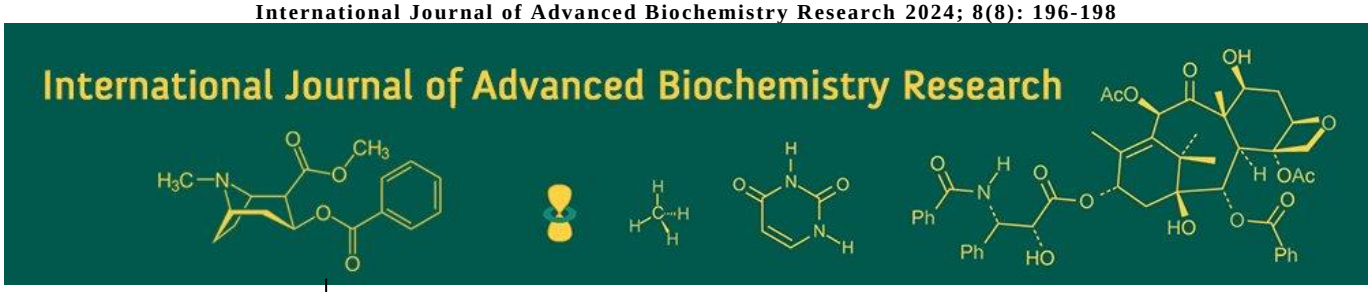

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Extraction and characterization of palmyra palm (*Borassus flabellifer*) fruit fiber

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Abstract
This study explores the underutilized potential of Palmyra palm fruit fibre, focusing on its extraction percentage, wet processing and chemical properties to assess its suitability for various applications. The results revealed that the cellulose is 58.56%, hemicellulose is 16.29%, lignin is 12.87%, pectin is 1.33%, ash is 2.38% and fat/wax is 0.63% for the wet processed fibres. This research paper emphasizes the value of agricultural waste fibers as environmentally friendly alternatives to synthetic materials, highlighting the chemical components, which was the deciding factor for utilization in various textile applications.

Keywords: Bleaching, chemical composition, extraction, palmyra palm fibre, scouring, softening

Introduction
Fibre-yielding plants hold significant economic importance, second only to food plants. Indigenous plant resources offer a substantial potential for fibre extraction, particularly for textiles. These fibres are renewable and carbon-neutral, as they absorb as much carbon dioxide as they produce. While common natural fibres like cotton, wool, silk, and jute are widely used in various textile applications; numerous unconventional fibres remain underutilized due to limited familiarity despite their potential.

The continuous rise in global population and improved living standards has driven an increased demand for fibres, with agricultural waste fibres gaining attention for their economic and cultural significance. These fibres, derived from oil palm plantations, rice husk, rice straw, sugarcane, pineapple, banana, and coconut, are used in building materials, decorative products, and as versatile raw materials. Their promising properties have prompted research into their use as eco-friendly replacements for synthetic fibres and as renewable energy sources.

The Palmyra palm, with its economically valuable fruits, sap, and tuberous seedlings, remains relatively under-researched compared to other palms like coconut, arecanut, date, and oil palm. There is a lack of systematic studies on Palmyra palm fruit fibre, highlighting the need to investigate its physical, mechanical, and chemical properties. This study aims to extract and process the underutilized Palmyra palm fibre, to explore new applications and emphasize the importance of natural fibres from agricultural waste as future materials.

Materials and Methods
Fully ripened Palmyra palm fruits were sourced from regions in and around Karnataka and Andhra Pradesh, where they are widely available. The Borassus flabellifer variety, commonly found in these areas, was selected for this study.

Fibre extraction
The fully ripened fruits were selected and the black husk was removed. Each fruit, containing 2-3 seeds, was separated along with the attached fibre, and the edible yellow mesocarp was removed. The seeds with fibre were then soaked in water for two days to loosen any remaining soft material. After soaking, the seeds were thoroughly washed and shade-dried. Once dried, the fibres were manually extracted from each seed using a sharp blade.

Wet processing

Scouring: The fibers were presoaked in a 0.5% Turkey red oil solution for 20 minutes, then boiled in 2% NaOH and 1 GPL Tween 80 for 45 minutes. After thorough washing and neutralization with 0.2% acetic acid, the fibers were rinsed, squeezed, and shade dried.

Bleaching: The scoured fibers were presoaked in a 0.5% Turkey red oil solution, then transferred to a boiling bleaching solution of 2% H_2O_2 and 1.5% sodium silicate at a 1:30 MLR for 60 minutes. After bleaching, the fibers were thoroughly rinsed and shade dried.

Softening: The fibers were softened using a 6% cationic softener solution at a 1:30 MLR. After dissolving the softener in water, the fibers were soaked in the solution for 60 minutes. The treated fibers were then rinsed to remove excess softener and residual chemicals.

Percentage extraction

The extraction percentage was calculated by using the below formula (Brindha et.al. 2013) [1].

$$\text{Fiber Yield Percentage} = \frac{\text{Weight of the fiber}}{\text{Weight of the plant material}} \times 100$$

Weight loss (%)

According to Temesgen *et. al*. (2012) [4], the assessment of weight loss in processed fibers was conducted using the below formula.

$$\text{Weight loss (\%)} = \frac{W_1 - W_2}{W_1} \text{ X } 100$$

Where,

W_1= Weight of fibers before processing

W_2= Weight of fibers after the processing

Chemical composition

The chemical composition of both raw palmyra palm fruit fibers and the optimized scoured, bleached, and softened fibers was analyzed. The tests included assessments of cellulose, hemicellulose, lignin, ash content, fats & waxes and pectin. The chemical composition was determined using the procedures given by Goering and Vansoest (1970) [2].

Results and Discussion

Percentage extraction: The average weight of a Palmyra palm fruit containing three seeds was found to be 1666.6 grams. The weight of the black waste husk was 15.8 grams. Each seed, including the yellow edible pulp and fibre, had an average weight of 549.3 grams. The average weight of the pulp per seed was 333.3 grams. The average weight of the seed after removal of edible pulp was 216 grams. The average weight of the extracted fibre, cleaned from pulp and waste of each seed was 20.86 grams, constituting 9.65% of the seed's weight. Overall, the total fibre extraction from each fruit with three seeds was 62.58 grams with extraction of 3.75 percent.

Weight loss percentage

The weight loss percentage was measured before and after wet processing. The results clearly indicate that the highest weight loss occurred in samples subjected to all the wet processing treatments *viz*., scouring, bleaching and softening (30%), followed by those that underwent scouring and bleaching (26.9%), scouring and softening (15.5%) and the treatment scouring (11.94%). These findings were statistically prone to significant difference in weight loss among the different treatment groups, suggesting that the treatments substantially have an impact on the weight loss of the fibres.

Chemical composition

Table 2 explains the chemical composition of raw, scoured and treated Palmyra palm fruit fibre.

Table 1: Weight loss percentage after wet processing of Palmyra palm fruit fibre

S. No.	Treatments	Control weight (g)	Weight after treatment (g)	Weight loss percentage (%)	SE±
1.	Scoured	100	88.06	11.94	0.309
2.	Scoured+ Bleached	100	73.1	26.9	0.451
3.	Scoured+ Softened	100	71.1	15.5	0.293
4.	Scoured+ Bleached+ Softened	100	70.0	30	0.300
P - Value		0.000***			

*** Significant at 1% level of significance

Table 2: Chemical composition of unprocessed and processed Palmyra palm fruit fibres

S. No.	Treatments	Cellulose %	Hemicellu-lose (%)	Lignin %	Pectin %	Ash %	Fat / Wax %
1.	Raw fibre (X_1)	70.27^{d}	25.48^{d}	16.19^{b}	2.58^{c}	2.72	1.49^{c}
2.	Scoured (X_2)	63.59^{c}	20.26^{c}	15.22^{b}	2.09^{bc}	2.50	1.15^{b}
3.	Scoured+ Bleaching (X_3)	61.65^{b}	17.67^{ab}	14.53^{ab}	1.89^{ab}	2.46	1.01^{b}
4.	Scoured+ Softening (X_4)	61.63^{b}	18.44^{bc}	15.03^{b}	1.79^{ab}	2.49	0.76^{a}
5.	Scoured+ Bleaching+ Softening (X_5)	58.56^{a}	16.29^{a}	12.87^{a}	1.33^{a}	2.38	0.63^{a}
P- Value		0.000^{***}	0.000^{***}	0.043^{*}	0.005^{**}	0.721^{NS}	0.000^{***}

Data followed by same letter within the columns are not statistically different according to Duncan post-hoc test.

NS: Non Significant

(***), (**) and (*) Significant at 1%, 5% and 10% level of significance respectively

It is observed that cellulose (70.27%) and hemicellulose percentages (25.48%) were highest in raw fibre compared with scoured (63.59% and 20.26%) and scoured + bleached + softened fibre (58.56% and 16.29%). This decrease od cellulose with increase in treatments because, the alkali treatment and bleaching break down cellulose and hemicellulose components along with impurities, resulting in a slight reduction in their percentage.

In the case of lignin content, the scoured + bleached + softened fibre showed lower percent (12.87%) followed by scoured (15.22%) and raw fibre (16.19%). Both scouring and bleaching involve chemicals that can breakdown the cleave bonds in lignin leading to dissolution and degradation.

The pectin content was also found to be highest in raw fibre (2.58%) and lowest in scoured + bleached + softened fibre (1.33%). Sodium hydroxide hydrolyses and breakdown pectin and hydrogen peroxide breakdown the pectin component causing it to dissolve and degrade.

The ash content remained relatively stable across treatments, with the highest in raw fibre (2.72%) and lowest in scoured + bleached + softened fibre (2.38%). This decrease is due to the dissolution of inorganic impurities in sodium hydroxide and hydrogen peroxide.

Lastly, fat/wax content was highest in raw fibre (1.49%) and lowest in scoured + bleached + softened fibre (0.63%). The decrease in fat/wax content with increased treatments because, during scouring, the chemical reaction converts fats into soap and glycerol which makes them soluble in water and washed away. Similarly, bleaching agents can oxidize fats and aids in degradation and removal from fibres. Similar results were observed by Pholam et.al (2017) [3] that the chemical composition of Palmyra palm fruit fibre decreases with cumulating treatments.

Statistical analysis showed significant differences ($p < 0.05$) for cellulose, hemicellulose, lignin, pectin and fat/wax contents among the treatments, while there is no difference in ash content. Duncan post hoc test was conducted to compare the means of different wet processing treatments.

Conclusion

- The total fibre extracted from each fruit with three seeds was 62.58 grams which was 3.75 percent.
- The Palmyra palm fibre exhibited 30 percent of weight loss with cumulative wet processing treatments
- The chemical composition *viz*. cellulose, hemicellulose, lignin, pectin, ash, fat & waxes decreased with increased wet processings

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