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Utilization of Cornhusk for Textile Usages

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Abstract—*As sustainability is the prime concern worldwide, textile industry is striving hard to find sustainable means for production of textiles. Some of such initiatives include using recycled raw materials rather than virgin materials for making textile products which in turn lead to conservation of natural resources, reduced energy consumption, less carbon dioxide and other emissions and waste going to landfills. Cornhusk which is an agro waste creates a huge problem of its disposal. If it is used to develop textile products, it would lead to value addition and generate additional income. Keeping in view the above, the study aimed at extracting fibres from cornhusk, determining composition, assessing various physico-chemical properties and morphology of extracted fibres. The dyeing behaviour of cornhusk fibres was also studied. Finally the fibres were put to different end uses as per their suitability and prototypes of different products were created.*

1. INTRODUCTION

Sustainability is the key mantra presently in all the industries across the world, especially textile sector as it is one of the largest industries of the world. Sustainability concerns with each and every aspect of industries, our lives and continuation of human life on the earth. The production of textiles has always added to the environmental problems, particularly due to huge water consumption and pollution caused by processing of textiles. The textile industry is continuously emphasizing on sustainable means for production of textiles. Sustainability in textiles refers to employment of those means which make the production of textiles environment friendly. Some of the environmental benefits of using recycled raw materials rather than virgin materials for making textile products are; conservation of natural resources, reduced energy consumption, less carbon dioxide and other emissions and waste going to landfills. Utilizing renewable natural resources through value addition is an ideal transition from a petroleum based economy to bio-based economy. Organic wastes, which are otherwise a challenge to the environment, could prove to be a potential alternative for production of value added products products [3].

Agro waste like sugarcane bagasse, rice husk and cornhusk etc. have traditionally been used as fuels but their burning adds to air pollution. They need to be utilized more efficiently to add to our existing renewable resources. One such agro waste that can be employed to broaden our textile resource basket is; cornhusk, the outer covering of the corn cobs. Cornhusk is an agro waste which poses a problem of its disposal. Using it to develop textile products would mean value addition leading to income generation.

Corn is the 3rd most important food crop after rice and wheat in India. In India, maize is cultivated in all the states except Kerala. It is cultivated throughout the year in different parts of the country for various purposes. Corn production in India has grown at a compounded annual growth rate of 5.5 per cent over the last ten years from 14 million metric tons in 2004-05 to 23 million metric tons in 2013-14 [1].

The cornhusk which is a bio-waste can be utilized for extraction of fibres which can be used for various textile applications. If 23 million metric tons of corn is produced in India annually, it could generate approximately 5 million metric tons of husks which could in turn lead to production of about 0.5 million metric tons of fibre [5]. The major advantage of using cornhusk fibre is; fulfilling the requirement of food and clothing from same land without using any additional resources. It is in tandem with current motto of economic sustainability which emphasizes on developing such means of generating income and wealth, which do not cause hazards to the environment.

By-products of food sources like pineapple and banana leaves, sugarcane rind and coconut husks have been already used for extracting fibres for use in textiles though the fibres obtained from these also have some limitations in quality, availability and geographical requirements necessary to grow these crops. On the contrary, cornhusk is easily available, with no geographical limitations, and does not have any commercial value till date. Utilization of a bio waste like cornhusk will also help in solving the problem of its disposal and reducing the cost of waste treatment. Therefore, cornhusk could be looked upon as a source of textile fibres.

2. MATERIAL AND METHODS

The study included extensive experimental work of optimizing the recipe for fibre extraction from cornhusk, characterization and analysis of physical and chemical parameters of extracted

fibres. Experiments were also conducted to develop a shade card of fibres using reactive and vat dyes.

To seek a logical application of the extracted fibres, a range of products was explored and created by blending cornhusk fibres with other fibres like cotton, coir etc. Cornhusk fibres were used to manufacture yarn, rope and hygiene products like sanitary napkins which were then tested for the desirable parameters. The study was carried out in following steps

2.1. Extraction of Fibres from Cornhusk

Cornhusk was collected from Atterna Village of District Sonepat, Haryana. It was sourced with the help of Directorate of Maize Research, Pusa Campus, New Delhi. The cornhusk was collected, cleaned, dried and stored in a well- ventilated room. It was treated with alkali. The alkali treatment was optimised with respect to alkali concentration, temperature and treatment time. This was followed by enzyme treatment which was optimized on the basis of enzyme concentration and treatment time. Enzyme treated cornhusk fibres were bleached using hydrogen peroxide. The concentration of bleach and treatment time was optimized. A softening treatment was given to impart a smooth handle to the fibres.

2.2. Physical and Chemical Analysis of the Extracted Cornhusk Fibres

The extracted cornhusk fibres were analysed for their composition and physico-chemical properties using standard test methods. Estimation of cellulose, hemicelluloses (pentosans) and lignin contentwas done in accordance with TAPPI standards at Cellulose and Pulp Division, Forest Reseach institute, Dehradun, Uttrakhand. Ash content was determined according to I.S – 199-1989 standard method and wax content was determined in accordance with I.S-199-1973 standard method.

The assessment of various properties of extracted cornhusk fibres was done at different stages of extraction to establish a relation between various parameters of extraction process and physical properties of fibres. The various properties evaluated were fibre length, fineness, bundle strength, elongation at break, moisture content and regain and absorbency (drop penetration time). Standard methods were followed to evaluate the above mentioned properties [2].

2.3. Dyeing of Cornhusk Fibres

The cornhusk fibres were dyed with reactive and vat dyes in different colours and assessed in terms of K/S values and colour fastness properties.

2.4. Product Development

Extracted cornhusk fibres were blended with different fibres to make various products. The corn husk fibres were blended with cotton and polyester to make yarns and fabrics. They were blended with coir to make coarse yarn, ropes and hand-made mats of different types; and with wood pulp for use as absorbent layer in sanitary napkins.

3. RESULTS AND DISCUSSION

3.1. Extraction of Fibres from Cornhusk

The husk was collected from fully mature cobs of Syngenta Sugar-75, a variety of sweet corn, from Aterna village in Panipat (Haryana) which was sourced with the help of Directorate of Maize Research, Pusa Institute (DMR). The cornhusk was cleaned and dried to prevent it from deterioration during storage. Dried cornhusk was stored in properly ventilated room.

3.1.1. Alkali Treatment

The fibre extraction process was initiated with alkali treatment of cornhusk using sodium hydroxide. The alkali treatment was optimized with respect to concentration of sodium hydroxide, temperature and time of treatment. The bundle strength and fineness of the fibres obtained were the parameters to be considered for optimising the treatment conditions. A concentration of 4 g/l sodium hydroxide with a treatment time of 60 minutes at a material to liquor ratio of 1:40 and a temperature of 98 -100˚C was finalized for alkalization of cornhusk to extract fibres as the fibres obtained in these conditions were optimum in terms of strength and fineness i.e. 1.59 g/denier and 130 deniers respectively. The temperature below 98 -100˚C did not lead to complete separation of fibres. The concentration more than 4 g/l resulted in significant loss of strength while at lower concentration, extraction was incomplete. Treatment time longer than 60 minutes also caused significant deterioration in the strength of fibres.

3.1.2. Enzyme Treatment

As the fibres obtained with alkali treatment were quite coarse and harsh in nature (Figure 1a), they were further treated with Pulzyme HC, a xylanase enzyme to make it softer and finer (Figure 1 b). For optimizing this treatment, two variables i.e. concentration of enzyme and treatment time were taken. Temperature and pH were specified by the supplier itself. The enzyme treatment was optimized at 5% Pulpzyme HC (owf) for 30 minutes with pH at 8-9 and temperature between 55 - 60°C as the fibres had highest bundle strength i.e. 1.56 g/d and optimum fineness i.e. 97 denier. Enzyme treatment did not have much impact on strength of fibres but improved the fineness considerably which also made the fibres more pliable. In fact strength increased on treatment with enzyme probably due to increased flexibility after removal of hemicelluloses.

3.1.3. Bleaching of Extracted Fibres

As the fibres extracted from cornhusk were yellow in colour, they were bleached using hydrogen peroxide. Bleaching treatment was optimised in terms of whiteness index and bundle strength of cornhusk fibres. The treatment led to improvement in fineness of fibres and some decrease in the

strength. Considering all the three parameters, concentration of 2g/l hydrogen peroxide for 60 minutes treatment time was selected, as the fibres had optimum properties at this combination i.e.1.33 g/denier bundle strength, fineness of 86 deniers and whiteness index of 60**.** To impart a smooth handle to the extracted cornhusk fibres, they were applied a cationic, silicone based softener. Application of softener made opening of fibres quite easy and their brittleness was also reduced.

3.2. Physical and Chemical Analysis of Extracted Cornhusk Fibres

After extraction of fibres from cornhusk, the composition of fibres was determined and their physico-chemical properties were analysed. The cornhusk fibres being ligno-cellulosic in nature primarily contain cellulose, hemicelluloses and lignin; and small amount of wax and ash. Bleached cornhusk fibres were mainly composed of 76% cellulose, 11.43% hemicelluloses, 7.5% lignin, 0.25% and 0.34% ash content.

Some of the physical properties of the extracted cornhusk fibres studied included length, fineness, bundle strength, elongation at break, moisture content and regain and absorbency (Table 1).

Table 1: Some Physical Properties of the Extracted Cornhusk Fibres

S. No.	Physical Parameter	Value for Cornhusk Fibres
1.	Length	10 cm
2.	Fineness	86 Denier
3.	Bundle Strength	1.33 g/denier
4.	Elongation at break	18.5 %
5.	Moisture Regain	11.4 %
6.	Absorbency (time in seconds) Drop penetration time	<1second

3.3. Dyeing of Cornhusk Fibres with Reactive and Vat Dyes

As the extracted fibres were cellulosic in nature, cornhusk fibres were dyed with reactive and vat dyes, which are suitable for this class of fibres.

The fibres were dyed at 4% shade using three reactive colours; C.I. Reactive Violet 5, C.I. Reactive Yellow 15 and C.I. Reactive Orange 16 and three vat colours; C.I. Vat Red 13, C.I. Vat Blue 6 and C.I. Vat Yellow 2 and their K/S values were determined (Table 2).

The fibres showed excellent fastness to washing and perspiration both for staining and colour change; and good to very good fastness to light in all the three colours of reactive dyes. The fibres showed very good to excellent fastness to washing and perspiration for all the three colours of vat dyes while good to very good fastness to light for all the three colours of vat dyes.

Table 2: K/s Values of Cornhusk Fibres Dyed with Reactive and Vat Dyes

Reactive Dyes	K/S Value
C.I. Reactive Orange 16	16.38
C.I. Reactive Violet 5	12.47
C.I. Reactive Yellow 15	9.41
Vat Dyes	
C.I. Vat Red 13	15.74
C.I. Vat Blue 6	18.93
C.I. Vat Yellow 2	16.84

3.4. Product Development

After knowing the basic characteristics of the extracted fibre, it was put to different end uses.

3.4.1. Manufacturing of Yarn

Yarns were spun by blending cornhusk fibres with cotton and polyester fibres in two ratios; cornhusk: cotton- 50:50, cornhusk: polyester- 50: 50, cornhusk: cotton- 30: 70 and cornhusk: polyester- 30: 70. Cornhusk fibre showed poor cohesiveness in both the yarn blends and could not be spun on ring frame due to lack of strength and cohesiveness in both the cornhusk and cotton fibres [4]. The yarns were very coarse and of low tensile strength. The fabric sample was constructed with ring spun polyester/ cornhusk (50/50) yarn on rapier loom but the fabric had a very rough texture and harsh feel.

3.4.2 Cornhusk-Coir Blended Products

Cornhusk fibres were also blended with coir fibre (50/50) to prepare coarse yarn and samples of various products like rope and different types of hand-made mats were manufactured using the blended yarn. Different types of mats like hand woven, sinnet and corridor prepared using cornhusk blended yarn were softer in feel and similar in appearance to the mats made by using 100% coir fibres.

3.4.3 Sanitary Napkins with Cornhusk Fibres Blended Wood Pulp

Keeping in mind their high water retention property, the cornhusk fibres were used in absorbent layer of sanitary napkins along with wood pulp in 30% and 50% proportion. The developed sanitary napkins were evaluated for various physical and hygiene parameters like pH, water retention, flexibility, absorbency and ability to withstand pressure, disposability, bacterial and fungal bio-burden and presence of common skin pathogen *Staphylococcus aureus* and common uterine pathogen *Candida albicans*. The developed cornhusk fibre napkins were compared with three branded and two locally made sanitary napkins for all the parameters and it was found that the performance of developed sanitary napkins was as per the established standards. Thus application of cornhusk fibres for hygiene products could be undertaken commercially.

4. CONCLUSION

Accumulation of unmanaged agro-waste especially from the developing counties has an increased environmental concern. Recycling of such wastes into sustainable, energy efficient textile materials is a viable solution for the problem of pollution and natural resource conservation for future generation. The manufacturing of coarse yarn from cornhusk fibres by blending with fibres like coir and its use for developing a range of hand-made products has ample scope. This would lead to employment generation for a large section of rural population. Another segment where cornhusk fibres could prove to be a promising alternative is their application in various hygiene products like sanitary napkins and diapers. As consumption of these products is on a continuous rise, alternative sources are required to replace wood pulp due to environmental concerns. Utilizing cornhusk for textile applications could become a major breakthrough in this direction.

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