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Sugathan, M, Cassidy, T and Carnie, B (2016) The development and evaluation of a speciality hand knitting yarn using appropriate technology for the empowerment of women in rural India. Research Journal of Textile and Apparel, 20 (3). pp. 136-154. ISSN 1560-6074

https://doi.org/10.1108/RJTA-03-2016-0005

The Design and Evaluation of a Speciality Hand Knitting Yarn using Appropriate Technology for the Empowerment of Women in Rural India

Abstract

The study is based on developing a speciality hand knitting yarn using silk remnants collected from sari weaving handlooms in Vellanchery village, South India. The research was built upon observations in the village designed to identify an appropriate method for the manufacture of yarn that would be acceptable for the unpaid female labour in the handloom sector. The initial field study lead to more sustainable methods of production and quality analysis of the resultant yarn. The speciality yarn was tested against five market available hand knitting yarns, which were similar in terms of visual effect and handle. The objective measurements of the yarn were triangulated with subjective data to provide a complete quality analysis. Finally, a branding strategy was developed for labelling and packaging. The aim of this paper is the identification and proving of the appropriate technology and thorough evaluation of the properties of the yarn and fabric.

Key words: Appropriate technology (AT), hand spinning, speciality yarn, observations, subjective and objective testing

1 Introduction

Observations and field studies were carried out in Vellanchery village Tamil Nadu state, South India, where the main occupation of male members in the family is handloom silk sari weaving. The weavers work in a government authorised worker cooperative which provides them with handlooms and silk yarns for weaving saris. The looms are installed in the weavers' homes where the whole family is involved in the weaving process. The worker cooperative in the village provides membership for the male members who are skilled in handloom waving in the family. However, women in the household are involved in silk reeling (fig 1) and setting up the loom.

Fig 1: Hand reeling of silk yarn

The work undertaken by women is unpaid and carried in addition to their many other household responsibilities such as cooking, washing and looking after the children. Therefore, this study is about developing a technique for the manufacture of a speciality yarn using the silk remnants collected from the handloom after weaving saris. The un-repeatability of the vibrant colours thus obtained and the relative attractive unevenness of the yarns makes them of no interest to mainstream fashion but of great interest to the hand knitting consumer who seeks a one-off quality to their products.

The purpose is to involve women in the manufacturing of yarn, which could provide employment and income. It was observed in the initial phase of the research that these women are skilled in silk reeling that they could easily adapt to a hand spinning technique to produce yarn. During later field visits one of the researchers had the capability to communicate with the community in their language and made a presentation of the process involved in the production of the yarn. In order to design the technology appropriate for yarn manufacture, observations of the geographical location and resource availability were necessary. Moreover, communicating with the community had created an opportunity to directly contribute to the understanding of the literature related with technology choice and identify a market gap via participatory learning (McIntyre, 2008).

2 Appropriate technology

Schumacher (1973) developed the idea of intermediate technology, which is more productive than indigenous technology and low in capital and running costs compared to

sophisticated technology used in modern industry. Intermediate technology is considered useful when work places are created where people live, reducing migration to urban areas. These work places can be created in large numbers without huge capital and production methods can be simple – mainly using local materials. The term intermediate technology has been criticised for implying a technological fix for development problems separate from the political and social factors involved (Hollick, 1982). The term "appropriate technology" (AT) has been suggested as a substitute, which includes the social and the cultural dimensions of innovation (Pellegrini, 1979).

Appropriate technology can be characterised into two areas: resource localisation and soft approach. Resource localisation means that the appropriateness of using AT is decided by the designer/technologist according to the use of available resources in the targeted community. The soft approach is related to sensitivity towards local conditions in the development of the technology (Sianipar et al., 2013).

In this context field study observations were used as a method to generate knowledge about specific issues in the village. According to Sapsford & Jupp (1996) there are two types of observation: structured observation and participant observation. Structured observation methods require systematic observation of behaviour, without directly questioning the people who are observed. Participant observation involves asking questions that arise naturally in the course of observation. At the initial stage of the study, the researchers followed participant observation where they approached observation with a relatively open mind, in order to minimise the influence of the observers' preconceptions (Sapsford & Jupp, 1996).

At present the most common practice of AT is to take western technology and modify it primarily by removing features in an effort to reduce cost with little regard for indigenous perspectives and skills (World Health Organisation 2013). In order to make the technology used successful within a particular locality, it has to be firmly related to the: technical, economic and social conditions in existence (Francis & Mansell, 1988) and (Lissenden et.al 2015). Culture is viewed as forming a context or background for the development of technologies. Hazeltine & Bull (2003) define culture as groups, customs and standards of taste. However, culture is not considered solely as a series of responses or adjustments to technology; rather, it is seen as an essential mediator and adversary to the non-cultural, the mechanical and artificial realm of technology. A cultural critique of technology is one in which the non-cultural elements are evaluated, judged and pushed in new directions as it fits the individual society or culture (Baark & Jamison, 1986). According to Long (1980) the selection of technology that accounts for regional social values plays an important role. For example, the appropriateness of technologies should not be decided purely on economic and factor endowment grounds. Accordingly, Lissenden et.al (2015) refers to AT as simple, labour-intensive and local-manufactured, technology solutions that aim to improve the lives and livelihood of people in resource constrained environment. AT is applied differently to each venture and there is no single framework through which AT ventures should be undertaken.

Dunn (1978) discusses AT as rural based and as a method, which attempts to recognise the potential of a particular community and help it develop gradually. This development progressively builds the skills of the community based on local resources. Hazeltine & Bull (2003) state the reason why AT relates well to cultures is because it can be adapted to the local needs and is controlled by those using it. The characteristics of AT like low cash requirements, being repairable and controlled by users matches the situation of women in the developing countries. If cultural factors are not taken into consideration while introducing a new technology, then it is likely that the aim of the new technology may not be met – perhaps because of unexpected contingencies or resistance by those involved. AT tends to put participants in control so that it can be adapted to local conditions, it does not require major changes in people's lives, and it is a promising way to improve living conditions without cultural damage (Sianipar et al., 2013) & (Pearce et al., 2012). Pellegrini (1979, p. 2) suggests that a technology should be considered appropriate "when its introduction into a community creates a self-reinforcing process internal to the same community, which supports the growth of the local activities and the development of the indigenous capabilities as decided by the community itself". According to Sianipar et al., (2013) researchers believe that AT as a

phenomenon emerges together from specific conditions from a local area that needs a technology that is appropriate with local people's needs and wants. AT projects should provide for the needs of the people, rather than the organisation (Ja-young, 2012). AT can have relevance into the future if AT scholars and entrepreneurs can unite to create ventures that match the scope of today's global problems (Lissenden et.al (2015)

2.1 Why is Appropriate Technology Suitable for Small-scale Application?

The benefits of AT outlined by (Francis & Mansell, 1988) & (Schumacher,1973) for small-scale application are summarised as follows:

- Employment can be created in the place where the unemployed live and that can restrict migration of unemployed people to urban areas
- Through reducing the needs for imports, and creating an export market, savings from wages and profits generated can be used for investment in further capital development
- There is a greater opportunity to use renewable resources (solar, wind, hydro, wood and biogas)
- Small-scale industries using AT can reduce pollution and ecological imbalances prevalent in most concentrated large-scale industry. Furthermore, ecological problems can be remedied at much less cost
- Growth of the industry can occur in small steps, as required by demand and made possible through new capital, which includes changes in the products through innovation

Accordingly, (Sawhney et al., 2002), & (Buitenhuis et al., 2010) defines AT as a technology that fits local condition and are easily and economically utilised from readily available resources in local communities to meet their needs.

Hazeltine & Bull (2003) discuss AT in a broader sense where the major concern is whether AT can produce sufficient goods and services. For developing countries AT can lead to national development in the sense of a trained work force. However, the problem exists whether people may accept an AT approach rather than high technology. Hazeltine & Bull (2003) highlight the fact that some leaders are understandably suspicious of AT as being a way to discourage the developing countries from industrialising and becoming competitors. The answer to this issue is that there is no other way to industrialise other than using the resources that are readily available. India has untrained labour; in order to channel it in the right direction a simple technology that is easy to adapt with simple training facilities will lead to economic development of the community.

Another problem faced by the AT approach is that it is specific to locality; thus transferring expertise from one locality/country to another is a difficult process. Technology transfer is difficult between communities because of limited and weak communication between the communities and researchers resulting in poor technological diffusion (Amiolemen et al., 2012). In this case changes must be made in technology choice depending on the requirements and skills of the community. Hazeltine & Bull (2003) points out that AT are small-scale and done by many independently; thus making it difficult for government officials to understand what is happening and take action when needed. With reference to India, central and state government has specialised departments such as: The National Mission for Empowerment of Women (NMEW) and The Ministry for Micro Small and Medium Enterprise (MSME), M S Swaminathan Foundation (MSSRF) and these departments aim to handle the socio-economic development of rural areas.

3 Methodology

As the research was conducted in a real world setting, there was a need to participate with participants to engage in a collaborative process aimed at improving and understanding their world in order to change the system. Participatory Action Research (PAR) is a philosophy more than a methodology and was chosen for the study. The aim of the research is achieved through a cyclical process including exploration, knowledge construction and implementation at different stages through the research process (McTaggart, 1997). PAR is a recursive process that involves a spiral of adaptable steps in four stages:

- Question the issue of recycling the silk remnants collected from handlooms to produce a value added speciality hand knitting yarn that could help empower

women in the weavers' community in Vellanchery village through their involvement in the production process
- Reflect and investigate the issue involving the participants in order to achieve clarity
- Develop an action plan by combining both quantitative and qualitative data generating methods
- Finally review the marketability of the yarn with potential end users who are hand knitters.

In order to test the marketability of the yarn various subjective and objective methods were undertaken with hand knitters and spinners to analyse the quality of the speciality yarn compared with five-market available yarns with similar tactile properties and at a range of price points.
This research was designed to answer the question of developing a speciality yarn using silk remnants collected from the handloom, identifying an appropriate technology that is acceptable for the village community and ensuring a quality level that is satisfactory for the end-users.

4 Development of Speciality Yarn Technology

Sari weaving is a domestic process carried out on handlooms using a warp of approximately twenty-one metres; from which, three six metre sari lengths are produced. This leaves close to three metres of remnant silk yarns on the warp beam. Past efforts to make use of these remnant yarns have been aimed at the production of fashion accessories, including items such as: bangles and necklaces, which crucially are of low value and are only sold in the local market. As such, the production of these items from remnant yarns provides minimal economic empowerment of the women in the village, which is very much needed. However, development of speciality hand spun knitting yarn using 30% of these silk remnants collected from handlooms blended with 70% scoured lamb's wool produces alluring and unique yarn colours that are non-repeatable, and have excellent handle and knit-ability can be produced. Notably, non-repeatable yarn colours make this product unsuitable for the mainstream fashion market, however the non-repeatability is extremely desirable for craft hand knitters.

It was decided that hand spinning would form the main production technique due to lending itself to the already assimilated hand reeling skills of the women in the village. However, two other factors must be understood: no need for power or fuel supply and the therapeutic effect of the craft. Small-scale mechanical cards of traditional construction use very little power, are quiet easily maintained was used for carding trials. At every stage of fibre preparation, spinning, yarn finishing and packaging, the choice of technique was driven by the context of appropriate technology.

In the initial stage of yarn development, a number of questions were raised: how to desize the silk remnants, the length to cut the silk filament remnants converted to provide staple silk fibres and the percentage of silk content to mix with the lamb's wool. Fig 2 shows the different stages of yarn production. The silk filament sari remnants are highly coloured and the colours vary across the warp depending on the design of the sari. When the filaments are cut into short lengths and mixed with the undyed lamb's wool, unique, non-repeatable and vibrant tones, tints and shades are obtained.

Fig 2: Stages in the production of the yarn

4.1 Evaluation of desizing and carding process

Mulberry silk is used for weaving a silk sari. A unique feature of the sari is its strength, which is achieved by the twisted yarn, and the yarns are dyed in a variety of colours. The dyed yarns are dipped in rice water (sizing) and sun dried. This is done in order to protect the yarn from damage while weaving. The rice starch used to size the silk filament yarn had to be removed as it causes stiffness of the filament. Three eco-friendly desizing methods were trialled and the results of which are given in table 1.

Table 1: Desizing experiments

The tests suggested that Acetic acid steeping is best for desizing silk yarn in a liquor ratio 1:200 (1g of fibre mixed in 200g of water) with 0.2% of acetic acid in grams added. Using water only would have been preferred but it was not sufficiently effective. The desized yarn is then dried at the room temperature and conditioned for 24 hrs before carding. The portion of acetic acid used for desizing is very minimal and effluent disposal would not be an ecological problem.

The next stage after desizing is to weigh the silk remnants in proportion to scoured lamb's wool. Two options were considered 50% of each or 30% of silk remnants and 70% of lamb's wool. There was minimal difference noticed in the form of colour or texture in the yarn spun using 30% silk and 50% silk content. Thus it was decided to keep the silk content as 30% and scoured lamb's wool 70% for cost reasons. Carding was then undertaken to open up the lamb's wool and silk and mix them together.

Fig 3: Carding machine used for carding silk remnants and scoured lamb's wool

The carding machine (fig 3) was small scale and consisted of a series of pinned rollers between which the fibres are shared, pressed and finally raised to form a web. Carding is the process by which fibre clumps or tufts are opened up and mixed to produce a coherent fibrous web assembly which can then be drafted (made long and thin) and twisted using a hand spinning wheel to produce a yarn of the desired count (fineness) and twist content. The silk yarn remnants were cut to three-inch length after desizing. Desized silk yarns were carded twice in order to open the twist and change to a single fibre state. The scoured lamb's wool was carded separately and then mixed with the silk fibres.

4.2 Hand spinning and plying of yarn

To mix the fibres effectively in the carding machine, the web was collected at the output end of the machine and cross fed back into the carder. This method of cross feeding the material gave an additional blending to the fibres and assisted in levelling the density across the width of the carded web to produce a well opened and mixed fibrous assembly for spinning.

The carded fibres were spun on a hand spinning wheel using a long draw technique (fig 4). The singles were spun in 'Z' twist and plied in 'S' twist. Plying was done using a lazy kate (spool rack). Two filled bobbins of hand-spun singles are removed from the spinning wheel and put on the spool rack or lazy kate. The two single yarns were guided to the bobbin through the orifice and then the wheel was turned in an anticlock wise direction to give 'S' twist to the plied yarn.

Fig 4: Hand spinning and plying

The yarns were washed in sensitive detergent used for washing baby clothes in hot water at 42 to 43 °c and allowed to cool. This process helped to bleed the excess dye content in the silk. It was then rinsed in cold water to remove the detergent. The rinsed yarn was put in the spin cycle of a washing machine with no added water to remove the moisture, and hung to dry in skeins (fig: 5 and fig: 6).

Fig 5: Drying of hand spun yarn

Fig 6: Speciality hand spun knitting yarn

5 Results and Discussion

5.1 *Objective and Subjective- Yarn and Fabric Testing*

To analyse the functional and aesthetic properties of the speciality yarn comparisons were drawn with five commercially available machine spun yarns, which would be typical competitors in the hand knitting market at a range of price points. The samples of hand knitting yarns were: 'Y1'- space dyed lamb's wool (3 ply), 'Y2'- lamb's wool angora (2 ply), 'Y3'- 100% silk (2 Ply), 'Y4'- oiled lamb's wool (2 ply), 'Y5'- speciality hand spun yarn (2 ply), 'Y6'- 100% acrylic (2 ply). The yarn selection was based on the visual impact and hand feel in both yarn and fabric stage. The knitting tension of the fabric produced from the yarns was the same for all samples though the manufacturing techniques and fibre content was quite diverse. The selection of these yarns was to determine the hand knitters' preference for various fibre contents, appearance and tactile qualities for a group of yarns. The six yarns discussed above were used to conduct the subjective (qualitative) and objective (quantitative) tests in both the yarn and fabric stage. The objective tests conducted were twist content to allow twist constant calculation of yarns, count measurement in Tex, calculation of course and wales density of fabric and fabric pilling. The subjective tests involved two focus groups with hand knitters to compare the quality of speciality yarn along with the five market available yarn. The wearer test was conducted with two participants for a period of 8 months using a hand knitted garment made of speciality yarn.

5.2 Objective Tests

The twist constants of the six samples were identified between 2000 and 2600, which categorised them as double knits.
Twist constant was calculated using the formula:
Twist constant = Turns/ meter x √Tex
(Rae & Bruce, 1973).
All the six yarn samples were knitted in 6" x 6" swatches. The hand knitted and machine knitted samples were washed in order to determine the physical properties like shrinkage, colour bleeding and handle. Three wash methods were used which included hand wash at 30°C using wool wash liquid detergent. Machine wash was done in a domestic front load washing machine at wool wash setting and the third method was commercial dry cleaning. The number of courses and wales were counted and recorded in order to measure the fabric density and dimension. The hand washed fabric samples of speciality yarn retained their fabric dimensions and softness compared to the machine washed and dry-cleaned.

Eight knitted swatches (four machine washed and four unwashed) in 5inch x 5inch of each yarn sample were tested in an ICI pilling box. The samples knitted using speciality hand spun yarn form more fuzz compared to the rest of the samples in both unwashed and washed state in the pilling test. Fuzz was caused due to breaking of weak fibres during the abrasion in the pilling machine (Gintis & Mead, 1959). The twist inserted in the hand spun speciality yarn was not exactly controlled like machine spun yarn which may be a reason for fuzz formation under severe abrasion.

5.3 Subjective Tests

The subjective experiments included two focus groups consisting of hand knitters and spinners with six participants in each group. The details of hand knitting yarn samples Y1, Y2, Y3, Y4, Y5 and Y6 were kept anonymous and the participants were asked to analyse the yarn features including their tactile properties, colour and texture. The focus groups were conducted in UK as the speciality yarn was aimed as an export product. The participants' selection criteria were more than two years of experience in hand knitting and a fair understanding about the physical properties of the knitting yarn.

The researchers adapted a coding or categorising system to analyse the focus groups' data. A combination of thematic coding approach and KJ method to identify corresponding elements involved in a problem situation or event (Mizuno, 1988) was used to analyse the qualitative data represented in table 2.

Table 2: Combination of thematic coding method and matrix diagram

The records of two focus groups were sorted, analysed and distilled into complete descriptions of yarn features representing: tactile properties, wash, sustainability factors and colour. A list of yarn features was gathered generating information about: the aesthetic and functional attributes the participants valued for the selection of hand knitting yarns. The key words in the transcript were assigned specific codes, and the word cells with similar phrases related to the yarn were moved together to assemble categories of: high usability, low usability, high quality, low quality. A coordinated system was constructed by a horizontal axis representing low quality to the left, and high quality to the right; and a vertical axis representing high usability at the top, and low usability at the bottom. Each word cell was coded in a 'small icon' since the word cells take too much space in graph. A colour categorising system was created based on the RGB colour fill feature of word software.
In this system the horizontal axis is defined with:

- Low quality in the left, which is assigned with the colour components 'G0/R255'
- High quality in the right, which is assigned with the colour components 'G225/R0'

The vertical axis is defined with

- Low usability on the bottom which is assigned with the colour components 'R0/G112'
- High usability on the top which is assigned with the colour components 'R225/G112'

A distilled description of the characteristics of 'Y5'- speciality hand knitting yarn taken from the focus group was explained in table 3, followed by a brief discussion about the positioning of codes in the matrix. Similar data analysis was carried out the remaining yarn samples Y1, Y2, Y3, Y4 and Y6.

Table 3: Distilled description of Y5- speciality yarn

5.3.1 Discussion regarding the positioning yarn colour codes

(Y5A) (Y5B) (Y5C) comments review the uneven colour distribution in the speciality yarn. The focus group participants found it very attractive and that this differentiates 'Y5' from the rest of the knitting yarn samples in the group. The soft handle of the speciality yarn was achieved through slow carding of fibres and the hand spinning process. Thus (Y5A) (Y5B) (Y5C) were positioned at (F,4) high quality and high usability.

(Y5D) (Y5E) (Y5F) were some of the unique features that excited the participants about the speciality yarn. Thus the above codes were positioned in (I,3) high quality and high usability.

(Y5G) The life cycle of a sustainable product starts from the raw material, the method of production and its final disposal. According to the participants in the disposal stage of 'Y5', the knitters could felt the fabric made from speciality yarn or unravel the yarn out from fabric and weave it to other interesting craft items that made (Y5G) position at (J,1) high usability and high quality.

(Y5H) The production of the speciality yarn draws focus on involving the women in the village community to provide employment and income. This is a good marketing and branding strategy to keep the consumer informed about the story behind the production of the yarn, so the consumers were aware about the cause before they decide to purchase. Therefore, (Y5H) was positioned at the middle of the axis (E,5).

(Y5I) Participants were aware about the extra care to take for hand knitted garment. They value the time and creativity that has gone into making of the product and stated that they would consider care while washing. So (Y5I) was positioned under (G,9) high quality and low usability.

(Y5J) although the yarn was of high quality and pleasant for hand knitters to knit, the receiver of the knitted garment may not have similar emotional attachment towards the garment and they may consider hand washing requirement tedious. Therefore, (Y5J) was positioned at (E,9) low usability and high quality.

(Y5K) In spite of the fact that the story behind the product is a good marketing strategy; the quality of the speciality yarn should be able to compete with other market available yarn to convince the customers to make their choice; which positions (Y5K) in the middle of the axis.

Fig 7: Positioning chart of focus group comments about the yarn samples

The description in (fig 7) shows that 'Y5'- hand-spun speciality yarn was given a profile, which was very similar to 'Y3' – the expensive 100% silk filament yarn and 'Y2' lamb's wool/Angora yarn.

5.4 Wearer Trial

An identified gap in the objective and subjective tests that impact the quality of the speciality yarn in the fabric stage was examined through a wearer trial. The wearer trial was conducted in an attempt to study the yarn behaviour in garment form and allow the researchers to examine the wash properties, colour bleeding and abrasion of the garment for a period of time. Two participants (P1 and P2) were involved in the wearer test over a period of eight months. The study covered a range of data collection methods including observations and recording of measurements before and after washing of the garment.

The participants for the experiment were carefully selected considering their gender, age, education and cultural back ground. Both the participants were English men where participant 1 is between the age group 55-60 and participant B is between the age group 25-30. Emirhanova & Kavusturan (2008) argue that the hand feel and the appearance are two important classes of the fabric. Berkalp et al., (2003) explains that the fabric may lose its aesthetic appeal due to wear which is a combination of several factors like abrasion, repeated laundering and the application of forces in the dry and wet stage which arises from everyday use and service. Surface abrasion is considered as one of the important factors in fabric testing. Therefore, the wearer trial addressed the following factors: the comments of the participants are given in table 4.

Table 4: Wearer trial comments

In a period of 8 months the garment was washed eight times. The noticeable difference was underarm pilling and minor difference in the

shoulder and sleeve length of the garment and loose rib in the cuff and bottom opening.

The findings in the subjective and objectives studies of the speciality yarn have provided sufficient information that makes it compatible with the market-sourced yarn. However, the wearer tests have delivered an insight into the behaviour of the yarn in the garment form. It provides information required for the hand knitters to consider while knitting with the speciality yarn and also care instructions for the garment. The garment should be hand washed and flat dried in order to maintain the original shape and measurements. The experiment results highlighted the fact that the garment can withstand the forces in dry, wet stages and repeated laundering.

6 Branding Strategy for Speciality Yarn through Packaging and Labelling

The yarn was developed considering the lowest possible impact on environment and concern for social considerations along with good quality performance at an affordable price. In order to make the customer aware about these factors, it should be communicated in an effective way by engaging them right from the product development to the final packaging. This can be attained through adapting a sustainable marketing strategy. A suitable way to define the marketing of speciality yarn is through maintaining a long-term relationship with the consumers, considering the social and natural environment. In order to market sustainability, the organisation has to interact with the stakeholders (workers, suppliers, distributors, shareholders and consumers) about the social, economic and environmental values of products and service ideas.

The packaging and branding of the yarn plays an important role through reflecting its unique characteristics and briefly describing the ethics behind the production in an eye catching and interesting way. A survey that included both closed questionnaires and open online discussions was conducted on www.ravelry.com a knitters website where the members exchange their knitting ideas and experience. More than 100 respondents participated and their feedback and comments helped to understand the packaging preference of the knitters. A comment received on Ravelry summed up the study of the target market for hand knitters, “Folks who buy yarn come in all ages, genders and socio-economic niches. You name the classification; there are fibre people in it. Goths to gamers, grannies and everyone in between and their cousins and co-workers besides. We do it for fun, for love, for fashion, for charity, for stress relief and artistic expression.”

Most of the participants preferred a simple packaging with yarn in skeins that included a brief story about the making of the yarn. A clean good quality reusable tag holding the yarn skeins was found to be preferred by the participants. It could be used as a gift tag with easy to understand care instructions. After receiving comments from the participants it was decided to use “Kamal” (meaning ‘lotus’ in Hindi) as a brand name.

The label was designed first and based on that outcome the rest of the deliverables were designed. The label included information about the composition of the yarn, the socio-economic impact, technical details like the needle size and hook size, weight of the yarn and care instructions. A write-up was prepared (fig 8) which explains the significance of the lotus (a beautiful flower rising out of dirty water) and the socio-economic impact behind the project. A photograph of the sari remnants with loose yarn ends was used as a design element to portray that the yarns came from silk remnants collected from handlooms after weaving sari. A recycled paper was used to give it a visually textured design evoking the recycling of materials embedded in the yarn.

Fig 8: Final labels for the speciality yarn

The textured background along with the photograph of the sari- remnants was used in all the deliverables to give the brand an identical look. The gift tag (fig 9) was double sided; one side had the logo and the wash-care instructions while the other side had a personalised message.

Fig 9: Final tags for the speciality yarn

A box was designed to sell multiple skeins in an eco-friendlier and attractive way. From the information gathered from the primary research conducted on labelling and packaging, it was evident that consumers bought yarns in bulk quantity, as they needed at least 6-8 skeins of 100 grams’ yarn to complete a sweater. Thus, the box

provided an incentive to buy yarns in larger quantities. The box (fig 10) was designed in a way that it could be re-used as a gift box. The background for the box was similar to that of the tag and labels to make them appear uniform and belonging to the same brand.

Fig 10: Gift box

7 Conclusion

Appropriate technology was designed with special consideration to natural environment, socio cultural and economic environment of the society. The technology identified for the production of speciality yarn is environmentally friendly, low cost and easy to understand for women in the village. The research provides a holistic analysis in two ways; first to understand the cultural context of the weavers' community in Vellanchery village. Based on recycling a waste material available in the village and identifying a method that is acceptable for the community is used as a platform to develop a technology that is suitable for women in the village. Second, a mixed method analysis using subjective (qualitative) and objective (quantitative) methods to analyse the quality of the specialised yarn compared with a selection of five market available yarns (technological experiments, focus groups, and wearer tests).

Findings from the literature review and the initial field study observations in the village had helped the researchers to select an appropriate method for the production of speciality yarn. The research confirms that along with identifying a sustainable method of production it is essential to ensure the quality of the product that can compete with other market available hand knitting yarns. The participants in the research reflected their views through active engagement with the researchers through critical dialogue and collective reflection, which helps them to recognise that they have a stake in the overall project. The uncertainties regarding the acceptability of the speciality yarn by the market can be reduced to a great extent through constant interaction and involvement of the customers in the process of product development along with the manufacturers.

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Figures

Fig 1: Hand reeling of silk yarn

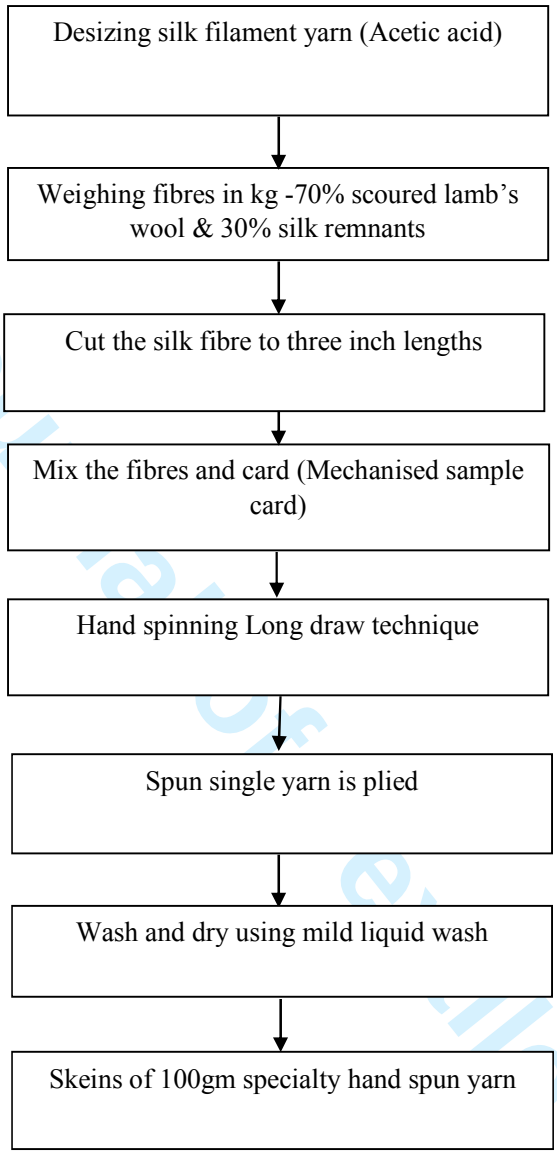


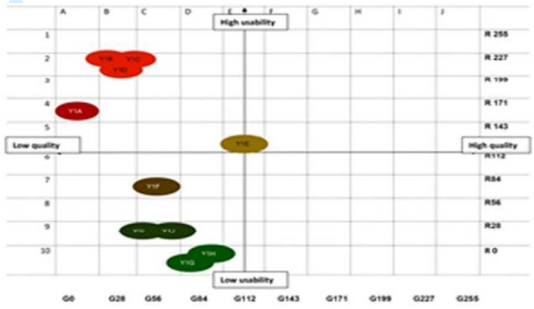
Fig 2: Stages in the production of specialty yarn

Fig 3: Carding machine used for carding silk remnants and scoured lamb's wool

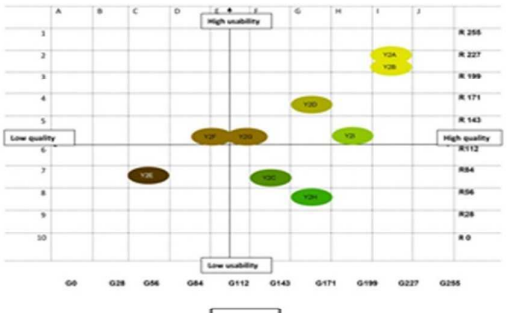
Fig 4: Hand spinning and plying

Fig 4: Drying of hand spun specialty yarn

Fig 6: Speciality hand spun knitting yarn



Y1



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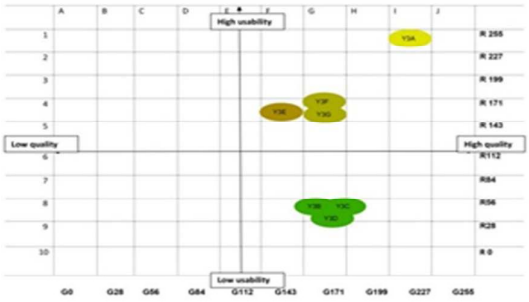

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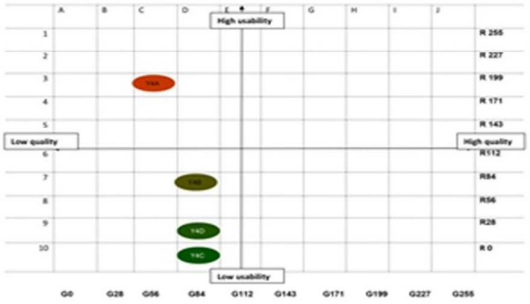
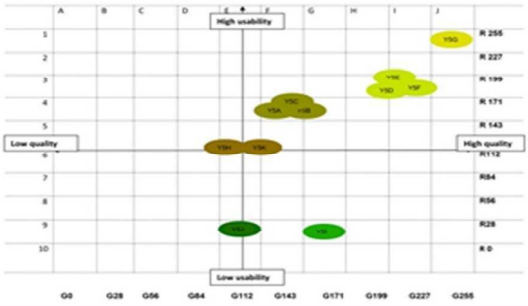
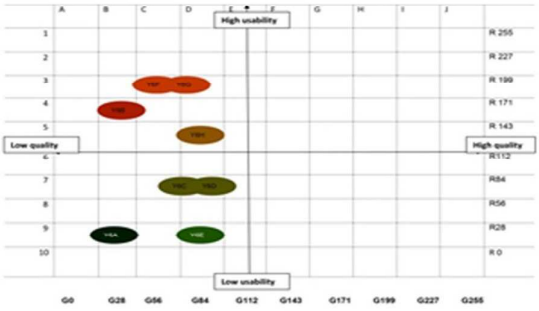


Y4



Y5



Y6

Fig 7: Positioning chart of focus group comments about the yarn samples

Fig 8: Final labels for the specialty yarn

Fig 9: Final tags for the speciality yarn

Fig 10: Gift box

Table 1: Desizing experiments

	Chemical	**Dwell time**	**Temperature (°c)**	**Yarn weight difference**
Rod steeping	Distilled water	10min	98	0.88%
Acid steeping	H_2SO_4 (Sulphuric acid)	7-12h	25	0.72%
Acid steeping	CH_3COOH (Acetic acid)	7-12h	25	0.71%

Table 2: Combination of thematic coding method and matrix diagram

Thematic coding approach	**KJ method used for the focus group data analysis and matrix creation**
Data Collection	**Data collection:** Data relating to the visual impact and handle of a group of six knitting yarns were collected through two focus groups
Transcribe data	**Transcribe data :**It is necessary to produce full transcriptions of the focus group in order to analyse them
Develop categories	**Develop categories:** The transcript was broken down to manageable pieces according to facts, incidence or phenomena and assembled them in categories
Naming categories	**Categorising facts:** Similar key phrases were given specific colours and the similar colors were assembled into categories
Saturate categories	**Matrix Diagram:** The data is presented in a matrix diagram where the information was easy to visualise and comprehended under assigned category
Main categories	**Categorising matrix axis:** Titles were assigned for each axis in the matrix according to the categories emerged from the data
summarize the category	**Data positioning:** Position the data according to their relationship with the assigned categories
Establishing core categories	**Establishing core categories:** Different attributes that relate with the physical properties of the specialised hand knitting yarn were identified under the core categories
Filling in gaps	**Filling in gaps:** The missing details under the core categories were filled by further subjective data collection method: wearer test

Table 3 Distilled description of Y5- Speciality yarn

Distilled description of the characteristics of 'Y5' taken from focus groups	Codes
The colour variations in the yarn will show in the knitted patterns	Y5A
Depth of colours and softness of the yarn makes it very interesting to knit with	Y5B
Each batch of the speciality yarn is slightly different and that is a feature (rather than a problem)	Y5C
Hand spun yarns gives the joy that somebody had made it specially for the knitter	Y5D
The spread of colours in the yarn are unpredictable and it is a joy to knit (rather than irritating for the knitter)	Y5E
Knitting or weaving with the yarn is like a story that the knitter starts and gradually develops	Y5F
The yarn has more potential for recycling	Y5G
Yarns made in India and China always visualise the sweat shop and people who are not paid well. So if the yarn label shows made in India then it should also narrate why it is produced in India. The reason is the use of silk remnants collected from the handloom. It has a brilliant story, a cottage industry, very small and local….	Y5H
Hand knitted fabric is 'something' which is hand wash only, then obviously the wearer should be careful about it and it is 'something' to bear in mind	Y5I
People do not necessarily go for the hand spun yarn. They may intentionally go for the commercial acrylic because they want to gift something hand knitted and machine washable	Y5J
The story could be used as a selling point more than that the customer should be satisfied with the product	Y5K

Table 4: Wearer trial comments

Attributes	Participant 1(May- July 2014)	Participant 2(August – December 2014)
Tactile (feel and comfort)	The garment had good comfort level and there was no skin irritation from the silk remnants	The comfort level of the garment was good and there was no ticking or scratchiness from the silk remnants in the yarn
Appearance	The complexity of the garment made from hand spun yarn and hand knitted added value to the appearance. The colour combination is attractive	The garment drapes well and colour combination is excellent
Shredding of silk remnants	In the first week of trial, prior to the first wash there was shedding of silk remnants which were less than three inches in length	There was no shedding of silk remnants from the garment
Laundering	Hand washed in warm water and spin dried in washing machine at delicate setting using a wool mark detergent and flat dried	Hand washed in warm water and flat dried
Colour bleeding	Grey colour bled from the garment during wash	Grey colour bled from the garment during wash