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BAGASSE: A SUSTAINABLE RAW MATERIAL FOR RURAL START-UPS

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Abstract– Bagasse is one the potential raw material for the textile application and it is extracted from sugarcane rind. Presently the bagasse is used for cogeneration and other industrial application. In spite of the wide consumption of bagasse as a fuel for mill boilers, electricity and steam generation, as well as animal feed, or as a raw material for paper and board manufacture, the residues still remain as a surplus which poses a disposal problem for mill owners. Hence, for proper utilization of bagasse is a need of an hour for local farmers and entrepreneurs for their livelihood. The study is focused on optimization of fibre extraction methods for textile application. Bagasse was procured from local sugarcane juice maker and jiggery units and subjected to different fibre extraction methods *viz.,* chemical, enzymatic, mechanical and manual method of extraction for separation of fibres and pith. Further, fibre yield, time of extraction and cost of production parameter were calculated. The result of the study revealed that, the fibre extraction method was optimized based on the fibre yield, time taken and production cost. Fibre yield was found to be more in case of the traditional method of extraction followed by mechanical (Raspader machine) extraction with least percentage of wastage and less time. Among the fibre extraction methods, enzymatic extraction method was found to be costlier with minimum fibre yield followed by chemical extraction method. Production rate per kg fibre was accounted least (Rs. 36.00) in the traditional method followed by mechanical and chemical extraction method (Rs.63.00 and 59.00). Traditional method of fibre extraction was the suitable technique for bagasse fibre extraction with greater fibre yield and less production cost can be effective agro startups for young farmers and local artisans.

INTRODUCTION

In recent years, increasing trends toward a more efficient use of agro-industrial residues have been reported by different groups (Rocha *et al.,* 2012). Sugarcane bagasse, an abundant agricultural lignocellulosic by-product, is a fibrous sugarcane stalk residue. In spite of the wide consumption of bagasse as a fuel for mill boilers, electricity and steam generation, as well as animal feed, or as a raw material for paper and board manufacture, the residues still remain as a surplus in which poses a disposal problem for mill owners (Kalderis *et al.,* 2008). This agricultural residue has received increasing attention, since it represents an abundant, inexpensive and readily available source of renewable lignocellulosic biomass for the production of environmentally-friendly industrial products (John and Thomas, 2007). Bagasse can also be used as raw material for various types of building boards, production of ethanol and polypropylene composites (Rocha *et al.,* 2012). Fibre extraction from bagasse is highly appreciable for the production of non-woven's and textile composites in the current scenario.

In many cases these natural plant fibres require tedious processes including human drudgery to extract the fibres from the plant component (Basu and Dutta, 2014). In addition, different toxic chemicals and energy consuming processes are being used to convert those fibrous materials into fibre and yarn. The fibre extraction process has an impact on fibre yield, fibre quality, chemical composition, structure, and properties of the fibre (Natural fibres, biopolymers, and bio-composites, 2005). The time has come to understand and implement environmentally friendly processes starting from agricultural practices to the final products, so that the products are bio-friendly and disposal will not be an issue. Hence, more efforts are

needed and in-depth research is necessary to eliminate toxic chemical usage and higher energy consumption for fibre extraction and processing.

Prevailing methods of bagasse fibre extraction

According Zimele *et al.,* (2018), cellulose has been successfully extracted from sugarcane bagasse through five different methods. The use of acidified sodium chlorite proved to be very effective in the digestion of sugarcane bagasse cell walls in contrast to the use of sodium hypochlorite. Acidified sodium hypochlorite yielded better results than its non-acidified counterpart. Characterization techniques showed cellulose extracted through 5% sodium sulphate at 100ºC for three hours to have crystallinity trailed than the 4 % Sodium hypochlorite. The properties are ideal and recommended for an application as fillers in the polymeric composites.

Asagekar and Joshi (2013) studied on Characteristics of sugarcane fibres. The soft core pith was removed from bagasse manually to get outer hard rind which was then cut across the length. The cut rinds were subjected to hot water treatment (1:50 MLR) at 90C for 1 hour for removal of coloring matters and sugar traces. Samples were dried under sunlight and subjected to chemical extraction, in which samples were treated with 0.1N NaOH solution (1:100 MLR) at boiling water temperature for 4 hours under atmospheric pressure. The samples were subjected to vigorous stirring for effective separation of fibres and yields better fibres properties.

Abdel-Halim (2014) carried a research on chemical modification of cellulose extracted from sugarcane bagasse: Preparation of hydroxyethyl cellulose. Freshly collected sugarcane bagasse were washed thoroughly in running water in order to minimize any microbial attack during drying bagasse in sunny area until its complete dry. The dried bagasse was collected and then grinded into fine particles using Fritsch mill, Type 15.302 (Germany).

Mohomane *et al.,* (2017) studied on effect of extraction period on properties of sugarcane bagasse and softwood chips cellulose. Sugarcane bagasse and soft wood were obtained from local sugar and wood factories were washed and dried at room temperature. Samples were initially treated with 2% (w/v) NaOH for 2 hours respectively and washed with deionised water to neutralise the pH. The alkali treated bagasse and soft wood were further subjected to treatment of 2% (w/v) NaClO2 for a further 2 and 4 hours and washed to obtain neutral pH and dried.

MATERIAL AND METHODS

Bagasse fibre extraction methods

The rise in demand for novel fibres has led to innovative ideas surging in textile industry. Sugarcane bagasse, which is an abundant fibrous residue of sugarcane, can be applicable in the field of technical textiles and other non-woven industry. The extraction of the natural fibre from the plants required certain care to avoid damage to the fibres. Ultimate aim of fibre extraction methods is to produce good quality fibres and cost effective processes. Sugarcane bagasse (SNK 09293) was procured from Agricultural Research Station, Sankeshwar, UAS, Dharwad. Sugarcane bagasse is a residue generated after juice extraction and mainly used for co-generation in sugar industry. Dried bagasse was subjected to different fibre extraction methods *viz*., chemical and enzymatic method of fibre extraction, mechanical extraction (Raspador Machine) and manual extraction of bagasse Fibre.

Chemical and enzymatic method of fibre extraction

Chemical softening

Softening is a process of treating the textile materials with softening agents to bring about an alteration in handle, resulting in the goods being more pleasing to touch. There are many techniques that can be employed successfully for softening of natural fibres to make them suitable for diversified application.

Bagasse was pre-soaked in water containing 0.5% Turkey red oil for 10 minutes; was boiled in alkali of 3 different concentrations (1.00%, 2.00% & 3.00%) with MLR 1:40 for 45 minutes with subsequent stirring and temperature maintained was 50 to 60ºC. The bagasse was thoroughly rinsed in running water, squeezed to remove excess water and dried in shade. Further, the same was bleached using 2% Hydrogen peroxide and 1.5% Sodium silicate with the MLR of 1:30 at boiling temperature for 60 min and beating was done using industrial mixer for extraction fibres. The bagasse fibres were rinsed thoroughly in running water and dried in shade. The dried fibre was subjected to bleaching to improve the whiteness.

Enzymatic softening

The bagasse was soaked thoroughly in 100ml cellulose enzyme preparation (10U/mg solid) and incubated at 50° C for 24 hours (Jabasingh and Nachiyar, 2012). The enzyme was completely inactivated after the treatment by boiling the bagasse in water for 5 minutes. The enzyme treated samples were then washed thoroughly in running tap water followed by distilled water and shade dried. Further, enzymatically softened bagasse was subjected to scouring using 3% NaOH with MLR 1:30 at 40 to 50ºC temperatures for 30 minutes and beating was done using industrial mixer for fibre extraction. The bagasse fibres were rinsed thoroughly in running water and dried under shade, further subjected to alkali treatment for removal of natural impurities and to makes the more absorbent.

Mechanical extraction (Raspador machine)

Bagasse stalks were split into length wise suitably and were fed into the raspador machine for fibre extraction. Further, extracted material was graded into 2 classes *i.e.*, slackened strips and pith/ shavings. Raspador consists of a rigid frame on which the roller rotates. The roller is made of horizontal bars with blunt edges, and it is driven by a one hp single phase electric motor. The machine reduces the drudgery and provides a clean working environment for the labourers (Das *et al.*, 2010).

Extracted slackened strips from raspador machine were soaked in required amount of hot water for 20 minutes and subjected to beating using electrical beater/ mixer to get good quality bagasse fibre. The whole content obtained after beating were thoroughly rinsed in water, squeezed to remove excess water and dried in shade. Beating process resulted into 4 grade classification *viz*., long staple fibre, short staple fibre, pith bounded shaves and pith.

Manual extraction of bagasse fibre

Dried bagasse was broken manually along with its node length and soaked in luke warm water for 2 hours to remove the surface impurities and improve the fibre quality. The softened bagasse was subjected to delignification wherein lignin content is removed. Sugarcane bagasse was immersed in 5% NaOH solution at room temperature with a liquor ratio of 1:15 for about 2 hours (Acharya *et al.*, 2011).The fibres were then washed with fresh water to remove the NaOH from the surface and delignefied bagasse was placed in industrial blender/ a mixer with water to separate bagasse fibre and pith for few minutes. The excess water was squessed out and fibrous mass was subjected to shade dried and separate the fibre and pith by sieving. The separated fibres and pith was used for industrial application.

Assessment of fibre quality chemical composition

Fibre chemical composition

The proportions of chemical components of any natural fiber vary with source of the fibre, area of production, variety, maturation of plant and extraction condition. The major constituents of a fully developed natural fiber are cellulose, hemicellulose, lignin and pectin.

Chemical composition of matter/substances aids in knowing the properties of the substance and its behaviour to various physical and chemical agents. Knowing the chemical composition of fibres helps a researcher to infer the suitability of the wet processing agents and the behaviour of the fibre to various treatments. Studies on chemical composition of bagasse fibre was carried out at National Institute of Research on Jute and Allied Fibre Technology (NIRJAFT), Kolkata, the details of the standard tests used are listed below:

Alpha (á) cellulose content	:	ASTM D1103-55T
Hemicelulose content and ASTM D1104-56T	:	ASTM D1103-55T
Lignin content	:	T-13 OS-54
Fat and Waxes	:	T-2040M-88
Ash	:	T-4130M-85

Fibre quality parameters

Fibre parameters play a significant role in deciding the spinnability of the extracted fibres. The effect of different treatments on fibre yield and fibre qualities such as fibre length, fineness, strength and elongation were assessed in the present study. Various fibre quality parameters fibre length (cm) fibre fineness (tex) tensile strength and elongation were tested National Institute of Research on Jute and Allied Fibre Technology (NIRJAFT), Kolkata and DKTE's Textile and Engineering Institute, Ichalkaranji.

Colour strength parameters

Colour is a sensation which occurs when light enters the eyes. Colour of any substance decides its ultimate appearance. Bagasse fibre was assessed for Colour strength parameters *viz*., Colour Strength (K/S), Lightness/Darkness values (L), Redness/ greenness values (a*) and yellowness/blueness

values (b*). Difference in colour parameters (dE, dL, da, db) were also recorded. The readings of the instrument and the principle of the equipment is in accordance with CIE L*a*b* standards. Spectrophotometer with QC colorlab + (Premier colourscan) Software was the instrument used to assess the colour strength parameters.

RESULTS AND DISCUSSION

Effect of extraction methods on fibre yield/ kg

Table 1 exhibits the bagasse fibre yield, extraction efficiency and wastage percentage which was extracted through chemical and enzymatic softening, mechanical and manual methods. Chemical softening was carried out with varied percentage of NaOH (1%, 2% and 3%) resulted that, fibre yield (622g/kg) was greater in 3% NaOH as compared to other methods. Enzymatic softening with 3 percent NaOH treatment yielded good quantity of fibre (657g/kg) with but the fibre did not get separated from pith bounded to the bagasse fibre. In mechanical extraction method the yield and extraction percentage of bagasse fibre using raspador machine achieved two classification *i.e.* slackened strips (697g/kg) and pith/ shavings (196g/ kg). Slackened strips were further beaten using industrial mixer to extract fibre and which were graded into four classes' *viz.*, long staple, short staple fibres, pith bounded shaves and pith. 1kg of slackened strips yielded 369g long staple fibre, 60g short staple fibres, 80g pith bounded shaves and 166g of pith, in total the yield is 675g/kg. Apart from the above mentioned extraction methods, another method was adopted to reduce labour, electricity and fuel consumption *i.e.*, manual method, this method yielded 620g/kg fibre and 265g/kg pith. Nevertheless, yield of fibre extracted from bagasse using manual method followed by beating yielded good quality and highest quantity of fibre compared to mechanical, chemical and enzymatic softening methods. Least percentage of wastage was observed in fibre extracted from raspador machine and manually extraction method.

Consumption of time during fibre extraction process/ kg

Table 2 highlights on the time taken for fibre extraction using various extraction methods. Based on the observation, manual extraction method consumes less time for fibre extraction (1 hour 15 minutes) as compared to other methods. Time required in the process of mechanical extraction is 2 hours 15 minutes which encompasses extraction from raspador machine and beating in industrial mixer followed by segregation of fibres. Further, chemical and enzymatic fibre extraction using different concentration of NaOH required 2 hours for chemical extraction method and Enzymatic softening registered 24 hours, this may be because

Table 1. Effect of extraction methods on fibre yield/ kg

Sl. No.	Extraction methods	Treatment	Yield (g/kg)	Percentage (%)	Wastage (%)
1	Chemical and Enzyme extraction	Chemical softening 1% NaOH	333 g	33.30	66.70
		Chemical softening 2% NaOH	500 g	50.00	50.00
		Chemical softening 3% NaOH	622 g	62.20	37.80
		Enzymatic softening	290 g	29.00	71.00
		Enzymatic softening + 3% NaOH Scouring	657 g	65.70	34.30
2.	Mechanical extraction (Raspador machine)	Slackened strips	697 g	69.70	10.70
		Pith/ shavings	196 g	19.60	
		On Beating			
		Grade 1 – Long staple fibre	369 g	36.90	32.40
		Grade 2 – Short staple fibres	60 g	6.00	
		Grade 3 – Pith bounded shaves	80 g	8.00	
		Total fibre yield	**509 g**	**50.90**	
		Grade 4 - Pith	166 g	16.60	
3.	Manual extraction (Cutting & Beating)	Fibre	620 g	62.00	11.50
		Pith	265 g	26.50	

of maximum was time required for the enzymes to activate and react with the fibres bound to sheath. Hence, enzymatic fibre extraction method was found to be less suitable for bagasse fibre extraction.

Production cost for fibre extraction with different extraction methods

Table 3 explains, the production cost for fibre extraction with different extraction methods. Local sugarcane bagasse was subjected to different fibre extraction methods *viz.*, chemical, enzymatic, mechanical and traditional method of extraction. The fibre extraction method was optimized based on the fibre yield, time taken and production cost. Fibre yield was found to be more in case of traditional method of extraction followed by mechanical (Raspader machine) extraction with least percentage of wastage and less time. Among the fibre extraction methods, enzymatic extraction method was found to be costlier with minimum fibre yield followed by chemical extraction method. Production rate per kg fibre was accounted least (Rs. 36.00) in traditional method followed mechanical and chemical extraction method (Rs.63.00 and 59.00). Traditional method of fibre extraction was the suitable technique for bagasse fibre extraction with greater fibre yield and less production cost can be effective agro startups for young farmers and local artisans.

Assessment of Fibre Quality

Chemical Composition of bagasse fibre

Chemical composition is important element that influences the physical, mechanical and thermal properties of the natural fibre. Most of the plant fibres except for cotton are composed of cellulose, hemicelluloses, lignin, waxes and some water soluble compounds as major constituents. However, the chemical contents are different according to the variety, location of plantation, climates, irrigation and environment aspects. Mechanically extracted bagasse fibre contain 39.70% of cellulose, 23.11% hemicelluloses, 23.32% lignin, 0.34% of fat & wax and 1.59% of inorganic matter (ash). Noticeable amount of reduction in chemical composition was observed on chemical softening of bagasse fibre (Table 1). These results are on par with results of Charani and Rovshandel, (2005) ; cellulose (52.42%), lignin (21.69%), hemicelluloses (25.80%), and ash (2.73%) respectively.

Physical properties of bagasse fibre

Bagasse fibre extracted from chemical, enzymatic and enzymatic + NaOH softening treatments exhibited almost similar fibre qualities as that of control (Table 2). The length of bagasse fibre procured from chemical softening (7.57cm) was found to be better compared to enzymatic (9.13cm) and enzymatic + NaOH (6.36cm) softening treatments. However the length of fibre was found to be higher on enzymatic treatment but the quality of fibre was not appreciable as the fibre yielded was bounded to pith. Observing the fineness, the fibre noted to be coarser compared to other bast fibres, enzymatic + NaOH (30.66tex) and chemical (30.20tex) treated produced similar results as of control (31.00tex); enzymatic softening (20.40)

Table 2. Consumption of time during fibre extraction process/ kg

Sl. No.	Extraction methods	Treatment	Yield (g/kg)	Percentage (%)	Time consumed / hour
1.	Chemical & Enzyme extraction	Chemical softening 1% NaOH	333 g	3.33	2 hours each
		Chemical softening 2% NaOH	500 g	5.00	
		Chemical softening 3% NaOH	622 g	62.20	
		Enzymatic softening	290 g	29.00	24 hours
		Enzymatic softening + 3% NaOH Scouring	657 g	65.70	
2.	Mechanical extraction (Raspador machine)	Slackened strips	697 g	69.70	15 min
		Pith/ shavings	196 g	19.60	
		On Beating and sieving			
		Grade 1 – Long staple fibre	369 g	36.90	2 hour
		Grade 2 – Short staple fibres	60 g	6.00	
		Grade 3 – Pith bounded shaves	80 g	8.00	
		Total fibre yield	**509 g**	**50.90**	
		Grade 4 - Pith	166 g	16.60	
3.	Manual extraction (Cutting & Beating)	Fibre	620 g	62.00	1hour 15 min
		Pith	265 g	26.50	

produced finer fibre compared to others. The strength of the fibre extracted from chemical (565.58gf/tex) is slightly increased over control (563.68gf/tex) whereas, enzymatic (554.43gf/tex) and enzymatic + NaOH (517.74gf/tex) softening was found to decrease significantly than the control. It was observed that the elongation percentage of fibres extracted from enzymatic softening + NaOH reduced to 3.79 per cent followed by enzymatic (3.29%) and chemical (3.18%) softening over control (4.62%).

Table 5 exhibits the effect of scouring on length of bagasse fibres. Among the scoured and scoured + bleached fibres, it was observed that the length of the fibres on scouring with 5 per cent NaOH reduced to 8.18cm and on bleaching with 2 per cent H_2O_2 further the length was reduced to 7.65cm over control (8.42cm). The fineness of the fibre extracted from scouring (30.00tex) decreased compared to control. Whereas, on bleaching the fineness of fibre remained the same 31.00tex as of control. On scouring, the strength of bagasse fibres is reduced 463.93 gf/tex over control (563.68 gf/tex), however, on bleaching (508.24 gf/tex) was increased over scoured fibre but decreased compared to control. The elongation ability of the scoured (2.95%) and scoured + bleached (2.76%) fibre under stress was reduced by half of the elongation of control fibre (4.62%).

Colour strength parameters of bagasse fibre

Colour strength (K/S) value of fibre extracted from chemical softening (38.256) is higher over mechanically extracted fibre (control 11.435) and other 3 treatments manual extraction (33.679), enzymatic softening + NaOH (27.180) and enzymatic softening (21.087). The Lightness/ Darkness indicator (L*) exhibited darker shades in all the

Table 3. Production cost for fibre extraction with different extraction methods

Sl. No.	Particulars	Chemical extraction		Enzymatic extraction		Mechanical extraction		Manual extraction	
		Qty	Cost (Rs.)	Qty	Cost (Rs.)	Qty	Cost (Rs.)	Qty	Cost (Rs.)
1	Bagasse @ Rs. 5000.00 / ton	1 kg	5.00	1 kg	5.00	1 kg	5.00	1 kg	5.00
2	Chemicals & Enzyme								
	3 % NaOH @ Rs. 308.00 / 500g	30g	18.48	30g	18.48	—	—	—	—
	5 % NaOH @ Rs. 308.00 / 500g	—	—	—	—	—	—	5g	3.08
	0.5% Turkey red oil @ Rs. 60.00/ litre	5ml	0.30	—	—	—	—	—	—
	1.5% sodium silicate @ Rs. 448.00 /500g	15g	13.44	—	—	—	—	—	—
	0.5% Acetic acid @ Rs. 300.00 / 500ml	—	—	—	—	—	—	—	—
	2.00% Hydrogen peroxide @ Rs. 360.00 / 500ml	20ml	14.40	—	—	—	—	—	—
	Cellulose enzyme (10U /mg solid) @ Rs. 5,151.00 / 10g	—	—	1g	515.00	—	—	—	—
3	Electricity - Raspador machine @	—	—	—	—	2 hours	8.50	—	—
	750 Watts Mixer for 1 hour a day @ 6.00 / kWh	1.06 15 min	15 min	1.06	15 mins	1.06	1 hour	4.25	
4	Fuel @ Rs. 776.00/ cylinder	1 hour	15 min	6.00	30 min	2.50	15 min	1.20	—
5	Labour charge @ Rs. 150.00/day	—	—	—	—	2 hours 15 mins	46.87	1 hours 15 mins	23.43
6	Miscellaneous charges								
	Total		58.65		542.04		62.63		35.76

Table 4. Chemical composition of extracted bagasse fibre

Treatment	Chemical composition				
	Cellulose (%)	Hemi-cellulose (%)	Lignin (%)	Fat and wax (%)	Ash (%)
Chemical and enzymatic extraction	37.86	22.97	21.96	0.26	1.12
Mechanical extraction (Raspador machine)	39.70	23.11	23.32	0.34	1.59
Manual extraction	39.00	22.12	22.00	0.34	1.43

extraction methods, wherein chemical softening fibres exhibited (72.159) darker shade compared to enzymatic (68.423), mechanical (70.081) and manual (55.593) extracted fibres. Irrespective of the extraction methods a* value of the fibres shows evidence of redder. Whereas, b* values of chemical (23.612), manual (22.384), enzymatic + NaOH softening (18.554), mechanical (18.291) and enzymatic (14.304), extraction methods exhibited more towards yellower (Table 3).

Effect of scouring and bleaching on colour strength of mechanically extracted bagasse fibre is exhibited in Table 3. Colour strength (K/S) values of fibre extracted from scouring (17.204) and scouring + bleaching (13.797) are increased then control (11.435). The Lightness/Darkness indicator (L*) showed evidence of gradual increase, when the fibre is scouring (71.888) and scouring + bleaching (73.950) over control value. Among a* and b* values of the fibre, it is observed that the fibre is redder (1.609) and yellower (22.437) on scouring over control, the redness decreased to 1.421 and yellowness increased to 26.531 on scouring + bleaching of the fibre respectively.

CONCLUSION

High performance, biodegradable materials and renewable plant materials can form new platform for sustainable and eco-efficient advance technology products and compete with synthetic/petroleum based products presently dominated in market which are diminishing natural petroleum feedstock.

Local sugarcane bagasse was subjected to different fibre extraction methods *viz.*, chemical, enzymatic, mechanical and traditional method of extraction. The fibre extraction method was optimized based on the fibre yield, time taken and production cost. Fibre yield was found to be more in case of traditional method of extraction followed by mechanical (Raspader machine) extraction with least percentage of wastage and less time. Among the fibre extraction methods, enzymatic extraction method was found to be costlier with minimum fibre yield followed by chemical extraction method. Production rate per kg fibre was accounted least (Rs. 36.00) in traditional method followed mechanical and chemical extraction method (Rs.63.00 and 59.00). Traditional method of fibre extraction was

Table 5. Effect of extraction methods on physical properties of bagasse fibre

Treatment	Fibre length (cm)	Fineness (tex)	Strength (gf/tex)	Elongation (%)
Chemical and enzyme extraction				
Chemical softening	7.57	30.20	565.58	3.18
Enzymatic softening	9.13	20.40	554.43	3.29
Enzymatic softening + NaOH	6.36	30.66	517.74	3.79
Mechanical extraction (Raspador machine)				
Mechanically extracted	8.42	31.00	563.68	4.62
Scouring	8.18	30.00	463.93	2.95
Scouring + Bleaching	7.65	31.00	508.24	2.76
Manual extraction				
Fibre	4.50	5.80	-	-

Table 6. Effect of extraction methods on colour strength parameters of bagasse fibre

Treatment	K/S	RFL	L*	a*	b*
Mechanically extracted fibre (Control)	11.435	19.941	70.081	1.761	18.291
Chemical and enzyme extraction					
Chemical softening	38.256	5.714	72.159(2.078)	1.681(-0.238)	23.612(5.321)
Enzymatic softening	21.087	4.373	68.423(-1.657)	2.316(0.555)	14.304(-3.986)
Enzymatic softening + NaOH	27.180	0.481	70.070(-0.033)	1.872(0.334)	18.554(0.233)
Mechanical extraction					
Scouring	17.204	4.564	71.888(1.807)	1.609(-0.454)	22.437(4.146)
Scouring + Bleaching	13.797	9.103	73.950(3.869)	1.421(-0.339)	26.531(8.229)
Manual extraction					
Fibre	33.679	9.635	55.593(14.488)	7.342(5.581)	22.384(4.093)

the suitable technique for bagasse fibre extraction with greater fibre yield and less production cost can be effective agro startups for young farmers and local artisans. The well designed and engineered products from bagasse fibre can help in making new revolution to sustain our natural resources. Thereby, based on this brief study on extraction process, chemical composition and physical properties, bagasse fibers can be utilized for advance engineered product development for different applications. An approach to develop an alternative way in product development, which can be particularly used for daily needs of common people whether it is house hold furniture, packaging, fencing, decking, flooring, and light weight car components, sports equipments and soon.

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