

ABSTRACT

Everyone in the World is constantly working towards sustainability in every aspect of textile industry that is search for sustainable raw material, processing, technology, products and finally and most important aspect of not adding to the landfill as environment plays a very important role for healthy living and possibility of life on Earth. Looking to present scenario of environment protection, climate change and bio-based economy, there will be a great market demand of sustainable environmental friendly fabrics from natural fibers by 2030. Apart from major fibers, many researchers and manufacturers are working on minor cellulosic fibers extracted from agricultural waste like Banana, Pineapple, Kenaf, Sisal, Ramie, Water hyacinth etc. These all fibers are extracted from the plant sources grown in terrestrial regions. In the present experimental work, challenging efforts was made to experiment the fibers present in the petiole of the national flower of India that is Lotus (*Nelumbo Nucifera Gaertn.*) pink variety grown in wetlands. After picking the Lotus flowers, fruits and rhizomes, the petioles are considered as a hygrowaste which is further abandoned for the decay. These petioles contain two types of xylem cells that are tracheids and vessels which contain fine microfibers. The study aims to experiment these precious fibers in the different areas of textiles that is yarn manufacturing, weaving, knitting and nonwoven.

Lotus fibers were extracted by the manual extraction process by varieting the number of petioles (one, two and three) in order to obtain fine counts of yarns and checking the feasibility for spinning and weaving. These extracted fibers were further spinned using *Ambar Charkha*. During manual extraction process it was observed that leftover petioles also contain fiber so separate extraction method was developed to collect these fibers manually over the woollen felt. These raw fibers were suitable for making nonwoven web and rotor spun yarns. The main drawback with these manual methods was high time consumption which hinders this precious fiber to reach in bulk production.

Hence two machines with different mechanism were designed and fabricated. Machine -1 was for fiber extraction and simultaneous yarn preparation. Machine -2 was for extracting raw fibers. Twelve different types of yarns were developed by three

different techniques: a). Hand spinning on *Ambar Charkha* (variation in number of petioles) b). Plying of Lotus yarn on *Ambar Charkha* with natural fibers (Variation in counts of major and component yarns and type of natural fiber in ply structure– Cotton, silk and Wool) c). Yarns developed from fabricated machine-1 (variation in speed of feeding and winding device) d) Yarns developed by rotor spinning technique (Variation in proportion of Lotus and Cotton fibers). Twelve sets of yarns consist of - two handspun yarns, three ply yarns, four machine extracted and spinned yarn and two rotor spun yarns were developed.

14 different woven fabrics with different composition of developed yarns were constructed on handloom and powerloom: two were Khadi fabrics, five handloom fabrics and seven powerloom fabrics. The developed yarns and fabrics were subjected for testing. Selected woven fabrics were subjected for KAWABATA analysis.

Coloration is the essential part of textile leading to aesthetics. The lotus yarn were experimented with few known natural dyes – Madder, Lac, Marigold, Sappan wood, Katho, Indian berries, Annato, Pomegranate rind and Natural Indigo. From the industrial perspective, Lotus yarns were also experimented for reactive dyes. Dyed yarns were subjected for the testing of color strength (K/S), washing and light fastness property.

Knitting is the second most popular manufacturing technique after weaving. Nowadays the fashion is more towards the seamless knitted apparels. Focusing on the properties of Lotus fiber – softness, good elongation, light weight and resistance from bacteria. Two different 100 % circular knitted fabrics were developed from two different counts (71's and 60's) of machine extracted and spinned yarns. The developed knitted fabrics were subjected for the testing of assessment of coarses and wales, thickness, GSM, stretch and recovery property, bursting strength and pilling.

Entire Lotus plant is endowed with numerous medicinal and health benefits due to the bioactive agents present in the different parts of the plant. Hence the fibers without any treatment were tested for functional aspect – absorbency, cytotoxicity and anti-bacterial property.

Today the Nation is moving more towards startups and entrepreneurship. Hence the skill development programmes were conducted in which group of women were trained to extract and spin Lotus yarns. The handloom stoles were developed from these yarns which were presented in three different exhibitions- a). Exhibition-1 was done on women's day 8 March, 2022 at Eva Mall, Vadodara b). Agripreneurs Conclave 2022 c). Weave knit exhibition -2022.

Results revealed that by varying number of petiole (1-3) it was found feasible for manual extraction and spinning on *Ambar Charkha*. The finer yarn of 96's count was achieved from a single petiole extracted manually and spinned on *Ambar Charkha*. Fabricated machine - 1 was found more effective than manual extraction process in terms of yield and strength. Yarns developed from fabricated machines can withstand strength on circular knitting machine and powerloom. Finer yarn of 71's count was achieved from the fabricated machine developed from three petioles whereas in manual process, 28's count of yarn was obtained by using same number of petiole. Developed ply yarns has a texturized appearance and found feasible to withstand strength on loom in warp direction. Rotor spun yarns developed by blending it with Cotton has a coarser appearance but it has good elongation property.

All the developed woven fabrics has different textures and aesthetics. Fabric developed with Silk warp and finer handspun Lotus of 96's count has a sheer appearance, light weight, less stiffness, lower drape co-efficient and piling resistant whereas the tensile and tearing strength was lower amongst all the fabrics. This fabric can be used where durability is not a factor. In terms of durability, the fabric consisting of yarns developed from the fabricated machine on powerloom has a higher tensile and tearing strength as compare to the fabric consisting of hand extracted and handspun yarns. All the developed fabrics has obtained rating of slight pilling and negligible pilling which is due to the properties of fiber – long length, high water absorbency, microfiber structure. Plying of yarns has helped to take the Lotus yarn in warp direction in handloom and the fabrics obtained were durable. Fabric with the Lotus: Cotton and Lotus: Silk ply yarns has an open and sheer appearance whereas the Lotus: Wool ply yarns has a slight rough appearance.

Selected two woven fabrics were tested for KAWABATA analysis revealed that fabrics were suitable for “**women’s suiting**”. The total hand value of Powerloom - PL Fabric -8 (Warp – Machine spun Cotton yarn – 80’s ; Weft – machine extracted and spun Lotus yarn : 3 petiole – 3/71’s) was high as compare to Khadi Fabric – HS Fabric -2 (Warp – Handspun Cotton yarn - 120’s ; Weft – Handspun Lotus yarn: 3 petiole - 3/28’s)

Slight pilling to negligible pilling was seen in the knitted fabrics. Both the fabrics has a good stretch and recovery property which was found suitable for form and loose-fitting apparels. Development of socks was possible using Lotus yarn extracted and spinned from Machine-1. Socks were soft in hand and comfortable to wear.

The Lotus yarns dyed with natural dyes has excellent light fastness and good to very good washing fastness property. Similarly, Lotus yarns dyed with reactive dyes has showed excellent light and washing fastness property.

It was found that Lotus fiber has a positive antibacterial activity, high free swell capacity and noncytotoxic in nature. Due to these properties sanitary napkin with 100 % Lotus nonwoven core layer was developed which was passed in the test of absorbency under load or pressure (AUL/AUP).

Group of women in the training project has learned this skill of fiber extraction and spinning (manual method). They are ready to continue this work in future which will be a source of income for them. In exhibition -1, mostly the visitors were from the Vadodara district they liked the feel and texture of the fabric. In exhibition -2 major focus was on agriculture waste visitors were from various start up agencies liked the concept of extracting fibers from hygrowaste. Exhibition -3 was entirely textile industry based. Visitors were mostly from the industry they like the sustainability concept of the entire work and also like the feel, texture, color and drape of the fabrics. Hence the fabrication of machines, development of finer to coarser count yarn, preparation of different fabric structure will help to commercialize the Lotus fiber which will add a novel fiber in the textile sector. The most important point of the entire study is not a single drop of chemical is been used from fiber to fabric processing which can be called as sustainability in true sense.

