PMSST

Journal of Applied Science, Innovation & Technology (JASIT)

Journal homepage: https://prakritimitrango.com/documents-reports-and-publications/journal/

Research article

Synthesis of textiles from pineapple leaves: A green approach from farm to loom

Thangjam Roshini*, Sharan Madhu

Department of Clothing and Textiles, Faculty of Family and Community Sciences, The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat-390002, India

ARTICLE INFOR

Article history:
Received: 23 August 2024
Revised: 16 November 2024
Accepted: 17 November 2024
Published online: 28 December 2024

Keywords:
Pineapple leaf fiber;
Agro-waste;
Weaving;
Textile;
Enzyme

ABSTRACT

Waste generation is rising as a serious problem with the increase in global consumption. Textile industry is one of the major sources of waste generation. The abandoned clothes are gone majorly in the landfills. Lots of water, chemicals, & energy are required to manufacture clothes and the raw materials used in making the clothes are predominantly synthetic fibre. Utilization of natural resources is being done in India to reduce the harmful impact on the environment. Use of agricultural waste in making textile products is becoming an effort in the country. With a systemic approach, minimization of any waste can be achieved. Natural fibre from agro-waste for making sustainable textiles is one of the systemic approaches being done by many researchers. In the current study, fibre from pineapple plants grown in Manipur is utilized in producing yarn for making handloom textiles. To enhance the value of the textiles, experimentation on colouration of yarns with reactive and plant dyes was done. Physio-chemical properties of the yarn and colour fastness and strength of the dyed yarn were tested. To get more use of pineapple waste after harvesting, fruit peel was used for extraction of bromelain enzyme since the enzyme from this fruit can be used in textile application such as softening of fibre, felting of wool etc. The study found excellent light fastness in Reactive Brilliant Yellow, Reactive Yellow, and Reactive Pink, with most natural dyes showing very good wash fastness (grade 4), except Silok Sougri and Kabrang (grade 2–3). Reactive Green had the highest K/S value (14.1) with 3.3 reflectance, while Ureirom showed a K/S value of 15.79 at 560 nm. Bromelain enzyme extraction was optimal at 10 minutes. Fabric tensile strength varied: the warp direction exhibited higher tenacity (0.32 Kgf/mm) and strain (19.34%) compared to the weft direction (0.27 Kgf/mm, 6.36%).Sustainability in textile and agriculture sector can be achieved by using pineapple leaf fibre in making textiles. The study will be beneficial in sustaining the tradition of handloom weaving (a part of green practices in a sustainable society) and waste management.

1. Introduction

In an era of increasing global consumption, the negative impact of waste production on the environment has become an increasingly urgent concern. The textile industry is at the forefront of this challenge, which contributes significantly to a growing pile of discarded clothing in landfills around the world. The production of garments requires large amounts of water, chemicals and energy, and synthetic fibres affect the raw material landscape (Sharan and Thangjam 2022).

In view of the fact that these unsustainable practices cast shadows on the environment, countries such as India are taking proactive steps to mitigate the ecological burden of textile production. To address the pressing demand for sustainable options, significant efforts are underway to harness natural resources and reduce the environmental impact of textile manufacturing.

***Corresponding Author:** *Email address: th.roshini5@gmail.com* (T. Roshini)

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/ 4.0/).
Copyright: © 2023 Prakriti Mitra Society for Science & Technology

A significant step in this direction is the strategic use of agricultural waste in textile production, which reflects a systematic approach aimed at reducing waste and environmental protection (Juraidi et al., 2013). In India, researchers are pioneering innovative methodologies with a This standard shift towards sustainability is established by a concerted effort to use agricultural waste in the production of textile products. In order to minimize waste through innovative practices, researchers across the country are adopting a systemic approach. Incorporation of natural fibers derived from agro-waste into textile production processes is an interesting way of exploring agricultural waste.

Plant fibers can be considered composite materials because of their major constituents are cellulose, hemicellulose, lignin, and pectin (Padzil et al., 2020). Plant fibers have greater characteristics, such as eco-friendliness, renewability, cost effectiveness and performance per mass as compared toconventional fibers. Fibers can be categorized according to the specific part of the plant they are derived from. Bast, seed, leaf, fruit, root, and grass fibers are the classifications of plant fibers (Kadolph 2017; Vatsala 2003).

Therefore, this study focuses on a systemic approach aimed at mitigating the negative effects of textile production by exploiting natural resources and agricultural wastes. In the production of sustainable textiles, the main focus is the use of pineapple leaf fibre, a renewable and abundant source of agro-waste. Present study was conducted in the context of Manipur, India, this study not only emphasizes waste reduction but also explores the potential of pineapple plants as a valuable resource for textile and agricultural industries.

2. Materials and methods

The waste pineapple leaves used for the extraction of fibre were collected from the local pineapple farms in Manipur, Indai in which Kew and Queen Variety were used**.**

Fig. 1 Pictorial view of collected pineapple leaves

2.1 Fibre extraction

Fiber was extracted from the raw material procured from local pineapple growers by manual and mechanical extraction followed by water retting. Washing and scouring were carried out to remove the residues from the fibers after extraction, and it was sun dried.

2.2 Preparation and of yarn

Different spinning tools such as charkha-drop spindle, traditional charkha, and Pheonix charkha were used to prepare yarn. However, scoured 100% pineapple leaf fiber hand-spun yarn without any treatment were obtained using the motorized pineapple leaf charkha made by the researcher. Joining the fibre strand ends to the ends was done to obtain a continuous length before spinning with the motorized charkha.

particular focus on the integration of natural fibres derived from agro-waste into sustainable textile production processes (Sharan and Thangjam, 2022).

Fig. 2 Pictorial view of pineapple leaf fiber and prepared pineapple yarn

The length of yarn, denier, yarn count, yarn evenness, twist per inch (TPI) were obtained (Booth, 1996). 100% pineapple fiber yarn was also produced on laboratory scale by Ismoilov et al. (2019).

2.3 Dyeing process

To enhance the aesthetic appeal and market value of pineapple fiber yarn, this study incorporates experimentation with reactive and plant dyes on pineapple fiber yarns. This not only diversifies the colour palette but also introduces environmentally friendly dyeing methods and promotes sustainable production practices in the textile industry (Kovacevic et al., 2021).

Dyeing was carried out on the yarn using nine reactive dyes and twelve natural dyes using the conventional exhaust dyeing techniques such as. Kamala or Kumkum tree (Local name- Ureirom laba) - *Mallotus philippensis*, Malabar melastome (Local name- Yachubi) -*Melastoma* malabathricum, Koda tree (Local name- Lamuk) - *Ehratia acuminate*, Hill glory bower (Local name- Kuthap) -*Clerodendrum infortunatum*, Roselle (Local name Silok sougri)- *Hibiscus sabdariffa*, Mulberry (Local name- Kabrang)-*Morus nigra*, Red cedar (Local name- Tairen) - *Toona Ciliata*, Indian Trumpet tree (Local name- Shamba)- *Oroxylum indicum*, were collected for the natural dyes from Manipur except Marigold (Local name Sanarei)- *Tagetes erecta*, Pomegranate (Locall name Kaphoi) - *Punica granatum*, Lac- *Kerria lacca* and Manjista-*Rubia cordifolia*.

The reactive dyeing process was conducted using 2% of dye concentration, 20 g/L soda ash, and 30 g/L sodium chloride at a material-to-liquor ratio (MLR) of 1:30. The procedure lasted 45 minutes at 60°C under its natural pH, followed by washing with a 2% soap solution. For natural dyeing process, the dye was extracted by boiling in distilled water at an MLR of 1:40 for 30 minutes, then filtered and kept for settling. Pre-mordanting of the yarn involved using 10% aluminum (based on material weight) for 30 minutes before the dyeing process. The natural dyeing was performed with 4% dye concentration at a 1:30 MLR for 45 minutes at 60°C, maintaining its natural pH. Excess dye was removed by rinsing the yarn in running water.

2.4 Analysis of coloured samples

The color strength, CIE L* a* b* values, and K/S values (measured across the 360–700 nm wavelength range) were analyzed using an SS5100A spectrophotometer. Wash and light fastness tests were conducted following ISO standard test no. II (IS: 764: 1979) and AATC test method 16-B-1977.

2.5 Bromelain Enzyme

To extent out the use of pineapple, bromelain enzyme was extracted from pineapple peel biomass by centrifugation and filtration. The enzyme is used to treat wool, agro-waste fibres, softening of fibres, etc. (Costa et al., 2020).

2.6 Weaving of textile

The yarn produced (29's) was used as a weft for the textile sample. Rayon/pineapple union fabric was developed for resembling traditional textiles. The yarn count of Rayon i.e. 22's was used as the weft. Dyed yarns were used to weave extra weft motifs on the rayon/pineapple fabric. The physical properties of the developed fabrics were checked.

3. Results and discussion

3.1 Extraction and spinning of fibre

In the manual extraction, the hammering and retting process produced very long and smooth fibres. The hammering process saved a greater quantity of fibre than the other conventional scrapping method. However, manual extraction was laborious and time consuming. Therefore, machine extraction is recommended for the production of larger quantities of fibre. The prepared yarn (29's i.e. 178 Denier) was very fine, lustrous, even and stiff, which was very suitable for the production of traditional Manipur textiles. Preparation of similar fine texture of textile used in the state textiles was achieved with the use of the prepared fine yarn. Good tensile strength with low elongation was found- 2.13g/den tenacity, 1.4mm elongation.

3.2 Analysis of dyed yarns

Colour palettes were created using the using the SS5100A spectrophotometer. Separate colour palettes were made for the total nine reactive dyes and twelve the natural dyes.

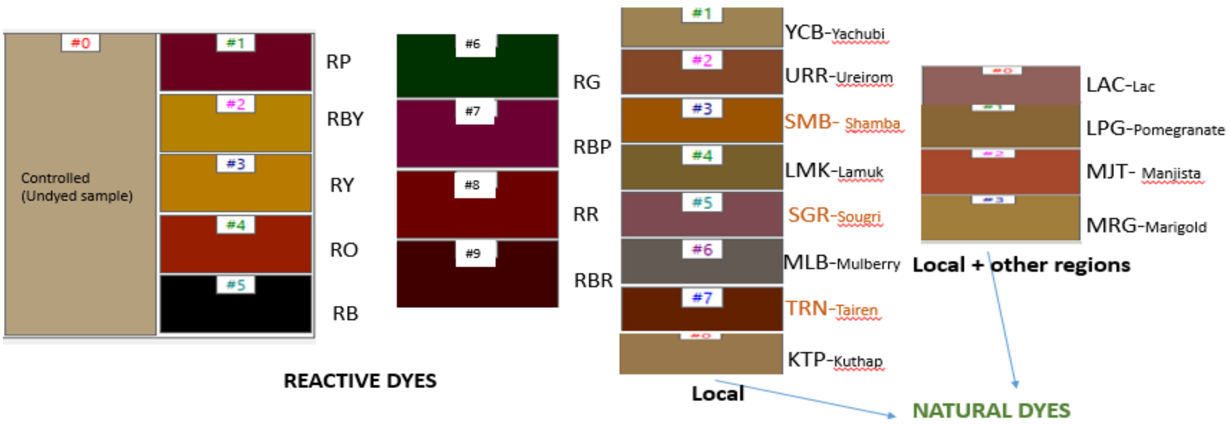

Fig. 3 Colour palettes of reactive dyes and natural dyes

Note- The nine reactive colours with the code- RP- Reactofix dark pink, RO-Procion brilliant orange M-2R, RBY-Procion brilliant yellow M-4G, RY- Procion yellow M-3R, RR-Procion brilliant Red M-5B, RB-Procion black, RG-Procion green, RBP-Procion pink and RBR- Procion brown

The L*a*b*c*h* values were analyzed with a controlled sample. The a* value indicates red or green tones, with positive values signifying red and negative values signifying green. Similarly, the b* value reflects yellow or blue tones, where positive values represent yellow and negative values indicate blue (Rejo et al., 2018). The c* value denotes chroma, representing the distance from the lightness (L*) axis, while the h* value identifies the hue angle measured from the central point (Sricharussin et al., 2009). In case of natural dyes, the value of L* was highest in Kuthap (Hill glory bower) followed by Sanarei (marigold), highest b* value was observed as 66.02 in Shamba (Indian Trumpet tree), chroma c* was found lowest in *Kabrang* which gained 5.48 and highest in shamba i.e.70.54. The angle of hue was highest in *Lamuk* and lowest in *Silok Sougri* this may be due to the pink shade of Silok Sougri which was near the red (0^o) on the color space.

From the results, RBY had the highest value of L* since it had the lightest in shade followed by the RY. The negative value of a* indicates the greener value of the dye, therefore the value of RG (-37.61) had shown the justification and RP had the reddish value of a* followed by RR. The yellow value of b* was highest in RBY and RY and lowest in RBP and RP. Since controlled had no shade it had the lowest c* value and RY showed highest value. The hue angle was highest in case of RBP. In the analysis, RB had zero values in the data since black is not in the visible spectrum of colours and it can exist in no light.

3.3 Wash fastness

The colourfastness of the dyed pineapple yarn towards washing and light was observed. A rating scale of 1-5 (1-Very poor, 2-Poor, 3- Good, 4-Very Good, 5-Excellent) was used for grading the performance of the dyed yarns in the wash fastness test. All the reactive dyes showed very good to excellent results. From the results, it was observed that the wash fastness of all the natural dyed samples was 4 grade (very good), except for the two dyes Silok Sougri and Kabrang, which had a rating of 2–3 (poor-moderate).

Table 1: L*a*b*c*h* values for samples dyed with the natural dyes

Sample	L*	a*	b*	c*	h*
1. Controlled (undyed)	68.10	2.77	20.74	20.93	82.35
2. Kabrang	38.52	3.12	4.50	5.48	55.25
3. Kaphoi	49.51	8.28	28.59	29.77	73.80
4. Kuthap	56.88	3.90	29.40	29.65	82.39
5. Lamuk	41.33	3.82	34.03	34.24	83.55
6. Sanarei	55.53	6.77	40.83	41.38	80.56
7. Shamba	43.30	24.86	66.02	70.54	69.33
8. Silok sougri	36.66	25.45	4.79	25.89	10.66
9. Tairen	36.60	24.61	30.91	39.51	51.45
10. Ureirom	22.54	29.05	39.77	48.45	53.13
11. Yachubi	46.30	8.83	33.03	34.19	74.99
12. Lac	45.69	18.21	10.91	21.23	30.92
13. Manjistha	42.68	37.20	35.04	51.10	43.27

Table 2: L*a*b*c*h* values for samples dyed with the reactive dyes

(#)Sample	L*	a*	b*	c*	h*
Controlled (undyed	68.10	2.77	20.74	20.93	82.35
RP	18.87	49.53	12.623	51.11	14.86
RO	32.674	45.071	56.30	74.03	49.49
RBY	57.54	9.75	90.70	91.23	83.83
RY	56.31	14.86	90.38	91.59	80.63
RB	0.00	0.00	0.00	0.00	0.00
RG	15.75	-37.61	25.47	45.42	145.92
RBP	19.13	52.17	-2.40	52.22	357.36
RR	19.10	47.36	32.73	57.57	34.63
RBR	9.65	29.90	16.62	34.21	29.05

(#)reactive colours with the code- RP- Reactofix dark pink, RO-Procion brilliant orange M-2R, RBY-Procion brilliant yellow M-4G, RY- Procion yellow M-3R, RR-Procion brilliant Red M-5B, RB-Procion black, RG-Procion green, RBP-Procion pink and RBR- Procion brown .

3.4 Light fastness

A scale ranging from 1 to 8 (1–2, Very Poor; 2–3, Poor; 3–4, Fair; 4–5, Good;5–6, Very Good; 6–7, Excellent; 7–8, Outstanding) was utilized for the light fastness test. Reactive Brilliant Yellow (RBY), Reactive Yellow (RY), and Reactive Pink (RP) demonstrated excellent light fastness ratings. In natural dyes, Shamba, Tairen, Yachubi and Sanarei dyed samples showed excellent light fastness, whereas the remaining samples showed very good to excellent. The plant dyes are therefore suitable for dyeing pineapple leaf yarn. Similarly, Akhtar et al. (2014) also reported that mordanted natural dye showed increase in colour fastness.

3.5 Colour strength analysis

The K/S values at 500nm were observed from 360 to 700 nm using the SS5100A spectrophotometer. K and S are the absorption and scattering coefficients of the dyes, respectively. Among the obtained values of natural dyes, the K/S value of Ureirom started at 560 nm (K/S = 15.79 with reflectance = 2.81). Most of the values of K/S were obtained from wavelength starting from 400nm to 700nm for each dye as shown in Fig. 4. The K/S value of the reactive dyes was highest in RG (Reactive green) i.e. 14.1 with 3.3 reflectance value while the value of RBY had the lowest value 6.17 with reflectance 7.00. The K/S value of RB (Reactive black) was zero since the reflectance doesn't exist in it. (Fig. 5).

3.6 Extraction of bromelain enzyme

Extraction of the bromelain enzyme was performed using different material liquor ratios and medium 1.Extraction with ground water at 1:30 MLR 100°C and 2.Extraction was performed using distilled water at 1:20 MLR at 100^{o}C. Optimization of regulator time and speed for centrifugation. Different centrifugation time intervals were observed after 2, 5, 10 and 15 min; however, 2 min and 5 min were not sufficient for the separation of the solid from the liquid. Therefore, 10 min was found to be the optimum time after which no further separation was observed. The centrifuge machine has a regulator with a speed of 5 stages. However, the 2-stage speed was found to be optimum. Filtration was performed after this process. It was stored in the refrigerator.

3.7 Weaving of fabric

Construction of Rayon/Pineapple fabric was achieved with the properties- Fabric count (Warp-16 Weft 36), 9.24 cover factor mm with a low standard deviation of 0.0065 , 77.48 GSM (Gram per square meter) with a slight standard error of 0.0088 and a standard deviation of 0.0153 and thickness of 0.26 mm.

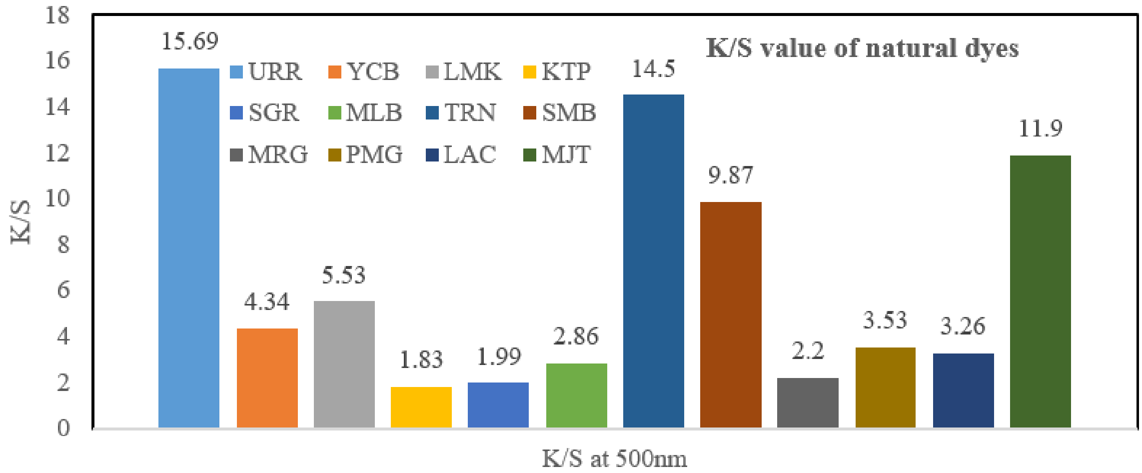

Fig. 4 K/S value of natural dyes

The tensile strength of the fabric demonstrated different mechanical properties between the warp and weft directions. In the warp direction, the fabric had a tenacity of 0.32 Kgf/mm, with a maximum load of 15.91 Kgf, and a strain of 19.34% at this maximum load. On the other hand, the weft direction showed a slightly lower tenacity of 0.27 Kgf/mm, with a maximum load of 13.46 Kgf and a strain of 6.36% at the maximum load. A standard deviation of 0.39 kgf and a standard error of 0.22 kgf were observed in the tensile strength suggesting notable resistance to stretching along this axis. Fig. 6 shows weaving of Rayon/Pineapple fabric with different dyes. The fine texture, lightweight, stiffness properties of the woven fabric was suitable for making sustainable handloom textiles of Manipur. The dyed yarns were also experimented in the making the extra weft motifs on woven fabric. This study identified handloom weaving's cultural and traditional significance. Incorporation of sustainable practices not only pursues to maintain tradition, but is also aligned with broader green initiatives that contribute to waste management and environmental protection. Kamarudin and Yusof (2016) reported that pineapple fibers hold potential as a useful thread for application in the conservation field, particularly in traditional textile restoration.

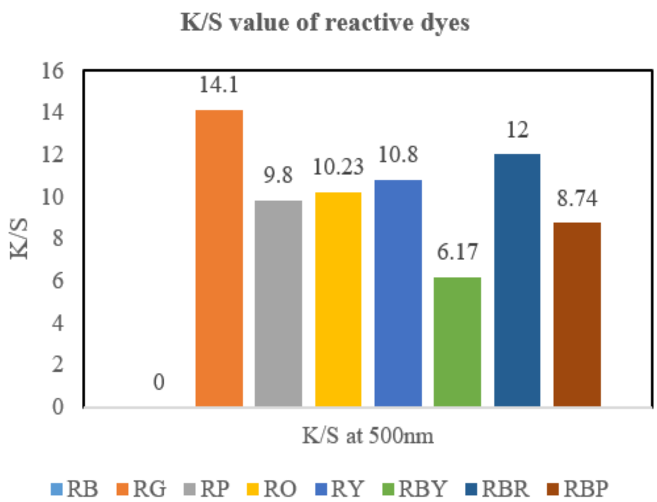

Fig. 5 K/S value of reactive dyes

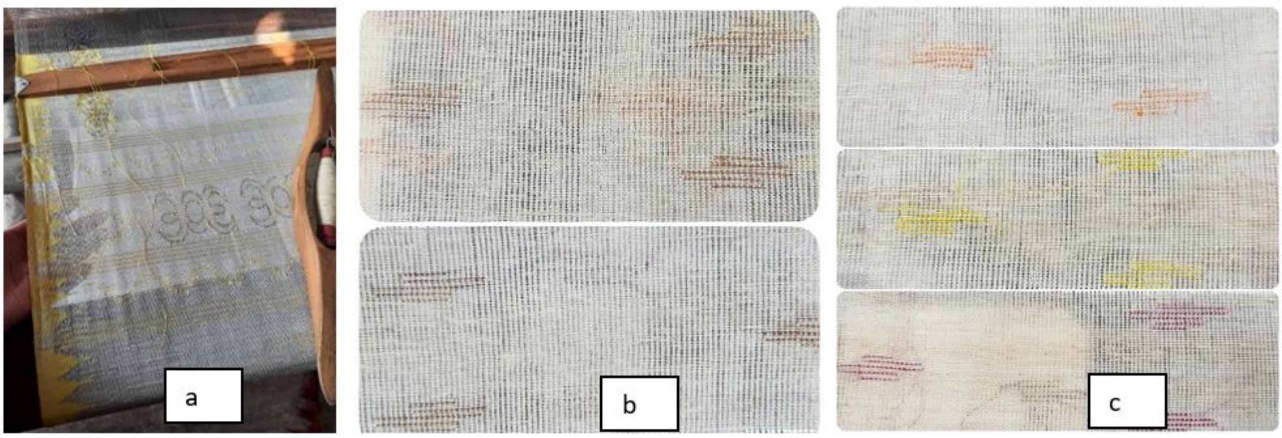

Fig. 6a) Weaving of Rayon/Pineapple fabric with extra weft motifs b) extra weft yarn dyed with natural dyes c) extra weft dyed reactive dyes

4. Conclusion

Present study embodied a comprehensive and innovative approach to sustainable textile production. By exploiting the potential of pineapple plants and its waste did not only address environmental issues but also contributed to a broader objective of promoting a more sustainable and responsible society. As the textile industry continues to search for greener alternatives, the demonstrated compatibility of reactive and plant dyes with pineapple leaf fibre yarn has opened up a promising way of creating vibrant and sustainable textiles that meet both environmental requirements and aesthetic preferences. The findings of this research have the potential to inspire further progress in sustainable textile production and set a valuable precedent for the intersection of tradition, innovation, and environmental protection.

Conflict of interest
Authors have declare no conflict of interest.

Author contribution
Thangjam Roshini has drafted and edited the manuscript and Sharan Madhu has supervised the study.

Acknowledgement
The authors sincerely thank the CSIR-NEIST Laboratory in Lamphel, Manipur, for providing fiber extraction facility and the Department of Textile Technology at The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, for their crucial support in technical testing. They are also profoundly grateful to the skilled weavers who crafted the textiles analyzed in this research and the people of Manipur who provided their valuable insights related to the study.

References

Akhtar, A., Hossain, K. M., Khatun, S., 2014. Dyeing effect on silk-fabric with vegetables dye using green-coconut (cocos nucifera) shell. IOSR. J. Appl. Chem. 7(4), 23-26.
Booth, J.E., 1996. Principles of textile testing. CBS Publishers and Distributors, Pvt. Ltd. New Delhi, India, 100-230.
Costa, A.S., Ceron, A. A., Petreca, B. B., et al., 2020. Fibers of cellulose sugarcane bagasse with bromelian enzyme immobilized to application in dressing, SN App. Sci, 2(285).
Ismoilov, K., Chauhan, S., Yang, M., Heng, Q., 2019. Spinning System for Pineapple Leaf Fiber via Cotton Spinning System by Solo and Binary Blending and Identifying Yarn Properties. J. Text. Sc. Tech. 5 (4), 86-91.
Juraidi, J.M., Shuhairul, N. A., Syed, S. A. et al. 2013. A comparison of tensile properties of polyester composites reinforced with pineapple leaf fiber and pineapple peduncle fiber. OP Conf. Ser.: Mat. Sci. Eng. 50(1)
Kadolph, J.S., 2017. Textile. Pearson publication, Pearson Prentice Hall, 75.
Kamarudin, Z., Yusof, M. 2016. Pineapple leaf fiber thread as a green and innovative instrument for textile restoration. Int. J. Sus. Fut. Hum. Secu. 4 (2), 30-35.
Kovacevic, Z., Sutlovic, A., Matin, A. et al., 2021. Natural dyeing of cellulose and protein fibres with the flower extract of *Spartium junceum* L. Plant, Mater. 14(4), 91.
Padzil, F.N.M., Ainun, Z.M.A., Abu Kassim, N., Lee, S.H., Lee, C.H., Ariffin, H. and Zainudin, E.S., 2020. Chemical, physical and biological treatments of pineapple leaf fibres. *Pineapple Leaf Fibers: Processing, Properties and Applications*, pp.73-90.
Rejo, A., Adhiguna, R.T., Rajagukguk, D,G., 2018. Study of Natural Dyes and Pineapple Leaf Fibres Growing locations within Plant Stems on Dyeing Intensity. 1st SRICONEV 2018, E3S web of conferences 68, 1030.
Sharan, M., Thangjam, R., 2022. Introducing pineapple leaf fiber as an indigenous fiber in hand woven traditional textiles of Manipur. 34th Biennial Natl. Con. Home Science Ass. of India. 91.
Sricharussin, W., Ree-iam, P., Phanomchong, W. et al., 2009. Effect of enzymatic treatment on the dyeing of pineapple leaf fibres with natural dyes. Sci. Asia 35, 31-36.
Vatsala, R., 2003. Textbook of Clothing and Textiles, Indian Council of Agricultural Research, 76.

Cite this article:
Roshini, T., Madhu S., 2024. Synthesis of textiles from pineapple leaves: A green approach from farm to loo. J. Appl. Sci. Innov. Technol. 3 (2), 76-81.