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Utilization *of Heliconia rostrata* (Lobster claw) Fibre for Developing Eco-friendly Home Textile Products

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***Abstract*:** '*Heliconia rostrata'*, an ornamental plant was treated in aqueous medium for 45 days to extract the fibre. The functional groups of the fibre were studied using FTIR spectroscopy for better understanding of their behaviour. Various physical characterizations like fibre length, fibre diameter, bundle strength, moisture content and fibre yield percentage were performed on *H. rostrata* fibre. The TGA analysis proved that the *H. rostrata* fibre was thermally stable at a higher temperature range of 250-300°C. Due to the larger diameter and coarser nature of fibre, *H. rostrata* fibre could not use to develop yarns. Therefore, textile products were developed directly by inserting 4 to 5 fibres in weft direction and different count of cotton and jute yarns were used as warp yarns, thus eliminating yarn preparatory process. Total six eco-friendly home textile products were developed directly from fibres on handloom using plain weave and cost of each product was calculated. The results indicate that the price of developed eco-friendly home textiles was high as compared to products which are commercially available in the market. However, the costs can be brought down by scaling up the production. Therefore, developing eco-friendly home textile products directly from fibres will create a variety in fabric types and cater to the requirements of the present fashion world.

Keywords: Ornamental plant, *H. rostrata*, Retting, Properties, Eco-friendly

In the time of globalization and industrialization, the major concern is not only development but also environmental pollution which is also being taken into consideration. Nowadays, natural fibres have earned a great deal of attention because of use in industrial applications. Natural fibres have been used for the preparations of sacks, hessian bags etc. since very early times but synthetic fibres largely replace them starting in the middle of the 20th century as they have number of properties. These synthetic fibres provide a number of benefits, including better mechanical property. However, the concern of the society with a sustainable development promoted a comeback to lignocellulosic materials, and today natural fibres are replacing synthetic ones, such as glass fibres in the automotive industry (Naik et al 2022). Lignocellulosic fibres are highly appealing option from economic and ecological perspective because they are non- toxic, typically inexpensive, have a low density, and are less abrasive to molds and processing machinery equipment. Besides they consume less energy to be produced as they are sustainable materials which are available in nature and are biodegradable and eliminate carbon emissions together (Girijappa et al 2019). Many common lignocellulosic fibres such as jute (*Corchorus capsularis*), sisal (*Agave sisalana*), and flax (*Linumu sitatissimum*), used in several commercial products. Several other less common fibres also have a great potential to be used as reinforcement in polymer matrix composites. These less common fibres are not yet largely exploited due to being restricted to a certain ecosystem and/or region or simply because they are only obtained as a by-product of other harvests (Navarro et al 2013).

Heliconias (Heliconia spp.) belong to the family Heliconiaceae and are members of the diverse taxonomic group Zingiberales. Quinaya and Almeida (2019) observed fibres extracted from the stem of *H. rostrata* plant have microstructural characteristics and thermal properties similar to several other commonly used lignocellulosic fibres, such as coir (*Cocos nucifera*). From the thermo gravimetric analysis, the onset of the thermal degradation of *H. rostrata* fibre, is higher than 230°C. Therefore, this fibre could be used with several common thermoplastic matrices in the manufacturing of composites, because processing temperatures will be lower than the beginning of the thermal degradation of the fibres. Therefore, in this work the physio-chemical properties of fibre obtained from the stalk of *H. rostrata* ornamental plant was determined to explore the use of this fibre for developing eco-friendly home textile products.

MATERIAL AND METHODS

Fibres extraction and processing: The *H. rostrata* fibre used in the experiments was extracted in Thoubal district, Manipur, India (Fig.1). The fibre was extracted for different retting days, i.e., 14, 21, 30, 45 and 60 days. These time durations were used to optimize the days for water retting.

Visual and tactile observations were used to evaluate each retted fibre sample. Fibre strength was checked manually by hand. The fibre with better strength was selected and time taken for retting of selected fibre samples were considered as optimum time for water retting.

Optimization of bleaching concentration by whiteness index: The optimization of bleaching agent was done at different bleaching concentration 1.0, 2.0, 3.0, 4.0 and 5.0% for 45 min at 70°C, measured weight loss and whiteness index were calculated with the help of Colorflex. Fibre that showed minimum weight loss with good whiteness index was considered as optimum bleaching concentration.

Sample preparation & conditioning: The retted dried samples were oven dried for 24 hours at 105°C before milling and conditioned at 65 ± 2% relative humidity and 27 ± 2°C temperature for 24 hrs to ensure environmental equilibrium moisture content, prior to testing. (NIS: 43:1980) and (ASTM: D1776-79).

Fibre morphology: Longitudinal and cross-sectional surface of *H. rostrata* fibre images were recorded using Field Emission Scanning Electron Microscope (FESEM) Model number JSM 5400, JEOL ltd. Japan.

Fourier transform infrared spectroscopy (FTIR) analysis: The Fourier transform infrared (FTIR) spectra of fibre sample was recorded in the region of 400-4000 cm^{-1} at a resolution of 0.5 cm^{-1} on Perkin-Elmer Spectrum 2 equipped with an attenuated total reflection (ATR) attachment.

Thermo -gravimetric (TGA) analysis: TGA analysis was done with Perkin Elmer TGA 4000 and degradation of the sample with respect to temperature was recorded. The analysis was done by heating the fibre from 30 to 500°C with a rate of 20°C/ min and nitrogen as purge gas.

Fibre diameter: Diameter of 200 *H. rostrata* fibres were measured using projection microscope (magnification 10x) supplied by Leica Microsystems.

Bundle strength: For the determination of bundle strength, pressley strength test method (IS 3675:66) was used and small tuft of 80 to 120 fibres was taken for measurement. About 10 reading of sample were tested and analyzed.

Fibre moisture content: The moisture content of fibers was expressed in percentage on oven dry basis.

$$\text{Moisture content }\% = \frac{(a - b)}{a} \times 100$$

Where, a = original mass in g of the test specimen, and
b = oven dry mass in g of the test specimen

Fibre yield percentage: The yield percentage of the fibre was calculated.

$$\text{Yield }\% = \frac{\text{Weight of the fibres}}{\text{Weight of the plant material}} \times 100$$

Development of eco-friendly home textile products from *H. rostrata* fibre: To develop the fabric from *H. rostrata* fibres, 4 to 5 fibres were directly inserted as weft and different yarn counts (cotton and jute) were used as warp using plain weave on handloom.

Out of these developed fabrics, total six eco-friendly home textiles were prepared and costing of each product was calculated. The cost price of each textile product was calculated by considering the cost of weaving, designing, cost of raw material used and the labour involved in making it. The selling price of each product was calculated by adding 30 per cent profit to the cost price of each product as it considered as genuine profit margin and consumer acceptance.

RESULTS AND DISCUSSION

Optimization of days for water retting: The optimization of time duration for water retting was done to obtain the good quality fibre, for which the stems of *H.rostrata* were kept in water for 14, 21, 30, 45 and 60 days (Table 1). Fibres looked fresh and difficult to separate the fibre from the bark till 14, 21 and 30 days of retting Good quality shiny with good strength fibre was achieved during 45 days of retting. However, with increase in the retting time from 45 to 60 days, there was slightly loss in strength of the fibre and fibre was disintegrated on rubbing. Therefore, 45 days was considered as optimum time duration for extraction of *H. rostrata* fibre from stem.

Optimization of bleaching concentration by whiteness index (WI): The increase in bleaching concentration from 1.0 to 5.0 %, loss in fibre weight from 4.9 to 9.78% and whiteness index was increased from 48.23 to 63.84 (Table 2). Weight loss was due to removal of unwanted impurities from the

Table 1. Optimization of retting days of *H. rostrata* plant (Water retting)

Retting time (Days)	Observation recorded
14	Barks look fresh, difficult to separate the fibre
21	Barks are not fully retted
30	Fibres are not fully separated
45	Fully retted fibre with better strength
60	Fibres disintegrated on rubbing

Table 2. Optimization of bleaching concentration by whiteness index

Bleaching concentration (%) (Hydrogen hypochlorite)	Weight loss (%)	Whiteness index value (WI)
1.0	4.93	48.23
2.0	6.01	57.88
3.0	7.10	59.62
4.0	7.20	60.12
5.0	9.78	63.84

fibre. The fibre “*H. rostrata”* showed minimum weight loss in 1.0% bleaching concentration which is 4.93% but WI value was minimum (48.23). Thus, the 2.0% hydrogen hypochlorite bleach concentration is suitable for *H. rostrata* fibre, which also maintains its weight and improves whiteness as well.

Fibre morphology: The wavy strands on the surface are present throughout the length of the fibre and have rough surface in the longitudinal view (Fig. 2a). These also have large oval shaped pores in between them (Fig. 2b). In the cross sectional view, it looks like a greyish matter with the left border being whitish. There are also longitudinal strands in the background towards the left and the right corners (Fig. 2c). The shape of the cross-section of *H. rostrata* fibre is irregular and cannot be defined of having any particular shape.

Fourier transform infrared spectroscopy (FTIR) analysis: FTIR spectrum of the *H. rostrata* fibre showed well defined broad peaks at 3333, 1424, 1027 and 554 cm^{-1}. The broad peak observed corresponds to the stretching vibration mode of intra and intermolecular hydroxyl (-OH) bond of cellulose. The peak 1424 cm^{-1} proved the presence of alcohols, carboxylic acids, esters, ethers and aliphatic compounds. The strong and broad bond at 1027 cm^{-1} is for C-O of which indicates presence of cellulose in the fibre. The strong bond at 554 cm^{-1} was assigned to C-X of which confirms the presence of bromo-alkanes in the fibres.

Thermo -gravimetric (TGA) analysis: The fibre mass decreased slightly in low temperatures (25-150°C) due to the loss of moisture content (Fig. 4). The hemicellulose degradation process was between the temperature 200-300°C and the decomposition of cellulose and lignin was between the temperatures of 300-400°C. There was

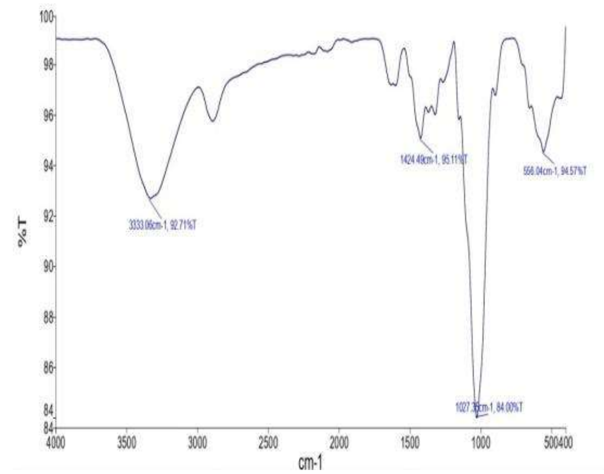


Fig. 3. FTIR analysis of *H. rostrata* fibre

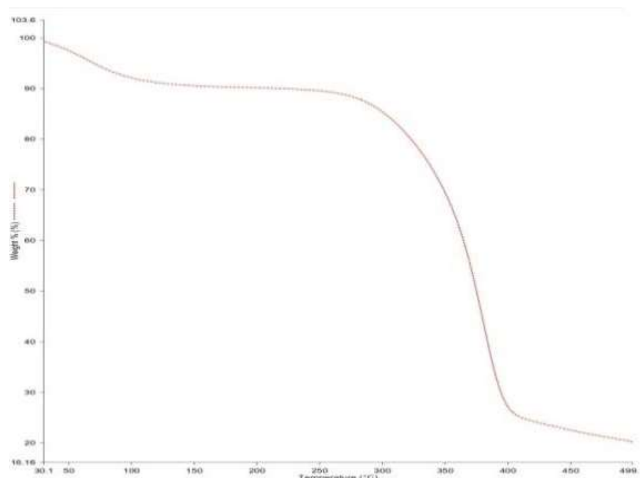


Fig. 4. Thermo-gravimetric analysis of *H. rostrata* fibre

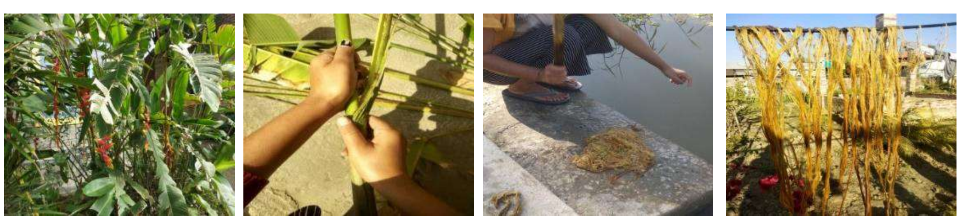
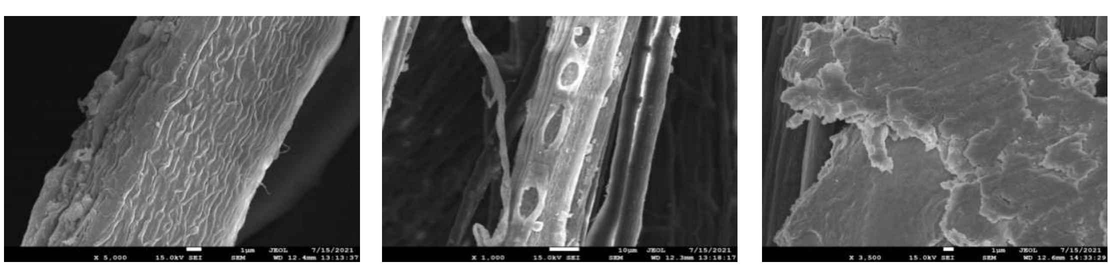


Fig. 1. Extraction of fibre from *H. rostrata* plant



(a) (b) (c)

Fig. 2. (a-b) Longitudinal and (c) cross sectional view of *H. rostrata* fibre

significant drop in weight (mass of the fibre) between 300 and 400°C, proving that the cellulose had completely broken down due to the breakdown of its molecular structures. Most of the cellulose's structure is crystalline, making it strong and resistant to hydrolysis. Strong intramolecular and intermolecular hydrogen bonds in this crystalline structure require higher energies to be broken down. It was observed that at high temperature 400-500°C, pectin and wax present in fiber were degraded. These indicate that thermal decomposition of the fibre is not a single step process but involves the initial degradation of primary products followed by the cellulose and secondary products. Thus, from the thermal analysis it can be summarized that *H. rostrata* fibre is thermally stable up to a range of 250-300°C.

Physical properties analysis of *H. rostrata* fibre: *H. rostrata* fibre showed larger diameter (35.71µm), exhibited very coarse nature (Table 3). This coarse nature of *H. rostrata* fibre opened a new arena of application. The coarser fibre had high importance in the end-use specific applications like floor covering, carpet backs, mattress and other non-apparel purposes. Fibres are typically used in groupings rather than separately, such as in yarns or fabrics. Thus, during the tensile break of yarns or fabrics, bundles or groups of fibres are involved. Additionally, there is a correlation between spinning efficiency and bundle strength that is at least as strong as the correlation between spinning efficiency and intrinsic strength as measured by testing individual fibres. Compared to testing individual fibre, testing bundles of fibres takes less time and exerts less force. These factors have made determining the breaking strength of fibre bundles more significant than determining the strength of a single fibre. The fibre bundle strength and length of *H. rostrata* fibre were 55.43 cm and 29.77(g/tex). The important consideration when using natural fibre as reinforcing materials is moisture content, which affects natural fibre's dimensional stability, electrical resistivity, tensile strength, porosity, and swelling behaviour in composite materials (Razali et al 2015). The moisture content of *H. rostrata* fibre possessed lower moisture content (8.35 %). Usually, between 4.5 and 7.5 per cent of the weight of the plant is composed of fibre. The soil's fertility, the variety sowed, the plants' fibre content, crop management, harvesting stages, season, and the prevalence of disease and pests all have impact on yield of fibres (Fatma and Jahan 2017). Therefore, *H. rostrata* fibre have fibre yield percentage of 5.25%.

Table 3. Physical properties analysis of *H. rostrata* fibre

Physical parameters	*H. rostrata* fibre
Fiber diameter (µm)	35.71
Fibre length (cm)	55.43
Bundle strength (g/tex)	29.77
Moisture content (%)	8.35
Fibre yield (%)	5.25

Development of fabrics and eco-friendly home textile products from *H. rostrata* fibre: Different home textile products are prepared from the *H. rostrata* fibre. Firstly, the fabric was developed on handloom in plain weave by directly inserting the fibre as weft yarn and one or two ply cotton and jute yarns as warp yarns. After weaving, the fabrics were cut, stitched, decorated and finished to develop total six eco-friendly textile products.

Details of developed eco-friendly home textile products from *H. rostrata* fibre: A thin table runner (Fig. 5a) of size 36” x 14” was prepared by inserting *H. rostrata* fibres as weft with one ply cotton yarns of 20Ne yarn count as warp. Raw edges of runner were finished by knotting. Another table runner of size 36”x 14” was prepared by inserting the fibre in weft direction and 1.5Ne yarn count cotton in warp direction (Fig. 5b). Net embroidered lace was used for decoration and two laces have been used in the centre of the table runner facing each other. A table mat (Fig 5c) of size 19”x 14” was prepared by using 2 ply cotton of 1.5Ne yarns as warp. Net embroidered lace was used for decoration. One pair of round placemats of diameter of 12” were developed by inserting the fibres of 1.5 yarn count cotton as warp. For finishing, the raw edges were

Table 4. Calculation of cost for prepared eco-friendly home textiles

Product name	Raw material cost (in ₹)					Selling price (₹)
	Weaving cost (a)	Finishing (Lining, zipper and embellishments) (b)	Labour cost (c)	Cost (a-c)	Profit margin (30%)	
Thin table runner	1800	-	200	2180	660	2840
Thick table runner	1800	100	250	2050	620	2650
Table mat	900	60	200	1160	350	1500
Handbag	900	240	300	1440	430	1900
Round placemat	900	60	200	1160	350	1500
File cover	500	90	250	840	252	1100


a) Thin table runner b) Thick table runner c) Table mat
d) Round place mat e) Handbag f) File cover

Fig. 5. Eco-friendly home textile products developed from *H. rostrata* fibre

stitched with pico machine and lace has been attached in the sides of the placemats (Fig. 5d). Hand bag was prepared by inserting the fibre on the one ply cotton of 20 Ne yarn count as warp yarns. White colour jute fabric was used on the side, up and bottom of the bag. Cotton rope was used as handle. And for decoration, embroidered net lace was placed in the centre in both sides of the bag (Fig. 5e). Lastly, file cover of size 9.5"x 12" was prepared on 2 ply jute yarn of diameter 2 mm as warp yarn. For decoration, border laces of black colour were paste in the centre of the file cover. Non -woven fabrics were used as lining material for file cover. Wooden button and elastic strings were used to fold file cover (Fig. 5f).

Economics of friendly home textile products: The total cost of thin table runner was ₹ 2180.00 and a profit margin of 30 per cent has been added to the cost price to calculate quoted price. Thus, the selling price was ₹ 2840.00. For thick table runner, the total cost was ₹ 2050.00 and a profit charges was ₹620.00, thus selling price of product was ₹2650.00. In case of Table mat, the total cost was ₹1160.00 and the selling price was ₹ 1500. Data in Table 4 also indicated that for a handbag, the total selling cost of handbag was ₹1900.00 which includes total cost of ₹1440.00 and profit charges of ₹430.00. The selling price of round placemats was ₹1500.00 in pairs which comprises of total cost of ₹1160.00 and profit charges of ₹350.00. Lastly, the selling price of file cover was ₹1100.00 which covers total cost of ₹ 840.00 and profit charges of ₹ 250.00.

Therefore, the price of the developed eco-friendly home textile products was quiet high as compared to products which are commercially available in the market. The reason is due to the higher fibre extraction cost. The weaving cost was also high because the fabric was developed directly from the fibres and weavers inserted 4 to 5 fibres at one time as weft. Among the developed textile products, the cost of thick table runner was high as compared to other products. However, the costs can be brought down by scaling up the production.

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CONCLUSION

The present study includes extraction of fibre from *Heliconia rostrata* stem, analysis of fibre properties and development of textile products. The suitable time of retting for *H. rostrata* fibres was 45 days. Fibres have rough surfaces and have oval shaped pores in longitudinal surfaces which highlight possibility useful in acoustic and insulation application. The fibre bundle strength, fibre length, fibre yield percentage and fibre diameter of *H. rostrata* fibre were 55.43 cm, 29.77 (g/tex), 5.25% and 35.71 µm, respectively. Due to the larger diameter and coarser nature of fibre, *H. rostrata* fibre could not be possible to develop yarns. Therefore, textile products were developed directly by inserting the 4 to 5 fibres in weft direction and different count of cotton and jute yarns were used as warp yarns, thus eliminating yarn preparatory process.

REFERENCES

Fatma T and Jahan S 2017. Extraction of unconventional bast fibers from *kydiacalycina* plant and their characterisation. *Journal of Natural Fibers* **15**: 697-706.

Girijappa YGT, Rangappa SM, Parameswaranpillai J and Siengchin S 2019. natural fibers as sustainable and renewable resource for development of eco-friendly composites: A comprehensive review. *Frontiers in Materials* **6**: 1-14.

Naik V, Kumar M and Kaup V 2022. A review on natural fiber composite materials in automotive applications. *Engineered Science* **18**: 1-10.

Quinaya DCP and d'Almeida JRM 2019. Possibility of exploring and applying wastes from some ornamental plants (*Elatioretlingera; Costuscomosus; Heliconiabihai*) as sources of natural cellulosic fibers. *Journal of Natural Fibers* 1-9.

Razali N, Salit MS, Jawaid M, Ishak MR and Lazim Y 2015. A study on chemical composition, physical, tensile, morphological and thermal properties of rosellefibre: Effect of fibre maturity. *BioResources* **10**: 1803-1824.