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DEVELOPING GARMENT FROM WASTE BIOMASS OF CORN

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Abstract: *Cornhusks waste biomass was collected from in and around Delhi and used as raw material for the manufacture of blended yarns. The collected raw material was manually cleaned and then treated with alkali to extract cornhusk fibres. The extracted fibres were washed, neutralized and dried under ambient conditions and evaluated for various properties like tenacity, fineness, moisture content and ash content. To make fibre soft and pliable for spinning purpose, it was treated with modified polysiloxane micro emulsion. The extracted fibres were blended with various fibres such as cotton, polyester and acrylic in blow room in varying proportions and converted in to yarn using hand spinning technology. The yarns so obtained were tested for various properties such as count, tenacity and elongation. Finally developed yarns are converted in to garments.*

Keywords: *Alkali treatment, cornhusk, fibre fineness, Hand spinning, tenacity*

1. Introduction

The cornhusk is an agricultural waste biomass from maize, which is found in abundance in India. The outer protective covering of an ear of maize is called cornhusk. In India, maize is emerging as third most important crop after rice and wheat and both its area and production have steadily increased during the past two decades. The corn production in India was 20.5 MMT in 2010-11 [1]. As the production is increasing so the agriculture wastes. It is an underutilized waste and the common practice in India to get rid of this waste is to burn it. Cornhusk waste contains about 40% cellulose, 45% hemicelluloses, about 7% lignin, about 2% proteins and about 3% ash [2]. The application of this agriculture waste in textiles not only supports the rural community by adding value to their product but also will protect environment by prevention of burning of this waste, which is a common practice. So far not much work has been done on its application in the textiles [3-5]. This paper deals with the extraction of cornhusk fibre from the cornhusk wastes and converting it in to yarn using hand spun technology.

2. Materials and Methods

Dry cornhusk was collected from Aterna village in Panipat, Haryana and Azadpur Mandi, New Delhi.Laboratory grade sodium hydroxide and acetic acid was used. The softening agent was sourced from M/s Resil Chemicals Pvt Ltd.

The corn husk left after the cob is removed from it contains tassels and a hard stem, which has to be cleaned before further processing. The husk was cleaned manually and cut into 3-5 inches length depending upon the requirement of final length of the fibre. Figures 1 to 3 show the process collecting, drying, cleaning and cutting of corn husk.

Figure 1: Collection of cornhusks waste

Figure 2: Cleaning of cornhusks

Figure 3: Cutting cornhusks

The cornhusk raw material was treated at different concentration of sodium hydroxide (0.5, 1.0, 1.5 and 2.0 %) for different temperatures (45, 65, 75, 85 and 95^{o}C) and time duration (30, 45, 60 and 90 minutes) to optimize corn husk fibre extraction process. The material to liquor ratio was maintained 1:30 in all the experiments. The modified polysiloxane micro emulsion based softener was applied on the extracted fibres to impart a smooth lustrous handle.

2.1 Physio-chemical Properties

The various parameters, which were measured, are given below:

2.1.1 Fiber fineness

Fibre fineness (Fibre denier) was measured on Vibroscop. This is an indirect method of measurement of fineness of manufactured fibres. This is based on theory of vibrating strings. In this instrument fibre fineness is determined from the characteristic frequency of a transverse fibre oscillation.

2.1.2 Fibre strength

It is measured in grams per denier. It is determined as the force necessary to break fibres. It is an important parameter to judge the quality and strength of the fibre. It is next to fibre length and fineness in order of importance. It was determined by an instrument called Vibrodyn which is used in conjunction with single fibre fineness tester Vibroscop.

2.1.3 Moisture regain and ash content

Moisture regain and ash content were determined as per IS: 199 standards.

2.2 Spinning of Corn husk blended yarn

Hand spinning technique (Amber Charkha) was used to convert corn husk fibres in to yarn. Amber Charkha designed by Ekambar Nath, a Gandhian worker from Tamil Nadu, following an appeal by the Mahatma for a more productive version of the charkha [6]. After various trials it was found that the 100% corn husk fibre is not spinnable on the present system of spinning. Therefore, corn husk fibres were blended with other fibers such as cotton, polyester, and acrylic in various proportions as shown in the Table 1.

Table 1: Fibre blend percentage

S.No.	Blend percentage	Code
1	30% Cornhusk : 70 % Cotton	Ch:C-37
2	50% Cornhusk : 50 % Cotton	Ch:C-55
3	30% Cornhusk : 70 % Polyester	Ch:P-37
4	50% Cornhusk : 50 % Polyester	Ch:P-55
5	30% Cornhusk : 70 % Acrylic	Ch:A-37
6	50% Cornhusk : 50 % Acrylic	Ch:A-55

The properties of various fibres are given in the Table 2. The fibres used in the blend were first mixed with hand and then fed into the blow room for uniform and homogenous mixing. Thereafter, the lap formed in the blow room is passed in to carding machine followed by draw frame to get uniform sliver. To produce yarn, these slivers were taken directly to amber charkha. As the extracted corn fibre was coarser in nature, coarser count (9s count) of yarn was manufactured.

Table 2: Fibre properties

Parameters	Test method	Fibre			
		Polyester	Acrylic	Cotton	Cornhusk
Fibre Denier	ASTM D-1577	1.03	1.51	1.64	78
Fibre length (mm)	ASTM D 5867	38.7	51.66	29.5	30-40
Tenacity (gm/denier)	ASTM D-3822	6.29	3.48	2.55	1.38
Elongation at break,%	ASTMD-3822	17.04	25.08	7.84	22.3
Moisture regain, %	IS 199	0.4	1.3	7.5	10.5
Ash content, %	IS 199	-	-	1.2	0.8

2.3 Fabric and garment forming

Fabric was manufactured from cornhusk blended yarns on rapier loom (CCI, Taiwan) with EPI/PPI 40/20. Finally garments were fabricated.

3. Results and Discussions

3.1 Extraction of cornhusk fibre

The cellulose fibres in cornhusk are interconnected with each other primarily by lignin and hemicelluloses (two major constituents) to form large bundles of micrometers to millimeter wide. These large bundles are connected to each other by films. Therefore to extract cornhusk fibres from the cornhusk it is required to break the film and then separate fibres from the bundles by removing lignin and hemicelluloses. The extraction of corn husk fibre from cornhusk was carried out using alkali extraction method. The optimum treatment conditions such as concentration of alkali (sodium hydroxide), treatment time duration and temperature were decided on the basis of the following studies.

3.1.1 Effect of alkali concentration

The optimum concentration of the NaOH for extraction of fibre was decided on the basis of strength and fineness of the fibre obtained after the treatment. In this study treatment temperature (85^{o}C) and time (60 minutes) were kept constant, while NaOH concentration was varied from 0.2 to 2.0%. At 0.2% of NaOH concentration, fibres were not opened properly. Therefore for further experiment, the effect of concentration from 0.5 to 2% on fibre properties was studied.

It was observed that with the increase in concentration of NaOH, fineness of fibre is improving while strength of the fibre is decreasing. Earlier study on jute and corn fibre indicated that with the increase of sodium hydroxide concentration, fibre fineness improves [4, 7]. At 0.5 % NaOH concentration the fineness of fibre was 80 denier and fibre strength was 1.52 g/denier. However higher strength loss (0.89 g/denier) was seen when the concentration of NaOH increased up to 2%. It is also reported that the breaking force of cornhusk is significantly affected by alkalization duration and concentration. On the basis of this study, minimum NaOH concentration (0.5%) was selected for the further extraction work [4].

3.1.2 Effect of temperature

To optimize the extraction temperature, the raw cornhusk material was treated with 0.5% NaOH solution for 60 minutes at 45, 65, 75, 85 and 95^{o}C temperatures. From the study it was found that up to 70^{o}C, the corn husk fibre did not get extracted. The reason for extraction of corn husk fibres not occurring at this temperature may be the insufficient removal of lignin and hemicelluloses from the raw material. The complete fibre opening and extraction was done at 85^{o}C. The fibre extracted by this process was tested for tenacity and fineness properties. The tenacity of fibre was found to be 1.52 g/denier and fineness was 80 denier. With further increase in temperature up to 95^{o}C, the tenacity of fibre started decreasing (from 1.52 g/denier at 85^{o}C to 1.10 g/denier at 95^{o}C). The reason of decreasing tenacity at higher temperature might be due to some adverse affect on the cellulose. Therefore 85^{0}C treatment temperature was selected for further study.

3.1.3 Effect of time

In this study treatment temperature (85^{o}C) and concentration of NaOH (0.5%) were kept constant and time was varied (30, 45, 60 and 90 minutes). It was seen that at 30 minutes treatment time, there was no significant change in the fibre extraction. However with the increase of treatment time, extraction of fibre started. At 60 minutes treatment time, fibres are opened and extracted completely. Further increase in treatment time, fibre tenacity deteriorated from 1.52 g/denier (60 minutes treatment time) to 0.95 g/denier (90 minutes treatment time). The reason of decreasing tenacity at higher durations might be due to the damage done [4] to the cellulosic bone with prolonged treatment. Therefore, 60 minutes treatment time was selected for further study.

Finally for the 0.5% sodium hydroxide, 60 minutes treatment duration and 85^{o}C temperature treatment conditions were selected for bulk extraction of cornhusk fibre from cornhusk waste.

3.2 Physical and chemical properties of extracted fibres

The physico-chemical properties of corn husk fibre are shown in the Table 2. The fineness of a natural fibre is a major factor in ascertaining quality. Finer fibres are softer and more pliable. It is clear from the Table 3 that the corn husk fibre is coarser (78 Denier) than other fibres.

From the table it is also explicit that the tenacity of corn husk (1.38 g/denier) is lower than other fibres. The amount of extension or stretch on application of force that a fibre posses is referred to as elongation. Corn husk fibre is having higher elongation than cotton, polyester and acrylic. Elongation at break of cornhusk fibres was 22.3% (Table 2). The lower orientation and higher amorphous regions are responsible for the increased elongation, because when the fibre is stretched, molecules in these regions can align themselves to become more oriented to the fibre axis without rupture. The ability of bone dry fibre to absorb moisture is called moisture regain. Moisture regain of cornhusk fibres was found to be 10.5% (Table 2) Cornhusk fibres have higher moisture regain due to the presence of non-cellulosic substances, especially hemicelluloses which is hydrophilic. The higher amount of accessible regions, surface area and capillary effect contribute to the higher regain. The high moisture regain of cornhusk fibres suggests that apparel made from cornhusk fibres would be comfortable to wear. The percentage of ash content in cornhusk fibres was found to be 0.8 % as shown in the Table 2.

3.3 Treatment of corn husk fibre with softener

As the fibres obtained were harsh in texture these were treated with softener to make them soft and pliable. The modified polysiloxane micro emulsion is used to impart a smooth lustrous handle. Required amount of finish was taken and nine parts of water were added. It was mixed well and added to the finishing bath. After the bath was ready, fibres were introduced in it for 25 minutes. Afterwards the fibres were dried at ambient conditions. The application of softener resulted in smooth handle.

3.4 Yarns manufacturing and their evaluation

It is clear from the study that cornhusk fibres blends with cotton, polyester and acrylic are process able on blow room, carding and draw frame without any modification. However it is required to maintain proper moisture in the corn fibre as in the dry state it curls and make processing difficult. Beside this it was observed that cornhusk fibres being coarser and stiff compare to cotton, polyester and acrylic, some of the fibres were held by the card wire. Due to this the exact blend ratio could not be maintained during processing. The exact blend ratios were determined after manufacturing of yarn, which are given in the Table 3.

Table 3: Properties of Cornhusk blended yarn

Code	Actual Blend, %	Count (Ne)	Twist per Inch	Tenacity (g/tex)	Elongation (%)
Ch:C-3	18:82	8.7	11.8	5.4	6.14
Ch:C-55	30:70	9.2	12.0	5.0	7.9
Ch:P-37	16:84	9.3	12.8	10.7	12.47
Ch:P-55	29: 71	8.8	11.7	11.6	13.42
Ch:A-37	20:80	8.7	12.2	8.2	11.86
Ch:A-55	33:77	9.0	11.9	7.1	12.55

From the table it is clear that in all the yarns, tenacity decreases with the increase of cornhusk percentage. It may be due to lower tenacity of cornhusk fibre than other fibres as shown in the Table 2. It is also revealed from the Table 3, that the elongation percentage of Ch: C-55 yarn is higher than the Ch:C-37 yarn. The reason of higher elongation of Ch: C-55 may be due to higher cornhusk content in this yarn, which has higher elongation as shown in the Table 2. Tenacity of cornhusk and polyester blended yarn (Ch: P-37 and Ch:P-55) are found to be higher than corresponding cornhusk and cotton blended yarn (Ch:C-37 and Ch:C-55). This trend is expected as tenacity of polyester fibre is much higher than cotton fibre. It is also clear from the Table 3 that the tenacities of Ch:A-37 and CH:A-55 are higher than corresponding cornhusk and cotton blended yarns. It may be attributed to higher tenacity of acrylic fibre than cotton fibre as shown in the Table 2.

3.5 Fabric construction

Corn husk blended fabric samples were developed on repair shuttle less loom (EPI 42 and PPI 20).

3.6 Design and construction of Garments

The garments were designed and constructed using fabric developed out of various blends. Design and construction of two garments are shown in Fig 4 and 5.

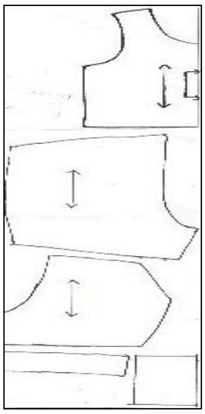
Figure 1 shows two piece ensemble with a short jacket and shorts in orange and grey colors was designed for preschoolers aged 3-4 years. The shorts have front hip pockets whose edges are embellished with running stitch in contrasting colors. The fabric used for construction was the cornhusk and polyester blended fabric.

SCALE: 1:8

DESIGN No. 1 **PATTERN LAYOUT**

Figure 4: Garments (Polyester and Corn husk blended)

Figure 2 shows two piece ensembles with a short top and shorts in pink and grey colors was designed for preschoolers aged 3-4 years. The shorts have front hip pockets whose edges are embellished with running stitch in contrasting colors. The fabric used for construction was the cornhusk and acrylic blended fabric.



SCALE: 1:8

DESIGN NO. 2 **PATTERN LAYOUT**

Figure 5: Garments (Acrylic and Corn husk blended)

4. Conclusion

It is evident from the study that the better extraction of fibre is achieved when cornhusk is treated with 0.5% of sodium hydroxide at 85°C for 60 minutes keeping MLR 1:30. with the increase in treatment temperature. With the increase of concentration of sodium hydroxide, treatment time and temperature the fineness of fibre improved but the tenacity of cornhusk fibre decrease as the pulping process started. The heavy metal analysis indicated that cornhusk fibres are having lower metal content than the raw corn husk. This may be due reaction of sodium hydroxide with the metals, present in the raw cornhusk, which form insoluble metal hydroxide. The insoluble metal hydroxide may be liberated from the surface of fibre, after repeated washings. It was observed that 100% cornhusk fibre could not be converted in to yarn as it was harsh. Various blended yarn of cornhusk fibres with cotton, polyester and acrylic were manufactured using hand spinning technology (Ambar Charkha). It was observed that with the increase of cornhusk percentage in the blended yarn, tenacity of the yarn decreases as the tenacity of the cornhusk fibre is lower than other fibres used in this study. Finally garments were fabricated using corn husk blended fabrics.

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