbency by removing the sticky covering. During alkaline degumming, the sericin that connects the silk filaments was eliminated to a greater extent, which may have caused a more considerable reduction in tensile strength, from 15.34 to 9.83 kgf. Since the silk polymer's hydrogen bonds and chain structure are unaffected by degumming with Sapindus extract, the tensile strength is less affected [6]. In all degumming methods, the elongation percentage increased with increasing weight loss. As seen in Figure 5 and Table 6, the alkaline-degummed fabric is darker and exhibits a similar dye absorption to Sapindus extract degumming. A higher sericin clearance rate improved the affinity of dye molecules for the fibroin of silk during alkaline degumming. Comparatively speaking, the alkaline-degummed fabric felt harder and stiffer than the fabric degummed with Sapindus extract and soap.

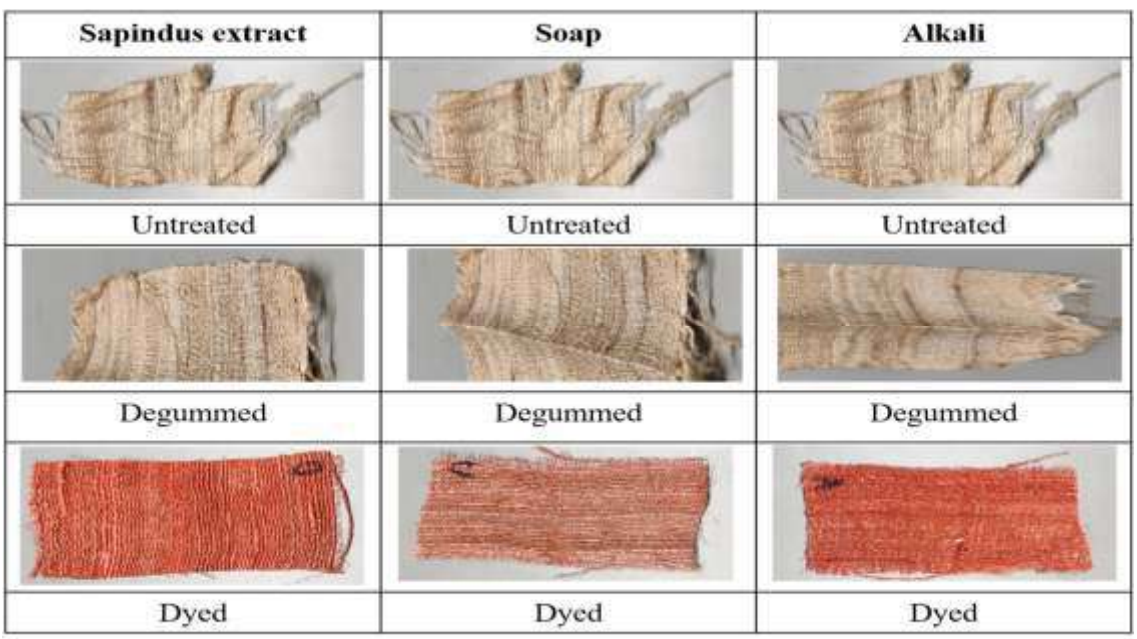

Figure 5: Pictures of untreated, degummed and dyed Tussar silk fabric of all degummed methods

4.4 Microscopic and Structural characteristics of degummed silk

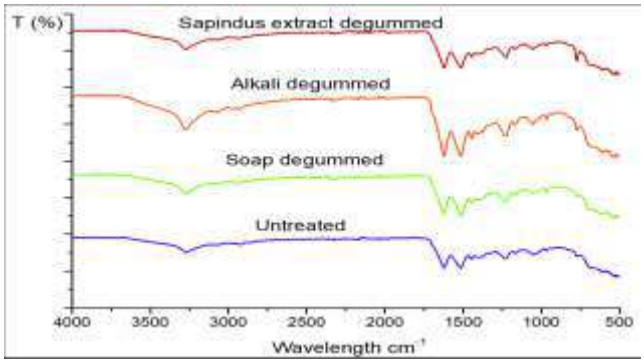

Figure 6: FTIR spectra of untreated, soap, alkali and Sapindus extract degummed Tussar silk

Figure 6 shows an FTIR analysis of structural alterations in Tussar silk that has been conventionally and Sapindus extract degummed. Absorption bands related to the β -sheet structure at around 1625 cm-1 (amide I, C-O stretching) and 1514 cm-1 are related to random coil conformation (amide II, N–H bending)[6]H bending)[6]. Tussar silk that has been degummed exhibits only slight modifications, including acidic O-H stretching at 2850 cm-1[27]. As a result, even after degumming, silk's molecular structure generally appears to be the same. After degumming the laser micrograph in Figure 7 indicates regularities on the surface of the Tussar silk; these regularities may result from the removal of surface-adhered detritus of sericin gum and non-proteinaceous material.

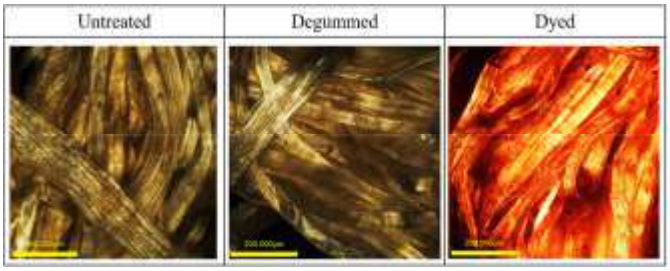

Figure 7: Microscopic images of untreated, Sapindus degummed and dyed Tussar silk fabric

5. Conclusion

In this study, an attempt is being made to establish a Sapindus soap-extracted degumming technique for Tussar silk. To focus on sericin removal, we looked at the absorbency, dye absorption, and hand feel of degummed Tussar silk fabric. The Sapindus extract degums the fabric, giving it a silky, smooth feel and increasing its absorbency and colour uptake without impairing the inherent strength and mechanical properties of Tussar silk fabric. After degumming, there is no change in functional groups observed in the FTIR spectra, and when viewed under a laser microscope, it showed a clean clear surface without any deformation. The exhaustive comparative results indicate that the basic objective of this study in terms of developing an environmentally friendly Tussar silk degumming process is achieved. The commercial viability needs to be ascertained.

6. Acknowledgement

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Preserving Heritage Textiles - Developing Novel Preservative Fabric for Long-Term Conservation

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Abstract:

Textiles are very delicate and hard to preserve, especially in tropical countries like India, due to the ease with which they can be damaged and the rate of deterioration. Natural fabrics such as cotton, linen, jute, leather, silk, wool, and others, being made up of cellulose and proteins are attractive to microbes, resulting in biological deterioration. Some natural compounds, such as essential oils, can act as biocides, like Azadirachta Indica (commonly known as neem) which has a broad-spectrum antimicrobial action. This study aims to create fabric that will preserve historical textiles when used as a wrapping material in museum storages, lining, backing, and covering material for shelving, drawers, and boxes, and as padding for hangers and rollers used for exhibits. For that purpose, neem essential oil nanoparticles of an average size of 189 nm with 78% entrapment efficiency (EE) and 8.83% loading capacity (LC) were formulated using nano-emulsion and ionic gelation technique and applied to cotton and polyester fabric to give them antibacterial properties. SEM analysis was also performed to understand the surface structure of the nanoparticles. Additionally, stability of the nanoparticle coated fabric over a time period of two months in different storage conditions was also tested. The study also compares the efficiency of the finish applied on cotton and polyester fabric.

Keywords: *Deterioration, Essential oil, Heritage textiles, Nanoparticles, Preservative fabric*

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1. Introduction :

Textiles are integral to the lives and customs of people from all cultures, and a museum collection typically displays objects that document the past and present of human life, cultural values, and artistic creations. Many traditional textiles are made from natural fibers, which make them vulnerable to degradation due to a range of biological, chemical and physical factors, such as light, temperature and humidity levels, dust, mishandling, and improper restoration methods [1]. This is especially true for cellulose, silk, and wool fibers, as they provide a favorable environment for microorganisms, insects, and other living organisms. These variables often result in discoloration, brittleness, corrosion of metallic components, a sweet or musty odor, and small irregular holes, which accelerate aging and result in irreversible damage [1,2]. In order to protect textiles from damage, conservators and curators utilize natural and synthetic compounds as biocides and insect repellents. In India, a traditional practice for preserving textiles involves using herbs and spices like clove, cinnamon, carom seeds, camphor, neem leaves, tobacco, tulsi, and eucalyptus [3,4,5]. Although these substances have biocidal and insect repellent properties due to the presence of active compounds, they do not create an extensive protective environment over a large circumference area. Additionally, these compounds are sensitive to light and cannot be applied directly to fabrics or surfaces. Nano encapsulation of essential oils is a potential solution to this issue, as it allows for controlled release of the active compounds and protects them from oxidation and UV degradation [6]. In encapsulation, chitosan, a polysaccharide derived from chitin has been used widely as a wall material. A cross-linking agent is usually employed as a connection between the ionic polymer and the ion with an opposite charge to create nanoparticles.

This research is conducted with the goal of forming chitosan nanoparticles with neem essential oil, utilizing tripolyphosphate (TPP) for cross-linking. This finish is then coated on a separate fabric for the purpose of wrapping, or using as a lining, padding, or to cover the heritage textiles. This comprehensive approach of having antimicrobial agents leach out of the fabric is necessary for slowing down the degradation process and preserving the distinctive characteristics of heritage textiles and making sure they remain intact for future generations.

2. Materials and Methods

2.1 Materials

Neem oil was purchased from Sigma Aldrich Co. Chitosan well known for its use in encapsulating essential oils and its antimicrobial and mucoadhesive properties, was chosen as the wall material/shell due to its great matrix capabilities. A medium molecular weight chitosan of 84.8% degree of deacetylation purchased from HIMEDIA was selected for the study. Tripolyphosphate (TPP), Tween 80, Glacial acetic

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acid and solvents such as Dichloromethane, Methanol were also purchased from Sigma Aldrich Co.

2.2 Preparation of neem essential oil chitosan nanoparticles

A two-step process of Nano-emulsion and Ionic gelation was used to make nanoparticles with an essential oil core and a chitosan polymeric shell. Figure 1 outlines the procedure. Dissolving chitosan in 1% acetic acid (v/v) and stirring the solution on a magnetic stirrer for eight hours at 25 °C ensured complete dissolution. Afterward, Tween 80 surfactant with different concentrations (0.5, 0.75, 1, and 2%) was added to the chitosan solution and was left to stir for one hour. Different chitosan/essential oil ratios (1:1, 1:2, and 1:3) were then prepared in 10 ml of dichloromethane by adding the oil and solvent solution to the chitosan surfactant solution drop by drop using a syringe. This mixture was stirred on a high shear homogenizer at 13000 RPM for 10 minutes and then agitated on a magnetic stirrer at 1800 RPM for two hours until the solvent evaporated completely. Subsequently, different concentrations (1, 2, and 3 %) of tripolyphosphate (TPP) were added to the solution drop wise using a syringe and stirred for one hour.

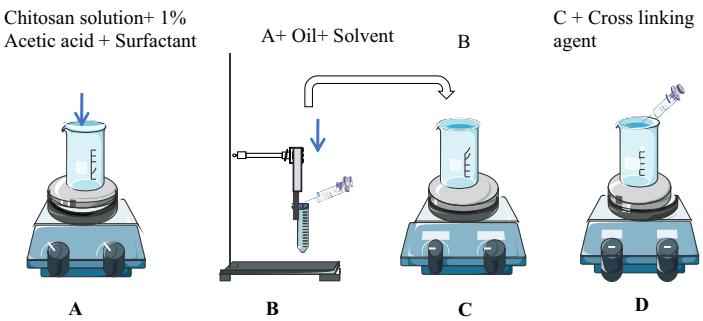

Figure 1: Nano-emulsion and Ionic gelation method of preparation of nanoparticles

2.3 Characterization of nanoparticles:

For determining the entrapment efficiency and loading capacity, in 100 µL of freshly prepared essential oil loaded chitosan nanoparticles, 900 µL of the solvent suitable for the essential oil was added to make up 1 ml. This solution was then centrifuged at 18000 rpm for 30 min. The supernatant was separated to estimate drug loading efficiency. Further, the free amount of oil was calculated by measuring the absorbance of all the essential oils at its significant wavelength (nm) using UV–vis spectrophotometer. This was then compared with their standard curve. The drug encapsulation efficiency and drug loading capacity were calculated using the formula below:

$$Entrapment\ efficiency\ (EE) = \frac{Total\ oil - Free\ oil}{Total\ oil}\ X\ 100$$

$$Loading\ capacity\ (LC) = \frac{Total\ oil - Free\ oil}{Total\ content}\ X\ 100$$

100 µL of freshly prepared nanoparticles was centrifuged at 18000 rpm for 15 minutes. The supernatant was diluted with distilled water to a concentration of (1 mg/mL), and viewed under a Zetasizer by Malvern in order to assess the particle size through dynamic light scattering (DLS).The nanoparticles obtained at optimized conditions were lyophilised and observed under SEM to understand the surface structure. The Minimum Inhibitory Concentration (MIC) was then calculated using two-fold dilutions in a 96-well plate containing Mueller Hinton broth (MHB). A series of dilutions of the nanoparticles (125 ppm) were prepared in a 96-well plate using Mueller Hinton broth (MHB). Bacterial suspensions were created and diluted in MHB until a turbidity of 0.5 McFarland was achieved, then added to each well. The plates were then incubated at 37°C for 24 hours. The lowest concentration that prevented visible growth of the test strains were then applied to scoured cotton and polyester fabrics with a citric acid binder via spraying and padding. The antibacterial activity of the fabrics was assessed using the AATCC 147 Parallel streak method against Bacillus cereus, Staphylococcus aureus, Pseudomonas, and Escherichia Coli. The stability of the nanoparticles was tracked over a time period of two months in different storage conditions. 2X2 cm of the nanoparticle coated cotton fabric was evaluated for 1 and 2 months. One set of samples was kept in a closed environment in a large petri dish, while the other set was exposed to an open environment at 25 ± 2°C. The amount of oil released from the nanoparticle-coated samples was determined by soaking them in a suitable solvent for 24 hours, and the absorbance was calculated using a UV spectrophotometer at278 nm and compared to that of the initial sample.

3. Results and Discussion

Neem essential oil chitosan nanoparticles were prepared using nano-emulsion followed by ionic gelation method. Chitosan was selected as a wall material to encapsulate the essential oil because of its ability of being biodegradable, cationic charge and being muco-adhesive nature proving best candidate to encapsulate. Negative charge TPP was used as a cross-linking agent to form the nanoparticles. It is important for the nanoparticle system to be successful that it has high entrapment efficiency, which allows the drug to be administered at smaller or more effective doses while reducing the amount of matrix components [6]. Therefore, the effect of change in the amount of chitosan, neem essential oil, Tween 80, and TPP was optimized based on highest entrapment efficiency of the neem essential oil observed in the nanoparticles.

3.1 Effect of Chitosan concentration on entrapment efficiency

By varying the chitosan concentration between 0.5, 1, 1.5 and 2 % while keeping the surfactant and TPP constant at 0.75% and 1% respectively. The percent entrapment efficiency of the neem essential oil was seen to be highest at 1% concentration with 79.24 ± 2.34 (Figure 2A). There was an increase of 7% in entrapment when compared to 0.5 % concentration, suggesting that with the increase of polymer, more oil could be encapsulated in the emulsion. However,

further increase of chitosan concentration led to decreased entrapment efficiency. This could be attributed to the increased viscosity of the solution caused by the higher concentration of polymer, which impeded the formation of the emulsion. Nguyen,G., and Le, X. (2021) noted a similar trend for Palmarosa essential oil encapsulated with chitosan; the efficiency of encapsulation increased from 22.8% to 34.0% when the concentration of chitosan ranged from 5.0 to 10.0 g/L, then decreased to 26.1% at 12.5 g/L [8].

3.2 Effect of % surfactant on the entrapment efficiency

Tween 80 was added at different concentrations (0.5, 0.75, 1, and 2%) to the chitosan solution. Tween 80 is a non-ionic surfactant that aids in the formation of a uniform oil dispersion by reducing the interfacial tension between the oil and the aqueous phase. This allows for a greater degree of oil droplet formation and stabilization, resulting in improved entrapment efficiency. Sun, W., et al. in their research demonstrated that when tween 80 is added, it results in a minor increase in the effectiveness of the encapsulation [9]. This occurs because tween 80 is adsorbed onto the surface. As observed in figure 2B, the encapsulation efficiency had an initial growth from 71.55 % to 80.36% which could be because of the adsorption of Tween 80 which might have caused decrease in surface tension leading to high entrapment efficiency. However, reduction to 64.61% and 54.38% at %1 and 2% surfactant concentration was observed with further increase of Tween 80. Formation of foam was noted by the researcher with the increase in 2% of Tween 80. This might have caused a barrier around the nanoparticles, leading to less entrapment efficiency.

3.3 Effect of polymer: oil ratio on entrapment efficiency

Oil concentration is one of the factors that affect the entrapment efficiency of oil-loaded nanoparticles. Three different concentration of neem essential oil was used to encapsulate with 1% chitosan concentration. the highest entrapment efficiency was observed at 1% oil concentration (78.65 ± 1.28), according to the figure 2C. As the oil concentration increased to 2% and 3%, the entrapment efficiency drastically decreased to 69.36 ± 2.54 and 62.12 ± 2.71, respectively. This decrease in efficiency at higher oil concentrations can be attributed to the oil droplets becoming more difficult to encapsulate within the nanoparticle matrix. With higher oil concentrations, the likelihood of oil droplets coalescing or merging increases, leading to larger droplets that are more challenging to encapsulate. This ultimately reduces the overall efficiency of the encapsulation process, resulting in lower entrapment efficiency. Several studies have investigated the effect of oil concentration on the entrapment efficiency of oil-loaded nanoparticles. For example, a study by Wong et al. (2010) investigated the effect of oil concentration on the EE of poly (lactic-co-glycolic acid) (PLGA) nanoparticles loaded with curcumin. They found that the EE decreased from 75% to 50% as the oil concentration increased from 0.5% to 2.5% (w/v) [11].

3.4 Impact of % TPP on the entrapment efficiency

Three concentrations of TPP (1,2, and 3%) was added as a crosslinking agent to the chitosan neem oil solution. The entrapment efficiency of 78.65% was highest when 1% of TPP solution was added as a crosslinking agent to the chitosan neem oil solution (Figure 2D). This could have been caused by the presence of a greater amount of cross-link bonds, which enhanced the amount of oil inside the chitosan capsules. As the concentration of TPP was increased to 2 and 3%, the encapsulation efficiency decreased to 69.36% and 62.12% respectively. This could be due to the formation of a more compact and cohesive structure, leading to a reduction in the size of the pores [8].

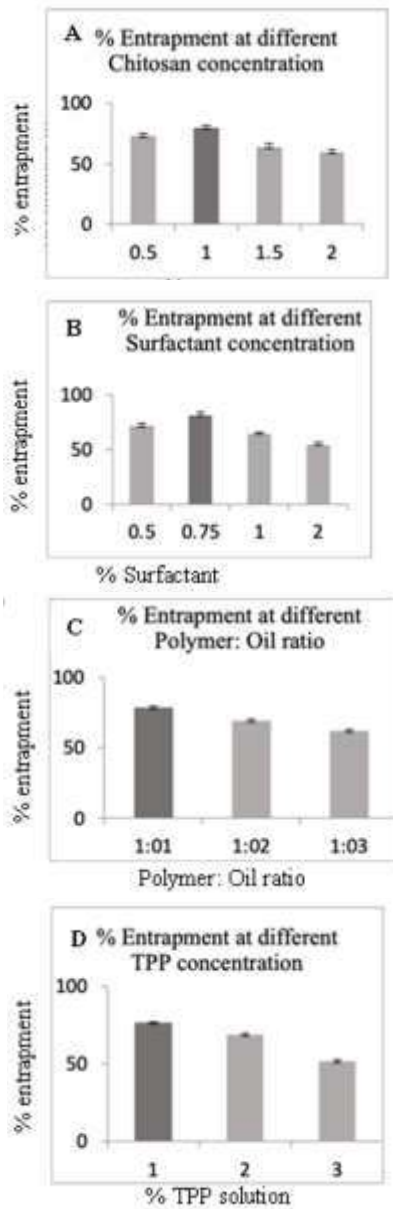

Figure 2: Impact of different parameters on entrapment efficiency of neem essential oil (Fig. 2A: %entrapment efficiency at different chitosan concentration, Fig.2B: % entrapment efficiency at different surfactant concentration, Fig. 2C: % entrapment efficiency at different oil concentration, and Fig.2D: % entrapment efficiency at different TPP concentration)

Table 1: Characteristic features of neem essential oil nanoparticle at optimized conditions

Essential oil Nanoparticles				Results						
Polymer: Oil Concentration	Surfactant (Tween 80) %	TPP %	RPM	Size (nm)	% EE	% LC	Antimicrobial Activity in Zone of inhibition- (mm) for cotton fabric			
							BC	SA	EC	PD
1:1	0.75	1	13000	189 ± 26	78.42 ± 1.56	8.83± 1.24	2.25 ±0.5	1.45± 0.39	0.57± 0.32	0.65± 0.3

3.5 Characterization of the neem essential oil chitosan nanoparticles

The neem essential oil chitosan nanoparticles obtained at optimized conditions when observed under scanning electron microscope showed spherical structures, absence of cracks and formation of a continuous wall layer (Figure 3). The average size of the nanoparticles was observed as 189 ± 26 nm. The average polydispersity index (PDI) detected was 0.2±3 using zetasizer, suggesting that the majority of the nanoparticles in the samples are relatively uniform in sizeWhereas, the loading capacity was8.83±1.24.Table 1 represents values that are the mean of triplicate measurements of the entire test performed.

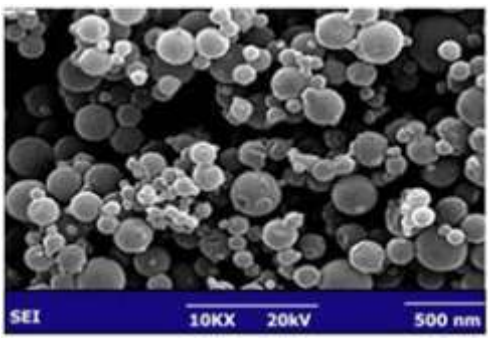

Figure 3: SEM image of Neem oil chitosan nanoparticles

3.6 Antibacterial assessment

The test bacteria used in this study includes two Gram-positive bacteria Bacillus cereus (BC), and Staphylococcus aureus (SA) and Gram-negative bacteria Escherichia coli (EC), and Pseudomonas (PD). Table 1 shows that the largest zone of inhibition observed was 2.25 mm against Bacillus cereus (BC). Figure 4 displays the antibacterial activity of neem chitosan nanoparticle-treated cotton fabric (on the left) and the no bacterial repellency on polyester fabric (on the right), as indicated by the absence of a zone of inhibition indicating no absorbance of the finish on the polyester fabric because of its hydrophobic nature. Staphylococcus aureus displayed 1.45 mm of inhibition, while both Gram-negative bacteria exhibited very little zone of inhibition. The limited zone of inhibition observed in Gram-negative bacteria may be attributed to their rigid and complex outer membrane, hindering the diffusion of hydrophobic compounds through it. In contrast, Gram-positive bacteria lack this extra complex membrane and instead have a wall that is not dense enough to resist small antimicrobial molecules, allowing for easier access to the cell membrane [10].

3.7 Effect of storage conditions on % oil retention

The % oil retention of neem chitosan nanoparticle treated cotton fabric was assessed with regards to its end use in both open and enclosed environments such as drawers or shelves, at room temperature referring the closed and open petri dish condition. The calculation was done after two months and compared to the initial zero time (after nanoparticle preparation). The findings revealed that the treated fabric samples that were kept covered in a petri dish demonstrated better stability compared to the ones left uncovered and exposed to the environment. The nanoparticles showed a 2.7% change in entrapment efficiency after two months in a covered condition and a 12.8% change in uncovered conditions.

Figure 4: Activity of Neem chitosan nanoparticle against Bacillus cereus on treated cotton fabric (left) and polyester fabric (right) side of the petri dish

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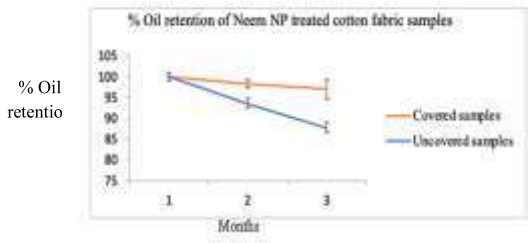

Figure5: % oil retention of the treated cotton fabric when stored in both covered and uncovered conditions

4. Conclusion

Neem essential oil was successfully loaded in the chitosan nanoparticle. As mentioned by Supraba, W., et al.,the good percentage of entrapment efficiency has to be more than 60% [7], the current study has observed entrapment efficiency of 78.42 ± 1.56 % with 189 ± 26 nm as an average size of the nanoparticle. The treated cotton fabric showed satisfactory antibacterial activity. Due to the control and release mechanism, the finish showed satisfactory stability in an open environment. Thus, the treated cotton fabric can be use as a preservative fabric for covering heritage textiles to protect from microbes. The fabric can also be used as a backing or a lining material when stored flat in shelves or drawers or as a padding on hangers and rollers. By doing so, it prevents direct application of the finish causing stress to the ancient textiles and helps preserve them for future generations.

5. Acknowledgement

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Fashion Sustainability & Tech-Intelligence in the AI Era

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Artificial Intelligence (AI) is more than just a tool. It is a transformative force that changes the way fashion is produced, promoted and consumed. Fashion professionals, businesses, and consumers need to stay on top of these trends. AI boasts the capacity to handle enormous data volumes and generate valuable business insights, leading to time savings, error reduction, cost minimization, and support for existing business operations (Mohapatra et al., 2018; Mohapatra, 2019). It's reshaping the way fashion is designed, produced, marketed, and consumed by leveraging computer algorithms and machine learning to perform tasks typically requiring human intelligence.

The introduction of AI technology has facilitated a shift towards customization and personalized manufacturing, driven by insights gathered from social media and user-uploaded data. This approach bridged the gap between online and offline shopping experiences, enriching the customer journey.

AI encompasses a set of technologies enabling computers and machines to mimic human intelligence. These capabilities include learning from data, recognizing patterns, making decisions, understanding natural language, and solving complex problems. Artificial Intelligence, often abbreviated as AI, encompasses several specialized domains, each with its unique focus and applications. These subfields include machine learning, computer vision, natural language processing, and data analytics.

Recent collaboration between Tommy Hilfiger and IBM on the 'Reimagine Retail' project represents a remarkable fusion of fashion and AI technology, leading to a mutually beneficial partnership that enhances both education and the customer experience. By providing fashion students with access to IBM's AI technology, including natural language processing (NLP) and computer vision, the project empowered these students with valuable technical skills that are increasingly relevant in today's fashion industry. Through deep learning and exposure to various AI and machine learning capabilities, including visual and voice recognition, social media listening, tone analysis, personality insights, and natural language understanding, the students gained a comprehensive understanding of how AI could be harnessed to innovate in fashion design and optimize the overall customer experience. This practical knowledge allowed them to craft creative, personalized outfits that catered to individual tastes and preferences.

The pilot concept shop launched at Hong Kong Polytechnic University's campus in collaboration with Alibaba's fashion AI project showcased the potential of computer vision and human fashion expertise working hand in hand. The inclusion of smart racks, smart mirrors, and next-generation fitting rooms demonstrated the integration of cutting-edge technology into the fashion retail space.

It's important to remember that while AI can significantly boost productivity in some design and production areas, it still lacks human creativity. The collaboration between designers and AI allows for a harmonious blend of both, enabling designers to showcase their unique creative abilities while leveraging AI's capabilities for more efficient and complementary design processes.

AI-Driven Design and Creativity

AI's uses in the fashion sector encompass every aspect of the industry, spanning from the creative design process to manufacturing, marketing, and the overall retail experience.

As AI continues to evolve, it offers fashion professionals new tools and strategies to meet consumer demands, improve sustainability, and enhance customer engagement. AI-driven fashion design is revolutionizing the creative process by furnishing designers with data-backed insights, inventive ideas, swift prototyping abilities, and tailored design choices. The fashion world is currently going through a remarkable change, blending the creative expertise of human designers with the computational capabilities of AI. This fusion is giving rise to fashion designs that are not only more creative but also environmentally friendly and tailored to individual preferences.

- Fashion by Algorithm : AI-driven design tools and generative algorithms have become indispensable aids to fashion designers. These sophisticated tools meticulously analyse extensive datasets encompassing fashion trends, historical designs, and consumer preferences, generating fresh, personalized fashion concepts that inspire designers to explore novel possibilities, streamline their creative processes, and expedite the introduction of new collections to market. The fashion sector is progressively turning to algorithms and AI to make operations more efficient, improve the customer journey, and keep pace with the ever-changing market landscape.

- Recommendation Engines: Online fashion retailers like Amazon, ASOS, and Zara utilize recommendation algorithms to suggest products to customers based on their browsing history, purchase behaviour, and preferences. These algorithms scrutinize extensive datasets to furnish personalized product suggestions, enriching the shopping journey and bolstering sales.

- Personalized Styling: Subscription-based fashion services like Stitch Fix employ AI algorithms to curate personalized clothing selections for customers. By considering individual style preferences and body measurements, these algorithms create customized fashion boxes tailored to each customer's taste.

- Trend Forecasting: Fashion labels and retail companies utilize predictive analytics algorithms to anticipate trends and gauge consumer demand. By analysing social media trends, search engine queries, and historical sales data, companies can make informed decisions about which styles and products to produce and stock.

- Virtual Try-Ons: Augmented reality (AR) and computer vision algorithms enable virtual try-on experiences. Customers can use their smartphones or computers to "try on" clothing virtually, visualizing how garments will look on them before making a purchase. This technology enhances confidence in online shopping and reduces returns.

- Supply Chain Optimization: Algorithms are employed to enhance several aspects of the supply chain, such as predicting demand, managing inventory, and handling logistics more efficiently. These algorithms help fashion companies minimize overproduction, reduce costs, and ensure efficient resource allocation.

- AI-Generated Designs: Some fashion brands experiment with AI-generated designs. Algorithms analyze vast design databases and consumer preferences to create unique fashion items. Although human designers often refine these designs, AI contributes to the ideation process. AI-powered tools assist fashion designers in generating creative ideas and designs. These tools can analyse fashion trends, historical data, and consumer preferences to suggest design elements and combinations.

- Pricing Optimization: Dynamic pricing algorithms adjust product prices in real-time based on factors like demand, inventory levels, and competitor pricing. This ensures that prices remain competitive and reflect market conditions.

- Consumer Insights: Social listening algorithms monitor social media conversations and sentiment around fashion brands and products. This data helps brands understand consumer sentiment and adjust marketing strategies accordingly.

- Quality Control: AI-driven computer vision algorithms have the capability to examine clothing items in the production phase to spot any flaws or inconsistencies, thereby upholding uniform quality standards.

Personalization and Customer Experience

AI is personalizing the fashion shopping experience like never before. Leveraging recommendation engines, virtual try-on technologies, and personalized styling suggestions, AI tailors fashion selections to individual preferences. This not only heightens customer satisfaction but also drives sales and cultivates customer loyalty.

Personalization: Individualized Recommendations: AI-driven recommendation systems analyze vast datasets encompassing consumer shopping behaviours, preferences, and past purchases to deliver customized product recommendations. This not only enhances the likelihood of successful purchases but also enriches overall customer satisfaction.

Tailored Content: AI tailors website content and email marketing campaigns to individual preferences, showcasing products and content that align with the customer's style and interests.

- Dynamic Pricing: AI can personalize pricing based on a customer's browsing history, location, and other factors, optimizing pricing strategies for maximum conversions.

- Virtual Try-Ons: AI-driven virtual try-on tools enable customers to see how clothing and accessories will appear on them before committing to a purchase, addressing the common online shopping apprehensions related to fit and style.

- Improved Decision-Making: Virtual try-ons enable customers to make more informed choices, reducing the likelihood of returns and exchanges and enhancing overall satisfaction.

- Augmented Reality (AR): Some fashion brands leverage AR to create immersive virtual try-on experiences, where customers can see themselves in various outfits via their smartphones or other devices.

- **Recommendation Engines:** Behavioural Analysis: AI analyses user behaviour on e-commerce platforms to understand their preferences, such as style, brand affinity, and budget.

- Collaborative Filtering: Recommendation engines use collaborative filtering techniques to suggest products based on similarities with other users who share similar preferences.

- Content-Based Filtering: AI also employs content-based filtering to recommend products with attributes that match the customer's previous choices.

- Real-Time Updates: These engines continuously update recommendations in real-time as customers interact with the platform, ensuring that suggestions remain relevant.

- Customer Insights: Data-Driven Insights: AI analytics provide fashion retailers with valuable insights into customer behaviour, enabling them to make data-driven decisions regarding product offerings, marketing strategies, and inventory management.

- Customer Segmentation: AI categorizes customers according to a range of characteristics, enabling brands to craft precise marketing campaigns tailored to specific demographics and preferences. The incorporation of AI into fashion retail is transforming the customer journey by providing tailored recommendations, facilitating virtual try-ons, and improving customer support via chatbots. This AI-driven personalization not only nurtures customer loyalty and contentment but also leads to higher sales and decreased returns, establishing itself as a critical element in contemporary fashion retail strategies.

Conclusion and Future Prospects

The current state of AI in the fashion industry represents a period of remarkable progress touching upon personalization, sustainability, design, and supply chain enhancement. AI has significantly enriched the shopping journey for consumers, equipped designers with cutting-edge tools, and championed sustainable practices.

In the present landscape, AI-powered personalization and recommendation systems have substantially elevated customer satisfaction and loyalty by offering tailor-made fashion choices. Simultaneously, designers have reaped the benefits of AI's support in crafting innovative and personalized fashion designs, expanding the horizons of creativity. The undeniable impact of AI on sustainability is evident, as it plays a pivotal role in promoting eco-friendly practices through supply chain optimization, waste reduction, and the advocacy for sustainable materials. Furthermore, AI's contribution to supply chain efficiency has translated into cost savings and more responsible resource allocation, rendering the fashion industry more efficient and sustainable.

Looking ahead, the future holds tremendous promise for AI in fashion. Collaborative design efforts between AI and human designers will push creative boundaries, ushering in unprecedented fashion innovations. AI-driven virtual influencers are poised to play an increasingly prominent role in marketing and customer engagement, heralding a new era in brand interactions. Sustainability will continue to be a focal point, with AI driving material innovation and the expansion of circular fashion initiatives. Moreover, educating consumers about AI's role in fashion will empower them to make informed choices, supporting ethical and sustainable brands, and ultimately shaping the industry's trajectory.

In summary, AI's imprint on the fashion industry is substantial, with the capacity to drive innovation, sustainability, and personalized experiences. Nevertheless, it is essential to address challenges such as data privacy and ethical considerations to fully unlock AI's potential while maintaining transparency and trust with consumers. The future success of the fashion industry hinges on the responsible integration of AI, a commitment to ongoing innovation, and collaborative efforts between industry experts and technology providers.

Bharat Trivedi

Surviving Recession: Smart Business Strategies with Innovation

Bharat Trivedi, Manager-Exports, Colorant Limited,

Introduction

Recessions are like unexpected storms that can hit any business, big or small. They bring economic challenges, reduced consumer spending, and uncertainty. However, successful businesses have shown that not only can you weather the storm, but you can also thrive during a recession. One key strategy is to embrace innovation.

In this article, we will explore how innovation can be a beacon of hope during tough economic times and the smart business strategies that can help your company not just survive but also flourish.

1. Adapt and Innovate – "Adapt to Thrive, Innovate to Excel!"

During a recession, consumer preferences and needs may change rapidly. To stay relevant, you must be ready to adapt and innovate. This could mean rethinking your products, services, or business models. Consider how your offerings can address new or evolving customer demands. Successful businesses pivot to align with the changing market landscape.

2. Cost Optimization – "Maximizing Efficiency, Minimizing Expenses"

Innovation isn't just about creating new things; it's also about finding more efficient ways to do what you already do. Look for areas in your business where you can reduce costs without sacrificing quality. This might involve process automation, supply chain optimization, or energy efficiency measures. These innovations can lead to substantial savings.

3. Market Research and Customer Focus – "Your Success, Our Priority"

Recessions often reveal hidden market opportunities. Conduct thorough market research to identify emerging trends and customer needs. Listen to your customers' feedback and use it to refine your products or services. Being customer-centric can set you apart from competitors and build customer loyalty, even in tough times.

4. Diversification and Risk Management – "Diversify for Strength, Manage Risk for Success"

Diversifying your product or service offerings and customer base can spread risk. If one area of your business is heavily affected by the recession, having other revenue streams can help offset losses. Innovation in this context involves exploring new markets or expanding your product range strategically.

5. Digital Transformation – "Digitalize for Progress"

The digital landscape is continually evolving, and it's essential to stay ahead. Invest in digital transformation to streamline operations and reach customers online. E-commerce, social media, and online marketing are avenues for growth, even in a recession. Embrace technology to enhance your business's resilience.

6. Talent and Training – "Talent + Training = Success"

Your employees are invaluable assets. Encourage a culture of innovation within your company. Invest in training to develop their skills and keep them engaged. Talented and motivated employees are more likely to contribute fresh ideas and help your business adapt to challenging circumstances.

7. Financial Prudence – "Smart Finances, Bright Future"

Sound financial management is critical during a recession. Innovate your financial strategies by closely monitoring cash flow, reducing unnecessary expenses, and exploring alternative financing options. Being financially prepared can help your business weather economic storms.

8. Partnerships and Collaborations – "Teamwork for Success"

Consider forming strategic partnerships or collaborations with other businesses. Pooling resources and expertise can lead to innovative solutions and shared costs. Such partnerships can open up new markets and revenue streams.

9. Expand Your Vision – "See More, Achieve More"

During a recession, the power of foreseeing and adapting to market changes is undeniable. Accurate forecasting empowers businesses to make informed choices, control risks, and grasp opportunities. The industry can greatly gain from adopting forecasting as a key strategy for success.

By recognizing the significance of forecasting and making it an integral part of our business, we can not only endure a recession but also set ourselves up for prosperity. Amidst uncertainty, it's the company's expanding their horizons through forecasting that emerge stronger and more resilient over time.

Conclusion

Surviving a recession requires resilience and innovation. By embracing change, optimizing costs, staying customer-focused, and leveraging technology, your business can not only survive but also thrive during economic downturns. Remember that recessions, while challenging, can also be times of opportunity. Smart business strategies combined with innovation can position your company for long-term success. So, during tough times, instead of retreating, advance with innovation, and emerge stronger on the other side.

Bharat Trivedi

Bharat Trivedi is an experienced international trade and export management professional with an MBA in International Trade from the International School of Business Management and a Master of Commerce degree from North Maharashtra University.

With over 22 years of industry experience, he currently serves as the Manager-Exports at COLORANT LIMITED, a leading manufacturer and exporter of Reactive Dyes.

Mr. Trivedi's contributions have led to significant export growth, earning the company numerous awards and recognitions from trade bodies and organizations. He has travelled to over 10 countries, enhancing his global understanding of Reactive Dyes markets.

Additionally, Mr. Trivedi is a sought-after speaker on international trade and export management and has actively participated in international exhibitions and technical seminars throughout his career.

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V. C. Gupte : The Golden Jubilee Journey into Colour Science

The art of making colour was known to humanity from pr-historic era, but to understand and explain the underlying principles of colour needs a 'Colours Guru'. And that 'Colours Guru' of this era is none other than Mr. Vilas Chandrakant Gupte, who has completed 50 glorious years with his passion for colours and colour technology. A Respected author of the path breaking book on Colour Technology, he is widely regarded as an authority and a pioneer in the field of computer colour matching and anything related with Colours.

It gives us pleasure to reproduce the interview given by Mr. V. C. Gupte which was published in Colourage, popular Plastics & Paint-India. We have taken the relevant portion to the textiles from this interview.

Q.: Can you share in brief, your illustrious career journey spanning from academia to research to industry to international.

Ans.: I started my career at Wool Research Association. I got an opportunity to work on 'Canary Coloration of Indian Wools' and jointly published 6-article series on the research work. I then initiated work on Computer Colour Matching for Indian Wools. The Bombay University computer department senior programmer, Mr. S. N. Baldota helped in developing the colour matching software with complete mathematics provided by my Director, Mr. (Late) A. D. Sule and myself. We presented a paper on the subject, the first by Indians in February 1973. In fact, it was beginning of my career in Computer Colour Matching. I completed 50 years in colour and colour science since then.

This Paper opened an opportunity for me to join Mafatlal Group in 1974 to work on the subject for the entire Group. From Research, it was good jump for industrial experience. This gave me a big opportunity to carry out extensive work on colour matching for cotton, polyester and their blends as well as use of the technique in dyes manufacturing. It was very challenging work, handling many textile processing problems. I worked for Mafatlal for 12 years.

I joined Milton Roy, USA as an application engineer for handling not only textiles, but also paints, plastics and other applications. I was based in Belgium at our European Laboratory Group. It was very high point in my career as from Indian Industrial experience, I jumped to international experience. I got total exposure to textiles, paints, plastics and automobiles industries. This international exposure gave me tremendous confidence to handle any colour problem, and my basics became very strong.

After working for Milton Roy, I joined Mr. Ravi Goyal, Advanced Graphic Systems and started from almost from 'A B C'. Ravi was really a great visionary and we both developed the team from mere 4 people to over 35. I helped the software team in developing colour software, 'NovaScan' and interphased with GretagMacbeth spectrophotometers. I am still with AGS and after 28 long association, would like to work further to build the successor.

Q.: Computer colour matching is now an established part of the manufacturing landscape. Could you share its beginnings in India as seen by you the initial years?

Ans.: The computer colour matching is over 60 years old now in textiles (for paints, it is over 50 years old). It is now very well established in India Textiles (paints) industries. There might be more than 2000 colour systems in India, in textiles, paints, plastics, automobiles, printing, packaging, soaps & detergents, cosmetics etc. Many industries have multiple systems. There would be hardly any colour industry which is not using colour system for their applications.

I remember when we first presented the paper at International Textile Conference in February 1973, while working at Wool Research Association, the delegates were spell-bound and had never thought that there could be such a thing for colour matching. Even the overseas delegates were wondering how and where we got the mathematics for the same, as it was not published. We used Bombay University IBM 1620 computer with 'punched cards' magnetic tapes, and exchangeable hard disks with 5.2 MB memory. I had used Log tables and slide rules for basic calculations during my M. Sc. Thesis, as even calculators with memory were luxury then.

To educate and train the colour chemists working in textiles and paints industries, I together with Dr. N. S. Gagakhedkar and Dr. Shalini Patwardhan (now deceased), formed Colour Group of India in 1977. Mr. Ashwin Dani was the first President of the Colour Group. It was also affiliated with the International Colour Groups, including Colour Group of Great Britain. We conducted several training programs to give basic knowledge to the colourists. We also jointly published two books on Fundamentals of Computer Colour Matching as the course material.

Q.: Your Book on Colour Technology is widely regarded as one of the best produced in not only in India, but also elsewhere. Could you share the inspiration and efforts that went into it?
Ans.: As I was teaching at some major engineering and technology institutes, I thought it would help & benefit the students as well as industrial colourists to understand the basics very well. The book should also help in solving or resolving industrial problems faced by the industrial colourists. So I decided to write the book accordingly. I kept the maths out of the book and also some high technical words out of the book. When a student understands the basics well, he/she can read and refer the other books which have covered the theory in great detail. However, no book has covered any applications, the way I have covered them.

Q.: How do you think the Industry and Research/Academia can better collaborate in mutual benefit?
Ans.: My observation is that nearly 99.5% colour systems used in the colour industries are just for colour difference, strength analysis and colour matching applications and not for any other work.

Today the major problem is getting qualified and trained man power for handling these advanced colour systems, which is one of the main limitation of effective use of the systems. There is tremendous shortage of skilled colour chemists, as this subject is not taught in any Indian technological institute, so the students do not get even the basic knowledge of colour theory.

I teach colour science now only at DKTE Institute, Ichalkaranji, M.S. Basically, the subject of colour science is not that easy, as there is more physics and maths involved. You have to make it simple and easy to understand with practical examples. When these students join the colour industries, they are totally ignorant about colour systems. I feel all technological institutes should have Colour Physics subject of 100 marks in their syllabus. Leave aside, research in this subject, first the basic knowledge should be imparted. The colour industries, particularly textiles, paints, plastics and automobiles should sponsor the subject at these universities by donating the systems and absorbing them in their companies.

I give you my experience. My Company established a Colour Science Laboratory by donating nearly US$ 100,000 at UDCT, Mumbai (now ICT) in 1999 and started co-guiding students for M. Sc. Tech as well as for Ph. D. and also maintained the lab for 5 years by adding new instruments. I was also teaching UDCT for textiles as well as paints/plastics students.

Q.: The Colour Museum is your dream project and you have been nurturing the idea of for the last more than 12 years. Can you please elaborate on the same?
Ans.: Yes. Setting up a Colour Museum is my dream project on which I am working for more than last 10 years. In reality, it is a Colour Science park. It would be a unique science centre for 'Entertainment, Education and Excitement' for the entire family to understand light, colour and vision. It can be built with the help from Colour industries and the State Government. The land required for it should be provided by the State Government. It would be quite different from conventional science centres. We can take help from international bodies like, Singapore Science Centre. It is nearly Rs 50 Cr project excluding land price. The complete concept is ready, once the land is plot is received, it would just take 2-3 years to build it. It should be built at the international standard.

Q.: What are the new developments and frontiers in the area of textiles in computer colour matching as seen by you?
Ans.: There are many new developments being introduced in the latest colour systems. You have now small hand held spectrophotometers which can be used at the production department to take quick decision whether the batch needs correction or not, which can reduce correction and obtain Right-First -Time. The systems can be used for making shift program by using Shade. Library type options. For standard shades at multiple manufacturing facilities, one can just transfer the data. The system is not used for Pass/Fail or Shade sort program. The statistical program for evaluating the performance of the production shades, performance of lab chemists, market analysis etc. are never used by any system user. The system should be fully exploited and not just for QC and colour matching alone.

Q.: Could you tell us about your other interests and achievements during this journey?
Ans.: I was involved in early 90s with a project on 'Identifying suitable colours for camouflage purpose in defense to protect it from IR spying cameras. I worked with Defense R & D lab for the work.

I am also involved in standardizing colours for the National Flag, though not nominated officially on the BIS-1 Committee. I have prepared a draft which is being circulated to the Committee members.

I am also involved in official capacity with BIS-5 standard for 'the Colours for Ready mixed paints and Enamels' for making standards, adding new colours for the Indian Paint industry.

I am involved in the Skill Council of India for Paints and Coatings for training the shop boys in handling the paint dispensers. I participated in a Webinar arranged by the Skill Council Team.

I was invited speaker at the Annual Conference arranged by the Computer Society of India (now NASSCOM) in 1983. The topic for the lecture was 'the development of Computer Colour Matching software'.

Being the Chairman of the Textile Association of India, Mumbai Unit, I got opportunity to organize several national and international conferences on very contemporary subjects. Some of the topics I covered included, 'Textile 4.0, Digitization Leading to Textile 4.0, Organic Cotton etc. I was fortunate to get renowned international speakers and also received overwhelming response from the delegates.

I am currently the Chairman of The Textile Association (India), Mumbai Unit since 2001-organized seminars and international 22 conferences till today. I was Honorary Trustee Treasurer of the Society of Dyers and Colourists, India 2009-2014; Vice-President, Marathi Vidnyan Parishad, Thane Chapter 2010-2019. I was nominated on International Colour Measurement Committee (CMC), UK by SDC, UK in the year 2012-2016 and also nominated as a Member on BIS Committee -5 on Setting up Colour Standards. I established Colour Standards for the National Flag BIS-1.

I was Awarded Chartered Colourist (C. Col) by the Royal Society of Dyers & Colourists, UK in 2006 and admitted as Fellow of the Royal Society of Dyers & Colourists (FSDC), UK in 2006. Awarded Silver Medal by the Royal Society of Dyers & Colourists, UK in 2009 "For Significant Contribution to the Advancement of Colour Science in India". I received Service Gold Medal by The Textile Association (India) for services rendered to the Indian Textile Industry.






TAI - Ahmedabad Unit

Special General Body Meeting - 10th July, 2023

Special General Body Meeting called by President of The Textile Association (India)-Ahmedabad Unit to amendments of some points in Memorandum (Rules & Regulations & By-Laws). During the meeting members of the association gathered to review and discuss about the existing memorandum and proposed amendments in the constitution of Association. Shri T. L. Patel, Trustee presented one by one proposed amendments and explained to the members. The special general body meeting concluded with the acceptance of the proposed amendments unanimously by the members.

Prize Distribution Function to Bright Students - 5th August, 2023

Special General Body Meeting called by President of The Textile Association (India)-Ahmedabad Unit to amendments of some points in Memorandum (Rules & Regulations & By-Laws). During the meeting members of the association gathered to review and discuss about the existing memorandum and proposed amendments in the constitution of Association. Shri T. L. Patel, Trustee presented one by one proposed amendments and explained to the members. The special general body meeting concluded with the acceptance of the proposed amendments unanimously by the members. The Textile Association (India) Ahmedabad Unit organised a prize distribution function Educational Awards Under: "Late Shri B. A. Shah Education & Welfare Fund and Other Donors. Association distributed 27 mementoes and 39 certificates to the selected qualified students of SSC/CBSE, HSC-Science & Commerce, Engineering (Chemical, BE, ME, B. Tech, M. Tech, Electrical, Computer, B. Sc & B. Ed) in the function. Dr. Minesh B. Shah son of Late Shri B. A. Shah handed over the certificates & mementoes. Shri Hirabhai J. Patel, Trustee also handed over the certificates & mementoes to the Textile Manufacturing & Technology pass out students of LDCE & RCTI, Ahmedabad. Every year association has been organizing this function to encourage the students.

Photo gallery of the prize distribution function

76th Annual General Body Meeting - 28th September, 2023

The 76th Annual General Body Meeting of The Textile Association (India) Ahmedabad Unit held on 28th September' 2023 at Dinesh Hall, Ashram Road, Ahmedabad Unit. The President Shri H. S. Patel presided over the AGM and conducted meeting as per the agenda. Apart from the agenda there was a declaration of Election of 14 seats for Managing Committee Members and 7 seats for Governing Committee Members for the term 2023-2027. Shri Hargovind R. Soneji, Election officer declared the results in the house and congratulated the elected members.

Election President & Vice President of the Association for the term 2023-2027

The house unanimously selected Shri Hasmukhbhai S. Patel as President and Shri Hirabhai J. Patel as Vice President for the said term.

PRESIDENT *VICE PRESIDENT*

Shri R. K. Vij, National President congratulated to Shri Hasmukhbhi S. Patel & Shri Hirabhai J. Patel by offering bouquet as selected New President & Vice President of TAI-Ahmedabd Unit

Selection three Board of Trustees for the period of 4 years (2023-2027)

The house unanimously selected to Shri T. L. Patel, Shri M. G. Shah & Shri M. T. Patel as Board of Trustees for the said period.

Shri H. S. Patel, President congratulated to all the three Board of Trustees by offering bouquet

CONGRATULATIONS

Office Bearers of THE TEXTILE ASSOCIATION (INDIA) - Ahmedabad Unit

For the term 2023-2027

PRESIDENT
Shri Hasmukhbhai S. Patel

VICE PRESIDENT
Shri Hirabhai J. Patel

CHAIRMAN
Dr. Ashwin Thakkar

VICE CHAIRMAN
Shri Rajeshkumar J. Shah

HON. TREASURER
Shri Jayantilal H. Patel

HON. SECRETARY
Shri Harish C. Shah

JT. HON. SECRETARY
Shri Hitesh V. Trivedi

JT. HON. SECRETARY
Shri Bhogibhai S. Patel

Governing Council Members of THE TEXTILE ASSOCIATION (INDIA) for the term 2023-2027

Shri Tulashibhai L. Patel

Shri Mahendrabhai G. Patel

Shri Hirabhai J. Patel

Shri Harishchandra C. Shah

Shri Damodarbhai I. Patel

Shri Ashokkumar D. Patel

Shri Hareshkumar A. Patel

Shri Shwetang R. Patwari

Trustees of THE TEXTILE ASSOCIATION (INDIA) - Ahmedabad Unit
For the term 2023-2026

Shri Tulashibhal L. Patel

Shri Mafatlal G. Shah

Shri Mahendra T. Patel

FELICITATION FUNCTION OF THREE PIONEERS

Founding Fathers of the Association

LATE SHRI P H. RAVAL & LATE SHRI B. A. SHAH

Shi H. S. Patel, President felicitated to the family members of Late Shri P. H. Raval

Shi H. S. Patel, President felicitated to the family members of Late Shri B. A. Shah

Shri H. S. Patel, President felicitated to the Shri T. L. Patel & his family members as Outstanding contributions, commitments and dedication in making the New Dinesh Hall

UNVEILING CEREMONY

THREE OIL PAINTING CANVAS (PO RTRAIT)

Group photograph of unveiled ceremony done by the hand of Shri H. S. Patel, President of TAI-Ahmedabad Unit

Birla Cellulose unveils new groundbreaking Circular Yarn Blend

Birla Cellulose, the division responsible for pulp and fibers within the Aditya Birla Group, stands as a prominent producer specializing in environmentally conscious Man-Made Cellulosic Fibers (MMCF), proudly announces the launch of its new groundbreaking Circular Fiber Blend. This innovative blend significantly enhances the proportion of mechanically recycled fiber to 50% while maintaining high-strength yarn, making it ideal for fabric and garment production across diverse categories.

The Circular Yarn Blend promises exceptional sustainability credentials, including recognition from the Global Recycle Standard (GRS) for PCW (Pre-& Post-Consumer Waste) materials, the Recycled Claim Standard (RCS), FSC certification, and High Index certification. It also incorporates blockchain technology, enabling full traceability of the yarn blend. Which also ensures the transparency and accountability throughout the supply chain. Furthermore, the mechanical recycling process used to convert PCW waste into fiber is chemical-free and the most energy-efficient process for sustainable yarn production.

This Circular Yarn Blend innovation offering by Birla Cellulose addresses multiple environmental concerns in the textile industry. Through mechanical recycling, the process minimizes energy consumption, making it highly energy-efficient. Additionally, it is eco-friendly and this method also have the lowest greenhouse gas emissions, significantly reducing their carbon footprint. Moreover, the process ensures minimal water usage throughout its lifecycle. An added environmental benefit is in-situ coloration, where recycled dope-dyed/mélange yarn negates the need for additional dyes or pigments, further lessening its environmental impact. This comprehensive approach underscores Birla Cellulose's commitment to sustainable and environmentally responsible textile production.

Mr. ManMohan Singh, Chief Marketing Officer, of Birla Cellulose adds “Birla Cellulose takes great pride in introducing an innovative approach to recycle mechanical textile waste, utilizing cutting-edge technology for both pre and post-consumer textile waste. As a team, we are deeply committed to fulfilling our social responsibility by addressing critical issues, minimizing water consumption, reducing energy usage, lowering greenhouse gas emissions, and embracing eco-friendly practices. Our goal is to create a sustainable environment, fostering eco-friendly practices. We are confident that this initiative will encourage the textile industry to adopt more sustainable options, meeting consumer demand while upholding the highest quality standards and sustainable practices."

Birla Cellulose's approach involves recycling mechanical textile waste, utilizing state-of-the-art technology to recycle pre and post-consumer textile waste. The resulting recycled fiber is expertly blended with Birla's proprietary cellulosic fibers, including VSF, Birla Modal, Excel, Reviva, and Dope Dyed, in a unique proportion. This innovative recipe produces a yarn blend containing an impressive 50% pre or post-consumer waste (mechanically recycled) fiber and 50% proprietary cellulosic fiber.

Birla Cellulose unveils new groundbreaking Circular Yarn Blend 01

Birla Cellulose unveils new groundbreaking Circular Yarn Blend 02

Rieter is raising the Bar with a New Generation of Draw Frames

Rieter is introducing a new generation of draw frames to the market. The new machines enable spinning mills to achieve the highest quality, productivity, and efficiency, even when processing recycled fibers. Innovations ensure stable running behavior for all raw materials and production speeds. The high sliver quality is an ideal prerequisite for the production of high-quality yarns.

Reliability is key in the production of sliver. The new generation of draw frames is more robust than ever. This ensures stable operation at highest quality and productivity. With the new draw frames – consisting of the single-head draw frames RSB-D 55 and SB-D 55 and the double-head draw frames RSB-D 27 and SB-D 27 – Rieter offers optimum solutions for a wide range of spinning mill needs.

Optimized for recycled fibers

Processing recycled fibers poses challenges like increased dust generation and a high short-fiber content. The new Rieter draw frames offer enhanced suction for cleanliness, even in the calender area, resulting in longer cleaning cycles and fewer thick places. When recycled fibers are processed, four-fold

Fig. 1 - Innovations in the new draw frame generation improve user-friendliness.

Fig. 2 - Reinforced power creel for enhanced robustness

doubling can be supportive. Here, an additional web nozzle improves web guiding and guarantees fault-free operation with a high short-fiber content. These optimizations bring advantages in the production of ring yarns with a high recycled fiber content. Moreover, recycled fibers can now be selected as an application in the expert system SLIVERprofessional, providing recommended settings for the entire machine based on raw material data.

User-friendliness at a new level

With an improved menu navigation and a convenient 10-inch display, operating Rieter draw frames is now even easier (Fig. 1). The SLIVERprofessional expert system provides suggestions for key setting parameters like coiler and can plate speed, as well as sliver spread before the drafting system. This allows quick material changeover and ensures excellent sliver and yarn quality.

New level of durability.

The new generation of draw frames ensures stable operation at the highest quality and productivity. Examples for this are new life-time lubricated top roller bearings and reinforced power creel rollers (Fig. 2). In addition, the drafting system has been improved thanks to a new force transmission which optimizes the load on the outlet cylinder.

Constant sliver quality

An innovative optional solution on the autoleveler draw frames RSB-D 55/27 keeps the sliver strength constant while stopping and starting the draw frame. It prevents the creation of a short length of sliver with around 50% lower sliver strength. This was previously unavoidable and occurred on all draw frames. When processing combed cotton on the roving frame, this can lead to undesirable incorrect drafts.

Fewer sliver breaks

The autoleveler draw frames also offer a unique solution to avoid blockages in the coiler tube caused by temperature fluctuations or bulky materials. A single-motordriven coiler eliminates sliver jams without interruptions. This reduces operational effort, prevents sliver breaks, and maintains high efficiency also in downstream processes.

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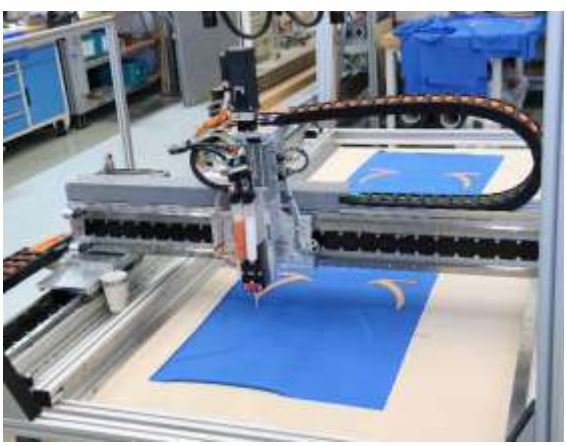
KARL MAYER Sharing expertise on New Manufacturing Technologies

Latest practical news and research to be presented at the 6th 'ADDITIVE MANUFACTURING in the textile industry' symposium in Frankfurt am Main on 8th November, 2023

This series of events will focus on a topic with far-reaching implications. Additive technologies, particularly 3D printing processes, offer completely new potential for developing innovative textile solutions and customised products, as well as for designing processes. “Thanks to industrial 3D printing, we can easily and quickly add design or functional elements to textiles. Prototyping is also more efficient. Less effort usually means less environmental impact caused by value-added processes too,” explains Michael Kieren, New Business Development Product Manager at the KARL MAYER GROUP.

The textile machine engineering company has developed a technological solution for combining warp-knitted textile



Printing trial at KARL MAYER

manufacturing with 3D printing, and is jointly organising the symposium. Other organisers include the Textile Research Institute Thuringia Vogtland e.V. (TITV Greiz) and the Saxon Textile Research Institute e.V. (STFI).

Together, these industry players have devised a varied programme for interested parties from the textile industry and plastics processing. The science and industry lectures will focus on topics including new materials, innovative manufacturing technologies and future-oriented applications. Participants will learn more about the latest developments in thermoplastic fused-layer modelling, printing using dispensers or screen printing, as well as materials and applications for protective applications and architecture. For the first time, the lectures will be complemented by an accompanying trade exhibition where companies with experience in working with additive manufacturing processes will be able to present their products and services.

Those attending the symposium will receive a four-day exhibition pass to Formnext, which takes place from 7th–10th November 2023.

For more information, please contact:

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TENCEL™ and Kaihara unveil premium denim capsule collection, achieving new partnership heights

- Kaihara sees growing interest and demand from overseas markets for premium Japanese denim offerings with unique craftmanship coupled with aesthetic, innovative and functional designs
- Three-decade partnership of combining traditional Japanese denim artistry and TENCEL™ branded Lyocell and Modal fibers set the foundation of Kaihara's international expansion to capture new growth opportunities
- "Kaihara x TENCEL™ Denim Week" during October 16–21, 2023 in Tokyo highlights the recent collections with different denim innovations

Lenzing Group, a leading global producer of wood-based specialty fibers, and Kaihara, the world-renowned Japanese denim manufacturer, elevate three decades of partnership towards new milestones. Leveraging the versatile applications of TENCEL™ branded fibers, the latest collaboration is set to propel Kaihara's time-tested craftsmanship to the international markets as part of its overseas expansion strategy. The collaborative innovation will debut at the "Kaihara x TENCEL™ Denim Week" in Tokyo, Japan, October 16–21, 2023.

Honoring craftsmanship through fiber and fabric innovation
Since TENCEL™ fibers were first introduced to the Japanese market in 1994, Kaihara has masterfully woven these fibers into their commercial collections. Together with TENCEL™'s excellence in fiber performance and responsible fiber production, Kaihara transcends the traditional boundaries of denim fabric manufacturing with innovative designs, authentic aesthetics and diverse functionality. As premium denim fashion continues to evolve, Lenzing and Kaihara embark on the next chapter of their progressive partnership – developing new fabrics with TENCEL™ fibers that cater to the demand of brand partners and consumers worldwide, capitalizing on the new frontiers of shared success.

"Kaihara is a well-respected and long-standing mill partner along our journey of denim fabric innovation," said Dennis Hui, Global Business Development Manager, Denim at Lenzing. "The adoption of botanic and biodegradable materials like TENCEL™ fibers in denim fabrics allows innovative creators like Kaihara to expand into new application categories traditionally dominated by synthetics while enabling their brand customers to achieve their sustainability goals. We share a commitment to excellence and a vision for creativity, offering brands and consumers worldwide limitless design possibilities through the versatile applications of TENCEL™ fibers. We are excited to continue our close partnership towards the future of global denim fashion."

HIROFUMI Inagaki, Executive Officer, General Manager of Sales Department at Kaihara, said, "Consumer demand for premium, sustainable fashion is stronger than ever globally. As we broaden our international reach, our long-standing partnership with Lenzing will prove pivotal to advancing our commitment to responsible practices, such as incorporating water-saving TENCEL™ Modal fiber with Indigo Color technology. To tailor specifically for luxury and high-end segments seeking superior quality and kindness to the planet, we have also been crafting denim fabrics with zero or reduced cotton leveraging TENCEL™ fibers for their sustainability, softness and performance benefits. We are confident that our strengthened, multidisciplinary collaboration with Lenzing will distinctively position Kaihara as a world-leading company in developing boundary-pushing innovations addressing diverse tastes and needs while preserving denim as a time-tested trend, whether in our Japanese home market or abroad."

Denim fabrics made with TENCEL™ branded fibers enable a versatile design with an authentic look and feel, creating soft and comfortable textures for the finished product that also comes with the inherent benefits of enhanced breathability and color retention. Such versatility caters to the different needs of global brands and consumers who seek variety in aesthetics, performance and functionalities. Incorporating TENCEL™ branded fibers also helps mills and brands that constantly seek ways to scale up their use of wood-based materials to meet their sustainability goals.

Envisioning the future of premium denim fashion
Lenzing and Kaihara will be unveiling a specially curated capsule collection of seven new denim fabrics using Jeanologia's finishing technology, embodying the myriad possibilities brought to life by TENCEL™ Lyocell and Modal fibers in high-end, high-quality denim applications. As an extension of the Tokyo showcase, this curation will take center stage at the Lenzing booth during Kingpins Hong Kong on November 6–7, 2023.

Highlights of the National Agrotech Conclave

"Accelerating Productivity of Agriculture & Horticulture Products" The Indian Technical Textile Association (ITTA) jointly with the National Technical Textiles Mission (NTTM), Ministry of Textiles, Government of India and in partnership with The Synthetic & Art Silk Mills' Research Association (SASMIRA),

COE - Agrotech successfully organised the NATIONAL CONCLAVE ON AGROTECH, "Accelerating Productivity of Agriculture & Horticulture Products" on Friday, 06th October 2023 at the India Habitat Centre, New Delhi.

Smt. Rachna Shah, Secretary, MoT, GoI, was the Chief Guest of the conclave and addressed the delegates. She highlighted

Smt. Rachna Shah, Secretary Textiles

that agriculture plays a significant role in the Indian economy and the life of its citizens. Agriculture is also a major contributor with its share in country's GDP has a long-term trend of around 18-20%. She opined that Agrotextiles can play an important role in addressing the agricultural challenges like climate change, water constraints and high demand of agri-produce with limited arable land available, improving agricultural productivity and quality of Agri-based products by extending the growing cycle of crops. Research and studies have shown that the use of Agro textiles in horticulture leads to increase in farm productivity by 2-5 times, increase in crop intensity, reduction in water consumption by 30-45%, reduction in fertilizer usage by 25-30%, and higher harvest cycle per year. She further stated that a collaborative approach between Certification Agencies, Research Organizations, Industry, Academia and Ministry is imperative to address the cost implications of Agrotextiles and work together in increasing awareness and education amongst farmers for wider adoption by the larger agricultural community for the growth of the sector, she further added.

Shri. Rajeev Saxena, Joint Secretary, MoT, GoI, in his key note address, highlighted that the India holds a tremendous potential in the global Agrotextiles market of ~USD 12 Bn wherein India's share is ~3%. Though India is one of the biggest markets for Fishing Nets, other Agrotextile products like mulch-mats, antibird nets holding significant share in

Rajeev Saxena, Joint Secretary

global demand, can also be promoted in the context of Indian domestic market. To ensure superior quality, wider safety, and comprehensive reliability of products in Agrotextiles, he mentioned that MoT has notified QCO for 20 Agrotextile items, which will come in-effect from 1st April 2024. Further, Ministry has also sanctioned 11 R&D projects in Agrotextiles valuing INR 13.67 Cr. for development of innovative products under NTTM scheme. He also announced that MoT is going to establish a Climate Smart Agrotextile Demonstration Center to Revolutionize Agriculture through Digitized Microclimate Farming in partnership with SASMIRA.

The welcome address was given by Shri. Amit Agarwal, Chairman, ITTA. He said that the Objective of the Conclave,

Shri. Amit Agrawal, Chairman

having Conference & Exhibition, was to create awareness on the latest product innovations & technology developments, acquire knowledge & ideas for new investments & export opportunities on Agrotextiles, enhance knowledge base on requirement of current Agrotech industries & market, to understand product standards & certification process and creating a B2B & B2G platform for Agrotextile industry.

Shri. Z. P. Patel, Vice Chancellor, Navsari Agriculture University, in his special address, highlighted that there is an average farming production loss of 10-40% due to climate change, especially in the rain-fed areas. Agrotextiles such as Crop Cover, Mulch mats, Polyhouses, etc. hold the potential

Shri. Z. P. Patel, Vice Chancellor

to manage and stimulate the microclimate for crops during farming leading to higher productivity for agriculture products, he emphasized. He mentioned that on the back of diverse geographical location-based benefits of Agrotextiles, the segment has proved to be tremendously beneficial for the agricultural sector in India. There is a need for bio-degradable agro-fibre based agrobags which can be automatically degraded in the soil after the mulching process overtime, leading to planting process and sustainability. There is a need of developing innovative Agrotextile products like soil degradable Agro fabrics, artificial soil which are nutrient rich and has water holding capacity, super absorbent polymer fibres to prevent waterlogging in high-rain areas, weather, and micro-organisms resistant fabrics, etc. He further informed that a Agrotextiles demonstration center is being planned in the university to educate the farmers.

Shri. Priya Ranjan, Joint Secretary, Dept. of Agriculture and Farmers Welfare & Mission for Integrated Development of Horticulture (MIDH) talked that his ministry is focusing activities on effective use of Agrotextiles. He stated that Agrotextiles has a critical role to play in overcoming the unprecedented challenges agriculture sector faces due to climate change, soil degradation, and water scarcity which can threaten the very foundation of our food security. Schemes such as Mission for Integrated Development of Horticulture (MIDH) has incorporated the different agrotextile products for wider usage and penetration.

Shri. Priya Ranjan, JS- Dept. of Agriculture

Furthermore, other collaborative segments within Ministry of Agriculture and Farmers' Welfare are being looked into for further inclusion of agrotextile products, he further added. He stated that by adopting the advanced technologies under Agrotextiles, our farmers can not only increase the agriculture yields but also increase functional benefits and reduced input costs. This, in turn, will translate into increasing farmer's income and the growth and development of the overall agriculture sector. More than 220 participants attended the conclave including officials and representatives from Central Ministries, user Departments of Central and State Governments, Institutes, industry leaders, scientific experts, researchers, and professionals related to Agro textiles. Two Books titled "CONCLAVE BOOKLET" prepared by ITTA and "FIBRE TO FIELD: INDIAN AGROTECH INDUSTRY OPPORTUNITY" prepared by Invest India were released during the conference. A special interactive session on future growth and opportunities in Agrotextiles, was organised in presence of Smt. Rachna Shah, Secretary and Shri. Rajeev Saxena, Joint Secretary, MoT, GoI. The farmers' associations actively participated the discussion and presented their issues along with the delegates. Their issued were addressed and the questions were answered.

There were Five Technical Sessions in the conference. First Session deliberate on the market promotion, export opportunities', Indian standards & Quality Control Order (QCO) on Agrotextiles and Investment Opportunities. Session was moderated by Shri. Amit Agarwal, Chairman, CTM Technical Textiles Ltd. and Eminent panelists were Ms. Bhavna Rathee, Assistant Vice President- Invest India,

Shri. Sarabjit Singh, Business Head- Garware Technical Fibres Ltd., Dr. Naveen Kumar Patle, Addl. Horticulture Commissioner- Min. of Agriculture and Farmers Welfare, Shri. Ajit B. Chavan, Addl. CEO, GeM- Ministry of Commerce & Industry, Dr. K P Singh, ADG- Farm Engineering, ICAR, and Shri. J. K. Gupta, Head, Textiles Department- BIS. The QCO and implementation of the QCO was discussed at length and also how to differentiate the low-cost material with the ISI marked quality especially in the case of Agro Shade nets.

Next session was moderated by Smt. Roop Rashi, Textile Commissioner, MoT, GoI, delt with Climate-Smart Agrotextiles: Harnessing Textile Innovations for Sustainable and Resilient Agriculture. Presentations and discussions by the following panelists were focused on details of the above areas- Shri. Ravi Prakash Singh, Asst. Director, SASMIRA-COE Agrotech, Shri. Anand Zambre, Executive Director-National Committee on Precision Agriculture & Horticulture (NCPAH), Shri. Sameer Mane, Senior Manager, Agro Textile Division- Emmbi Industries Ltd. and Shri. Vijay Ramakrishnan, Sr. Vice President- Technical & New Businesses- Garware Technical Fibres Ltd.

Third session was devoted to Innovations in the field of Raw Materials and Functional Additives: Enhancing Performance and Sustainability of Agrotextiles and moderated by Shri. Ravi Prakash Singh, SASMIRA- COE Agrotech. Panelists were- Dr. P. C. Tripathi, Principal Scientist- Indian Agricultural Research Institute (IARI), ICAR, Prof. Debabrata Maiti, Eliteck Industries Pvt. Ltd. (Start-up), Shri.

Akchaya Kumar Sinha, General Manager - Polymer Marketing, Reliance Industries Ltd., and Ms. Maya Grushka, Global Product Manager, Tosaf Compounds Ltd, Israel.

The fourth session focused on Sustainability, Circular Economy including Recycling issues and Global Benchmarks, which was moderated by Shri. Moloy Chandan Chakrabortty, Jute Commissioner. The eminent panelists were- Shri. Mahadeb Datta, Dy. Director- National Jute Board, Dr. Shanmuga Sundaram, Director- RDTE- (I/C), CCRI and Dr. Asha K. K, Principal Scientist, Central Institute of Fisheries Technology (CIFT), ICAR.

Last session was moderated by Shri. Ravi Prakash Singh, SASMIRA- COE Agrotech and Eminent speakers were- Shri. Rathinasamy K S, Director-Technical- Enthu Technology Solutions India Pvt. Ltd. (Start-up), Shri. V. K. Gupta, Chairman, V. K. Packwell Pvt. Ltd. and Dr. Naved Sabir, Principal Scientist, Centre for Protected Cultivation Technology, IARI.

The exhibition also demonstrated various Agrotextile products and their applications, which added value to the delegates and invitees and given opportunity to do networking with user ministry officials and farmers.

ITAMMA taking forward the slogan " ATMA Nirbhar Bharat"

ITAMMA taking forward the slogan "ATMA Nirbhar Bharat" through Seminar on "Skilling, lean & Textile Technology" on 9th Sept2023 (@ 4 PM at Hotel HYATT Regency, Ahmedabad.

Mr. Nimesh Shah, President, ITAMMA, said "Knowing the importance of Industry Experts-Industrialists-Govt. Bodies in resulting fruitful Industry Projects which can be successfully implemented at the Production level; this initiative of ITAMMA shall be helpful to all the categories of Textile Industry". In the special interactive B 2 B session on "Skilling opportunities in Indian Textile Engineering Industry the Government authorities attended.

- Mr. R. D. Barhatt, Joint Commissioner Industries, Gandhinagar, giving example of Bangladesh Apparel Industry informed about the Gujarat Textile Value Chain and the Skilling Gap
- Ms Shalini Singh, COO & acting CEO, Capital Goods & Strategic Skill Council, and New Delhi informed about the necessity of bridging gaps in skilling in textile industry and the strategy planned for the same by working jointly with ITAMMA.
- Mr. Nirav Desai, Class 1, Principal at Industrial Training Institute – Kubernagar (Ahmedabad) & Asst. Director at

Ms Shalini Singh, COO & acting CEO, Capital Goods & Strategic Skill Council, New Delhi, special interactive B 2 B session

Mr. Nirav Desai, Class 1, PRINCIPAL at Industrial Training Institute - Kubernagar(Ahmedabad) & Asst. Director at Skill Development Directorate, Surat, special interactive B 2 B session

Mr. N. D. Mhatre, Director General (Tech.), delivering the Opening Remarks

Skill Development Directorate, Surat along with his team members gave insight and benefits of each scheme of Gujarat State in the area of Skilling and Training.

This session was followed by lunch and thereafter the Seminar started by the presentations on "Lean Program and the latest schemes of MSME Ministry at Central level" by Mr. Rahul N. Kirkire, Regional Director, NPC, Gandhinagar. After learning the new schemes of Lean Competitiveness Program, ITAMMA's Gujarat Chapter decided to implement this scheme under different Clusters at Gujarat.

A session of Technology witnessed the presentations by Mr. Tarun Purohit, Founder, Limelight IT, Ahmedabad on "INDUSTRIES 4.0 SOLUTIONS" and by Mr. Tapan Upadhyay, Head of Application Engineering Business Region, Festo India on "Digitalization and Industry 4.0."

Mr. Tapan Upadhuay, Head of Application Engineering Business Region Festo India, delivering his presentations on "Ground Level automation"

Memento offering to Mr. Tarun Purohit, Founder, Limelight IT, by Mr. Nimesh J. Shah President, ITAMMA

Mr. Rahul N. Kirkire, Regional Director, NPC, Gandhinagar, receiving Memento Mr. Nimesh J. Shah President, ITAMMA

During the special session on "Skilling Opportunities in Textile Engineering" Mr. Sanjay Bharadwaj, Human Resource, Capital Goods & Strategic Skill Council, New Delhi informed about the activities organized by CGSSC in this field while Ms. Shalini Singh, COO & acting CEO, Capital Goods & Strategic Skill Council, New Delhi joined hands in signing MoU with Mr. Nimesh Shah, President, ITAMMA; to take forward the joint working of ITAMMA & CGSSC in this field.

Ms. Shalini Singh, Chief Operating Officer and Acting CEO, CGSSC, New Delhi delivering her presentations on Opportunities in Skilling-CGSSC initiatives

MoU Signing Ceremony – Ms. Shalini Singh, Chief Operating Officer and Acting CEO, CGSSC, New Delhi on behalf of CGSSC & Mr. Nimesh J. Shah President, ITAMMA

A special felicitation programme was organized for ITAMMA members for their remarkable contribution in the "The Chandrayaan-3 Space Mission of India" It is a pride for ITAMMA to felicitate M/s Siddhi Group, Ahmedabad, M/s Himson Industrial Ceramic Pvt. Ltd., Surat and M/s Precise Industries, Ahmedabad.

We have been working closely with SAMBUQ Team since last few months in the development of SMART DATA Clinic. The progress of the same was presented by Mr. Mehul Goswami, Director/ Digital Business Enabler, Sambuq.com India Pvt. Ltd. whereby ITAMMA feels that this Business Enabler Platform will bring Revolution in the Textile Industry.

Mr. Mehula Goswami, Director/Digital Business Enabler Sambuq.com India Pvt. Ltd. delivering his presentations on "ITAMMA's S mart Data Clinic Vision to Create a ITAMMA Specific One Stop Information Sharing and Market Research Platform"

Memento offering to Mr. Mehula Goswami, Director/ Digital Business Enabler Sambuq.com India Pvt Ltd. by Mr. Nimesh J. Shah, President, ITAMMA

Mr. Bhaveshkumar Patel, Vice- President, ITAMMA, delivering the Vote of Thanks

NETWORKING-DINNER

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