Value addition of *Dhaincha* fibres through dyeing for product development

MAMTA ARYA, ANITA RANI and MANISHA.GAHLOT

Department of Clothing and Textiles, College of Home Science, G. B. Pant University of Agriculture and Technology, Pantnagar-263145 (U. S Nagar, Uttarakhand)

ABSTRACT : The growing ecological consciousness and limited land availability for cultivation of fibre yielding crops have pressed researchers to explore under-utilized and new natural resources that could be used in place of conventional textile fibres for numerous end uses both technical and aesthetic. *Dhaincha* is a green manure crop used prior to paddy cultivation in Uttarakhand and is also one of the valuable medicinal herbs. Botanically, this plant is called *Sesbania aculeata* and also known by common names as *danchi*, *dhaincha*, *dunchi* and *danicha*. This plant belongs to leguminacea family that yields harsh, coarse and shiny fibres having potential of application in the different sectors. The present study was, therefore, planned to explore the use of *dhaincha* fibre in home textiles. Value addition of *dhaincha* fibres was done through dyeing. Non woven fabric was prepared by needle punching method and products were developed. Finally the assessment of prepared product was done on the various parameters by their prospective consumers i.e., women in the age group of 20-27 years. The result of the study revealed that the *dhaincha* fibres could be dyed effectively with direct, azoic and reactive classes of synthetic dyes. The dyed fibres could be used for non- woven production by needle punching technique. The articles prepared included hand fan, magazine holder and table mat. The articles were acceptable amongst all the consumers. It was noted that the hand fan was most preferred article prepared from *dhaincha* fibres.

Key words: Bast fibre, dyeing, product development, *Sesbania aculeate*, value addition

Natural fibres are major source of livelihood for millions of small-scale farmers and processors in the world. However due to the lack of research and information dissemination, only a few species have been identified and extracted commercially, leaving many more fibre containing species unidentified and under-utilized. Thus awareness regarding harvesting natural fibres for textile purposes is an issue of global concern not only to the producers and industry but also to the researchers, consumers, conservationists and the environmentalists. As of now, it is not possible to increase yield of natural fibres owing to land limitation. So research efforts are targeted towards exploration of natural textile fibres from less recognized unconventional sources to reduce the dependency on the manmade textiles which are identified universally as major source of environmental degradation at all stages in their life cycle i.e., during their production, use and disposal. Roughly about 2000 or more species of plants are now known to yield the fibres and only few of them are commercially important (Wealth of India, 1954). For this reason efforts are needed to extract textile fibres from natural resources to enhance eco friendliness in this sector. There are number of under-utilized fibres found in different regions of India that could offer large possibilities in future. Such fibres are available in sufficient quantities either at a negligible price as agro waste or free of cost as wild flora and are consumed for less valuable applications like cord making, fuel or animal feed, etc. These fibres can be used successfully for textile applications in varied fields by improving their texture and quality through processing. The value added products or apparels can be made either in pure or blended form of these unconventional fibres. Thus utilization of these types of fibre sources will help towards achieving of sustainable development approach in textile sector. *Dhaincha* is a green manure crop grown extensively prior to paddy cultivation in Uttarakhand state. It is also one of the valuable medicinal herbs found in the region. Botanically, this plant is called *Sesbania aculeata* and belongs to *leguminacea* family. It is also known by common names like *danchi, dhaincha, dunchi* and *danicha*. The harsh, coarse and shiny fibres are obtained from this plant that can have potential of application in the different sectors. Thus in the present study value addition of *dhaincha* fibres had been tried through dyeing with

different classes of synthetic dyes and further explored to develop few articles suitable for functional and aesthetic household applications.

MATERIALS AND METHODS

Procurement of raw material

The stems of *dhaincha* plants were procured from the Crop Research Centre (CRC), G.B.P.U.A.&T., Pantnagar. Direct, azoic and reactive dyes were used in the present study as these classes of dyes have affinity towards cellulosic fibres and were procured from the dye market of Jaipur (Rajasthan).

Retting of dhaincha stems

The collected cut stems of *dhaincha (S. aculeata)* plants were cleaned by removal of branches, leaves and pods. Thereafter, the stems were further cut into short length of 12" and were tied into bundles for ease in handling. Retting was done by following stagnant open tank water retting method as per procedure given by Singh, 2010. The retting was carried out for 21±3 days in the month of October in tubs (Fig. 1). The temperature ranged between 11°C to 27 °C at the time of retting. Relative humidity was in the range of 24 % - 38 % (minimum) and 79 % - 84 % (maximum). The fibres from *dhaincha* stems were drawn by hands while washing and laid on flat surface for drying in the open air. Thereafter, the dried fibres were combed manually with combing brush to separate the long fibres from short fibres, straightening of the fibres and removal of vegetative matter i.e., the bark, skin, etc. present in them.

Fig. 1. Stagnant water retting of *Dhaincha* (*Sesbania aculeata*)

Processing of dhaincha (S. aculeata) fibres

Combed fibres were processed by scouring, bleaching and dyeing. Scouring and bleaching was done as per method given by Negi (2011). Dyeing of fibres was done with three synthetic dyes following the standard recipes of dyes for cotton (Giles, 1974).

a) *Scouring*: The extracted *dhaincha* fibres were scoured using given recipe (Table 1). Then the fibres were washed in flowing water. After scouring fibres were neutralized with 2 % acetic acid for 1 hour and then washed thoroughly with water and dried.

b) *Bleaching*: The scoured fibres were bleached using the given recipe (Table 2) and washed throughly with cold water at the end. This was followed by neutral wash with 2% acetic acid and finally washed with cold water.

c) *Dyeing with reactive dyes*: Reactive dyes, unlike any other class of dyestuff, react and combine chemically with cellulose. It is this characteristic that gives them the name "reactive dyes" (Kaushik and Josico, 2003). Firstly 0.02 g of dye was dissolved in 30 ml of water to prepare the dye bath. The dye bath was initially set at 50°C for immersing the material in it. The temperature was gradually raised to 80°C. Then sodium chloride was divided in three equal parts and each part was added separately within 30 minutes, keeping the dye bath temp at 80°C ± 5°C (Table 3). Further sodium carbonate was added in two parts and dyeing was continued for next 45 minutes. MLR ratio was maintained by adding water intermittently throughout the dyeing process. After the dyeing was over, the fibres were rinsed in cold water and dried in shade.

Table 1: Recipe for scouring of *dhaincha fibre* (Negi, 2011)

Ingredients		Quantities
1.	Ammonium oxalate	5g/l
2.	Time	2 hours
3.	MLR	1:50
4.	Temperature	100 °C

*owm- on the weight of material

Table 2: Recipe for bleaching with hydrogen peroxide (Negi, 2011)

	Ingredients	Quantities
1.	H_2O_2	1 g/ 100ml
2.	Tri- Sodium phosphate	5 g/ l
3.	Sodium hydroxide	1 g/ l
4.	Sodium Silicate	10 g/ l
5.	Temperature	90^0C
6.	Time	30 minutes
7.	MLR	1:50

d) *Dyeing with direct dyes*: Direct dyes are one of the simplest classes of dyes to use. They are water-soluble and can be applied to almost all natural cellulosic fibres and viscose rayon, by simply heating the material in a weak dye solution preferably with the addition of common salt or Glauber's salt.

e) *Dyeing with azoic dyes*: These dyes are formed in the fibre itself by chemical reaction between two substances i.e., a coupling component and another is a diazo component. Two grams of coupling component was pasted with TRO. Then 20 ml of hot water was added to the paste and mixed well. Further caustic soda was added and stirred well to get clear solution. Fibres were then immersed in this bath for 10 minutes. Diazo component (dye salt) was mixed well in cold water at room temperature. After dissolving the dye salt common salt was added and naphtholated fibres were dipped in this bath for 30 minutes (Table 5).

Testing of processed fibres

The physical properties of *dhaincha* fibres namely, tensile strength, elongation, fineness, moisture regain and whiteness index were assessed after processing.

Table 3: Recipe for dyeing with reactive dyes

	Ingredients	Quantities
1.	Dye concentration	2% owm*
2.	NaCl	70g/l
3.	Na_2CO_3	20g/l
4.	M:L ratio	1:30
5.	Temperature	80^0C
6.	Time	75 min

*owm- on weight of material

Table 4: Recipe for dyeing with direct dyes

	Ingredients	Quantities
1.	Dye concentration	2% owm*
2.	NaCl	20% owm*
3.	M:L ratio	1:50
4.	Temperature	80 -95 °C
5.	Time	75 min

*owm- on weight of material

Cold bath was prepared by adding 0.02g of dye and 0.2g salt for dyeing of one g of fibre in 50 ml of water; further fibres were soaked with the water, squeezed and placed in this dye bath. Then the temperature was raised up to 80-95°C with continuous stirring in 15 minutes (Table 4). Finally the fibres were removed from dye bath, squeezed and rinsed in cold water.

Table 5: Recipe for dyeing with azoic dyes

	Ingredients	Quantities
1.	Dye concentration	5 % owm*
2.	Caustic soda	10%
3.	Naphthol	2g/5g of material
4.	NaCl	10%
5.	M:L ratio	1:50
6.	Temperature	Room temperature
7.	Time	40 min

*owm- on weight of material

Further the dyed *dhaincha* fibres were tested for fastness against washing, rubbing and light.

Preparation of nonwoven

The processed *dhaincha* fibres were used for preparing nonwoven following needle punching method at OBEETEE Textiles Ltd., SIDCUL, Pantnagar. The needle punching loom used for nonwoven manufacture was based on Dilo Technology of Germany using Delta card system and had synchronization with PLC drives. The dyed fibres were used to make web, which was then fed into the machine where needles entangled the fibres with each other through their motions. Thus the fabric production did not involve chemical. It was kind of true mechanical bonding method (Singh and Rani, 2013).

Product development

Three products were prepared for showcasing the potential use of dyed *dhaincha* nonwoven as home textiles. The products planned were hand fan, table mat and magazine/ newspaper holder. The techniques used in product designing involved quilting, taping and lacing. The shape and finishing of the articles added distinctive character to make them appear apart from the regular products available in the market. Finally the cost of the products was calculated.

Assessment of prepared products

The prepared products were assessed on the five parameters namely, design and shape of the article, durability as per end use, suitability to end use, colour of fabric, suitability of cost to judge their consumer acceptability. The assessment was done by the 30 consumers on five point rating scale.

RESULTS AND DISCUSSION

The study was aimed at exploring the possibility of dyeing of the processed *dhaincha (S. aculeata)* fibres

with selected classes of synthetic dyes and making of nonwoven for production of household articles. The results are reported under following heads:

Microscopic view of dhaincha (S. aculeate) fibres

The longitudinal and cross sectional microscopic structures of scoured dhaincha (S. aculeata) fibres as observed under microscope at 40X magnification are shown in Fig. 2 and Fig. 3, respectively. In longitudinal view the fibre appeared as a straight tube with the nodes similar to that of bamboo fibres. The surface of fibres seemed rough due to presence of longitudinal fissures. The cross sectional microscopic view of *dhaincha (S. aculeata)* fibres revealed that fibres were irregular in shape with serrated edges.

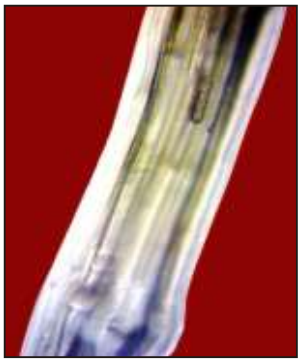

Fig. 2: Longitudinal view

Fig. 3: Cross sectional view

Fibre length and diameter of scoured fibres ranged from 167.64 to 281 mm and 80.95 to 97.80 micron, respectively. The *dhaincha* fibres are longer and coarser than hemp fibres as clear from the findings of Singh (2012) who reported the length and diameter of hemp fibre ranged between 30- 150 mm and 17.23 to 31.67 micron, respectively.

Physical properties of processed dhaincha (S. aculeata) fibre

The physical parameters namely, length, diameter, elongation, tensile strength, fineness, moisture regain and whiteness index were tested for the bleached fibres The results pertaining to the physical properties of the processed fibres are presented in Table 6.

The results are akin to the findings of Singh (2012) who studied the effect of bleaching on the hemp fibers' physical properties and found their tenacity 3.67 g/ denier, and moisture regain 8.11 percent. The results are in consonance with the findings of Chattopadhyay *et al*.

Table 6: Physical properties of *dhaincha (S. aculeata)* fibres after bleaching

S. No.	Property	Values
1.	Whiteness index	-7.00
2.	Tenacity (g/ denier)	4.06
3.	Elongation (percent)	3.47
4.	Fineness (denier)	16.33
5.	Moisture regain (percent)	8.87

(2006) who found elongation of jute as 3.16 per cent which is also a bast fibre.

Fastness properties of dyed dhaincha fibres

The colour fastness was tested against washing, rubbing and light. The fastness properties of processed fibres of *dhaincha (S. aculeata)* plants dyed with direct, azoic and reactive dyes are presented in Table 7.

In the case of direct dye, dry rubbing fastness was good with rating 4/5 which means there was slight colour change and slight staining. The wet rubbing fastness was very good as there was slight change in colour and slight staining on standard fabric on rubbing. Light fastness of *dhaincha* fibre dyed with direct dye exhibited fair light fastness (rating 3).

Table 7 further indicate that the fibres dyed with azoic dyes showed noticeable staining on cotton (rating 3/4) while wool was slightly stained (rating 4) and slight colour change was seen in washed *dhaincha* fibres (rating 4). Dry rubbing fastness was excellent with rating 5 which means there was neither colour change nor staining on standard fabric while on wet rubbing, there was slight change in colour (rating 4/5) and negligible staining (rating 4/5) was observed on standard fabric. *Dhaincha* fibres dyed with azoic dye showed fairly good light fastness with rating 4.

It can also be envisaged from data in Table 7 that the fibers dyed with reactive dye showed excellent fastness against washing and dry rubbing as depicted by ratings 5. The wet rubbing fastness was very good as slight change in colour (rating 4/5) and negligible staining (rating 4/5) was detected on standard fabric on rubbing. Light fastness of *dhaincha* fibre dyed with reactive dyes displayed good light fastness with rating 5.

Overall result shows that the fibres dyed with reactive dyes had best colour fastness due to chemical bonding of dye molecules with the fibre molecules.

Table 7: Fastness ratings of dyed *dhaincha* fibres

S. No.	Variables	Parameters		Fastness rating		
				Direct dye	Azoic dye	Reactive dye
1.	Washing Fastness	Colour stain on cotton		3/4	3/4	4/5
		Colour stain on wool		4	4	4/5
		Colour change		3/4	4	4
2.	Rubbing Fastness	Dry	Colour change	4/5	5	5
			Colour stain on cotton	4/5	5	5
		Wet	Colour change	4	4	4/5
			Colour stain on cotton	4/5	4/5	4/5
3.	Light Fastness			3	4	5

Front view

Back view

Plate 1: Hand fan

Plate 2: Table mat

Plate 3: Magazine holder

The dyed fibres' web was prepared for their feeding into needle punching machine for nonwoven preparation.

Product development

Three household articles specifically, hand fan, table mat and magazine holder were prepared from nonwoven made from *dhaincha* fibres and are presented in Plates1, 2, and 3, respectively. The cost of hand fan, table mat and magazine holder were calculated as Rs. 100/-, Rs. 104/- and Rs. 148/- respectively.

Assessment of prepared product for consumer acceptability

The evaluation of prepared articles were carried out on five point rating scale on the parameters viz., design and shape of the article, durability as per end use, suitability to end use, colour of fabric and suitability of cost. The WMS of each article was calculated and results were drawn. The WMS of prepared articles are given in Table 8.

The data presented in the Table 8 shows that all the three articles were accepted by the consumers very well as depicted by the values of the WMS which were above 3.0 for all the parameters.

Design and shape of all the prepared articles were acceptable as depicted by WMS 4.3. Hand fan and table mat were preferred more for the durability (WMS 3.93). Amongst the five parameters, colour of the fabric was rated high and acceptable by almost all the consumers as the WMS ranged between 4.4 to 4.5. Table mat and magazine holder were considered suitable to the end use as depicted by WMS 4.03 and 4.06, respectively. Figure 4 reveals that hand fan was rated best with average WMS of 4.19 followed by table mat and magazine holder with WMS of 4.09 and 4.01, respectively.

CONCLUSION

It can be concluded from the findings that dhaincha fibres could be dyed with synthetic dyes. The standard recipes of dyes for cotton could be used for dyeing of *dhaincha* fibres because the *dhaincha* fibres are of same generic class. Nonwoven were possible to be made easily with needle punching method using processed *dhaincha*

Table 8: Weighted mean score of prepared articles

Parameter for assessment		Weighted Mean Score		
		Hand fan	**Table mat**	**Magazine holder**
1.	Design/ shape of the article	4.33	4.30	4.36
2.	Durability as per end use	3.93	3.93	3.86
3.	Suitability to end use	3.90	4.03	4.06
4.	Colour of fabric	4.53	4.40	4.43
5.	Suitability of the cost	4.30	3.80	3.33
	Average WMS	4.19	4.09	4.01

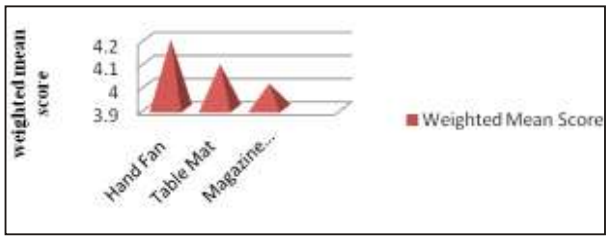

Fig. 4: Acceptability of the consumer for prepared article

fibres' web and along with polyester fibre backing. *Dhaincha* fibres dyed with reactive and azoic displayed excellent dry rub fastness which indicates that these fibres could find application as home textiles which are exposed to more abrasion. The articles prepared were acceptable to almost all the consumer. Overall it could be visualized that the colour *dhaincha* fibres offer great possibilities for its use in numerous life style promoting applications in rural as well as urban households.

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Received: March 18, 2015
Accepted: August 4, 2016