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Effect of mechanical and chemical treatments of arecanut (*areca catechu* L.) fruit husk on husk and its fibre

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ABSTRACT

Arecanut husk, a biomass is generated during extraction of nut and is stored in heaps in the backyards of processing units. Arecanut husk presently has no industrial/commercial applications and is a cause of major environmental hazards. Arecanut husk is rich in good quality lingo-cellulosic fibres which have potential applications in various fields. Presently there is no proper process and machinery available to extract these fibres on a mass scale. Designing such machinery requires characterisation of husks, bonding force between fibres and the shell, etc. The aim of the present study is develop suitable mechanical and chemical treatments to facilitate easy extraction of fibres and also to study the effects of theses pretreatments on tensile property of fibres. The variety used was Shreevardhini. It was noticed that the pretreatments of husk had significant effect on fibre separation. Highest fibre recovery of about 57% was achieved with pressed husks soaked in water for 24 h. Detachment force required for fibre / fibres separation from husk was least in 2.5% KOH treated husks. There was no adverse effect of pretreatments on tensile strength of fibres. Pressing of husks resulted in maximum fibre recovery due to weakening of bonds, hence pressing of arecanut husk before mechanical fibre extraction is recommended, whereas chemical pretreatment of husks with KOH is not recommended.

1. Introduction

Arecanut (betel nut) is grown in more than 12 Asian countries, with an estimated production of 1.2 million tonnes of fruits annually and provides livelihood to more than 10 million farmers (Fig. 1a).

Arecanut is an important plantation crop of India and it contributes to more than 50% of world arecanut production. Arecanut has agro-socio-economic-religio-politico-medicinal importance in producer countries. It is used as masticator by millions of people. After extraction of kernels in small scale units, husk generated (dry/green) is thrown away in the backyards. Production of arecanut fruit in India was 833,000 tonnes from an area of 497,000 ha in 2017–18 (NHB, 2019). Fruit consists of approximately 40% husk, which means an estimated 333,200 tonnes of husk was generated as biomass in India alone. Husks do not decompose rapidly due to ligno-cellulosic composition. Large heaps of the husk biomass creates environmental problems due to lack of proper disposal (Swamy et al., 2004). Hence the arecanut husks offer a good opportunity for proper utilisation of this renewable biomass.

Laboratory level studies were conducted to utilise husks and fibres for different applications. Several studies have reported that arecanut husks and / or fibres could be used - for the production of furfural (5.5% recovery) by acid catalysed HTHP process (Singh, 1956); - for the production of items such as thick boards, fluffy cushions and non-woven fabrics (Ghosh et al., 1975); - in the recovery of xylose and activated charcoal (Kapadi et al., 1982); - for the industrial production of furfural, xylose and activated carbon (Nayar and Annamalai, 1982); - for the production of cellulose and hemicellulose (Anonymous, 1999); -for the production of furnishing fabrics and textiles by blending with cotton, viscose and polyester (Rajan et al., 2005); - as resource for ethanol production (Prasad et al., 2007); - as a substrate for enzyme production (Rajan et al., 2010); - as fibres for production of non-woven fabric possessing good drape, strength, permeability, resistance to withstand strong sunlight; heavy rains and storms (Ashok Kumar et al., 2011); - for the production of biogas (Chanakya and Malayil, 2011); - as fuel in burning chamber (Rathod, 2011); - as natural fibre reinforcement in low cost, biodegradable polymer composites (Yusriah et al., 2012), - for the

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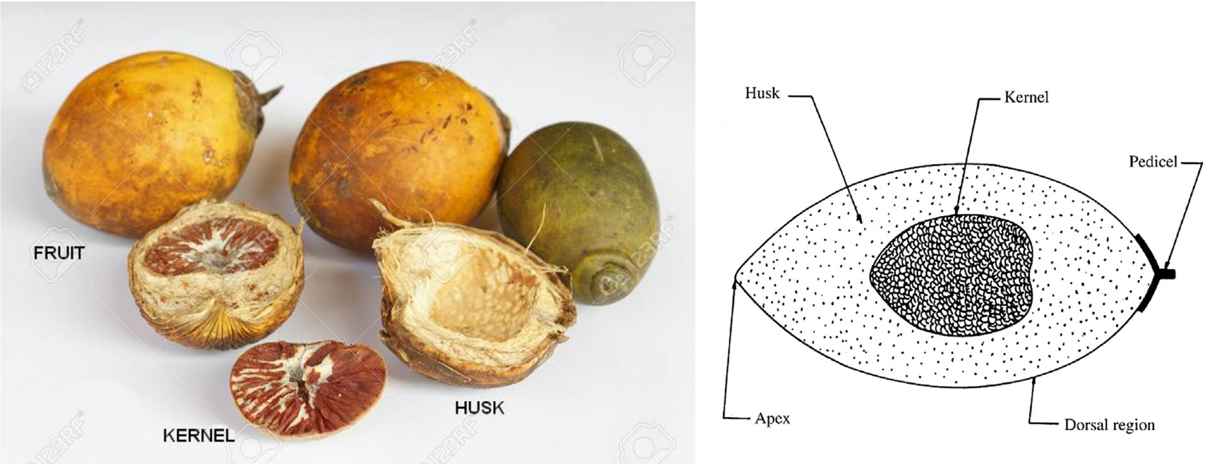

Fig. 1a. Fruit, husk and kernel of arecanut (©123RF) with cross section (Kaleemullah and Gunasekhar, 2002).

production of citric acid by SSF (Narayanamurthy et al., 2012), - as fixed bed for treating domestic wastewater (Shivakumaraswamy et al., 2013), - as a substrate for mushroom cultivation (APIB, 2016) and – as areca tea and air freshener (Bangalore Mirror, 2017). Ashok Kumar et al. (2011) estimated that approximately 1,30,000 m fibre per year might be available in India at the rate of 2.55–2.70 g of fibre per fruit.

Though several attempts have been made to gainfully utilise the husks, no attempt has been made to utilise the fibres due to non-availability of machines for fibre extraction. Hence suitable machine needs to be developed for extraction of fibres from arecanut husks. In the extraction of fibres using machines, the husks are to be fed to the machine as such or after pre-treatments, therefore it becomes highly essential to characterise the husks.

Earlier studies were carried out to investigate the effect of biological, chemical and mechanical treatments on arecanut husks and fibres. Pectinolytic bacteria were more effective than hydrolytic agents for rapid softening of arecanut husk and there by resulted in easy fibre separation (Baruah et al.,1957). Biosoftening/retting of arecanut husk fibre with microbes selectively removed lignin without loss of appreciable amounts of cellulose and fibre strength (Rajan et al., 2005). Murthy and Pillai (1982) reported that retting of arecanut husks in water for three weeks resulted into soft fibres. Arifulla et al. (2007) investigated effect of KOH treatment on mechanical properties of arecanut husk fibres, which were used as reinforcement in urea formaldehyde and epoxy polymer composites. Mohan Kumar (2008) soaked green husk of tender arecanut in water for 4 days before fibre extraction. Ashok Kumar et al. (2011) manually extracted arecanut husks fibres using retting process. Dried arecanut husks were soaked in deionised water for about 5 days, followed by extraction, washing and drying of fibres at room temperature for 15 days (Srinivasa et al., 2011; Dhanalaxmi et al., 2012; Yusriah et al., 2012b; Srinivasa and Bharath, 2013; Yusriah et al., 2014; Dhanalaxmi et al., 2015a; Dhanalaxmi et al., 2015b). As a physical pretreatment, Kapadi et al. (1982) disintegrated arecanut husk for study. Nirmal et al. (2012) crushed, soaked betelnut husk in water for 2 days before fibre extraction. Naik et al. (2014) crushed arecanut husk under heavy vehicle, soaked in water and dried for 2 days. These dried husks were soaked in water again for about 2–3 days and the loosened fibres were easily extracted.

Most of the above studies had optimised period of soaking of arecanut husks in water at laboratory scale for fibre extraction, however, effect of mechanical pretreatment of husks for fibre extraction was not investigated in depth. For mass scale production of fibres, like in coir, it is necessary to investigate the effect of mechanical pretreatments on arecanut husk before fibre extraction. Mechanical treatment of husk is usually imparted to change the physical properties of arecanut husk, which may facilitate easy absorption of media (chemical treatment) and result in easy and maximum fibre recovery. Hence, the present investigation was undertaken with an aim to study the effect of mechanical and chemical pretreatments of arecanut husk on fibre extraction. Dried arecanut husks were mechanically modified by pressing and busting, followed by soaking for 24 h at ambient conditions in water or alkali (2.5% KOH). Effect of these pretreatments on husk properties in terms of fibre recovery and detachment force required for separation of single fibre and bunch of fibres was examined. Results obtained were compared with earlier reported results of effect of alkali treatment on tensile strength of fibres.

2. Materials and methods

The study was carried out in Dr. B. S. K. Krushi Vidyapeeth (An Agricultural University), Dapoli, Ratnagiri District, Maharashtra State (India).

2.1. Materials

2.1.1. Arecanut husk

Dry husks of popular arecanut variety 'Shreevardhini' were procured from a small scale processing unit based at Shreevardhan, Raigad District, Maharashtra State (India). Husks were cleaned and the pedicels (Fig. 1a cross section) attached to husks were removed manually. Fluffy husks having loose fibres were discarded. Only firm husks were taken for experimental study and designated as untreated husks (Fig. 1b). Husks were stored in moisture proof polypropylene bags to avoid growth of moulds and fungi.

2.1.2. Water

Well water was used during the investigation.

2.1.3. Potassium hydroxide

Industrial grade potassium hydroxide in flake form of 85% purity, supplied by Molychem, Mumbai, was used.

2.2. Methods

2.2.1. Pressing of husk

Pressing of husks was done to break open the shell of husks and also to change the shape of husks from ovoid to a sheet form. This

Fig. 1b. Arecanut husks used in study.

was carried out by feeding husks between two iron rollers. The sheet bending set up available in the engineering workshop of university (Fig. 2a) was used for pressing of husks. The set up consisted of three solid iron rollers (ø 90 mm) rotating in the opposite directions with manual rotation of flywheel. The set up was modified by fitting an electric motor to drive the set up electrically rather than manually for processing of large quantity of husks. An electric motor (1Φ, 1 hp, 1390 rpm) was mounted on the frame of setup at the ground level. With V-belt (B68), CI pulley (ø 50.8 cm) and gear arrangement, the speed of the rollers was maintained at 38 rpm. The clearance between two rollers was 0.09 mm in no-load condition while the clearance between two rollers varied between 0.5 and 2 mm during pressing of husks.

Two operators fed individual husks in between rollers safely with the help of wooden sticks. Pressed husks drop down on a polythene sheet. Pressed husks were stored safely in polythene bags at ambient conditions.

2.2.2. Busting of husk

Busting operation implies puncturing or piercing of husk and simultaneously pressing it. By this treatment, surface area of husks was increased for chemical treatment. A rectangular tool set up of size 41 × 45 cm was fabricated to carry out busting. The set up consisted of top plate with punching nails, guide plate (holding and guiding nails firmly up to the base plate), base plate with holes, support frame and vertical sliding shaft with bushes. All the three MS plates had same number of coaxially drilled holes. 1028 MS nails (ø 2.75 mm and 50 mm length) were de-topped, inserted in holes (ø 3.17 mm) and welded on top plate (8 mm thick). Guide plate (4 mm thick) holds nails in the holes (ø 3.96 mm). Nails always protruded out of guide plate holes. Guide plate was hinged to top plate with the help of 76.2 mm headless stud bolts with compression springs at midpoint of four sides. Compression springs were provided to push back guide plate to no-load position and thereby pushing husk out of nails. Four MS bushes (ø 25 mm, 50 mm length) were welded to guide plate for sliding over four MS support shafts. These four corner shafts (ø 20 mm, 30.54 cm length) were welded to base plate. On vertical movement, guide plate touches down to base plate. Base plate was rested on bottom frame made of MS angles (25 × 25 × 5 mm). Base plate had countered holes (ø 6.35 mm) on upper side. MS support shafts were welded in vertical alignment to the bottom frame at four corners. MS angle (40 × 40 × 5 mm) frame was welded on upper side of the top plate with an angle piece at centre. MS bar (ø 32 mm, 240 mm length) (pull-push bar) was welded vertically on the centre MS angle of the MS frame. To securely hold the push-pull bar in vertical position, four MS angles from four corners of MS frame were welded to it. The push-pull bar was provided to fasten it with the screw press holder. Screw press set up with horizontally rotating flywheel of weight 150 kg was used to slide top and guide plates up and down.

The set up was placed below screw press to carry out busting of husks. Pull-push bar was inserted in the holder of screw press and bolted to it. Base frame of set up was fixed to the base of screw press with hinges, nuts and bolts. Top and guide plates were lifted up with anti-clockwise rotation of flywheel manually. Approximately 30 to 50 husks were uniformly spread over the bottom plate (Fig. 2b). Proper handling and safety precautions were followed during operation. Flywheel was allowed to rotate clockwise, thereby the top and guide plates were forced to slide down due to the moment of inertia of the flywheel. Guide plate firmly holds the husks, while nails pierced through husks. Simultaneously husks were pressed between base plate and guide plate; and were busted/damaged. Top and guide plates were lifted up by rotating flywheel anticlockwise. Husks were removed from the surface of bottom plate. Busting of husks was carried out to obtain 20 kg of busted husks. Busted husks were stored safely in ambient conditions.

Fig. 2a. Pressing of arecanut husk in sheet bending setup.

Fig. 2b. Setup for busting of husks.

Fig. 3a. Mechanically treated husks.

2.2.3. Chemical treatment of husk

Pressed, busted and untreated husks (Fig. 3a) were soaked in water and 2.5% KOH solution for 24 h. KOH concentration of 2.5% was selected on the basis of preliminary study conducted. For every replication, 250 g of husks was used. Husks mass to chemical solution ratio was 1:20 (w/v). After filling containers with 5 l of solution (water or alkali), husks were poured into it. Light weight husks tended to float over the surface of the solution, so it was ensured that husks were completely soaked in the solution. The containers were kept in safe place at ambient condition (Fig. 3b). The experiment was conducted in the month of May of 2015. During this period, the temperature and relative humidity at Dapoli were in the range of 22.7–34.6 °C and 56–87%, respectively. After soaking for 24 h, husks were removed from the containers. Water soaked husks were washed 3 times with water. Then water was wiped out by keeping them on metal screen. The KOH treated husks were thoroughly washed 15 times in running water. Husks were poured on metal screen to remove water completely. Care was always taken not to apply any force on husks. Such husk samples were used for measurement of dependent parameters.

2.2.4. Experimental details

The experiment was statistically designed in factorial randomised block design (FRBD) with three replications. Experimental data was analysed using SAS 9.1. Fibre recovery is an important parameter to evaluate the effect of any pre-treatment. Effect of mechanical and chemical treatments on husk was assessed by measurement of detachment force required for separation of single fibre and bunch of fibres from husk. The detachment force value could be useful in the design of fibre extraction machine or processing equipment. Tensile strength of fibre is very important property for any intended use of fibre. Tensile strength of fibre helps to decide force required to separate the fibres without causing breakage.

2.2.4.1. Fibre recovery from husk. Fibres from husks were carefully removed manually. Husks have evenly distributed and axially arranged fibres from pedicel to apex. Fibres were stripped off from pedicel. Fig. 4 shows husks, shells and fibres of an arecanut. Care was taken not to lose any fibre. Fibres were attached firmly at apex region. Hence maximum possible uncut fibres were separated from shell. Shells and fibres were dried in a hot air oven at 70 °C for 24 h. Fibre and shell weights were recorded with digital precision balance (LC 0.01 g). Procedure was replicated for 40 husks from each sample. Fibre recovery of husks was calculated as per Eq. (1).

$$\text{Fibre Recovery}, \% = \frac{\text{Weight of fibres, g}}{\text{Weight of fibres and shells, g}} \times 100 \qquad (1)$$

2.2.4.2. Measurement of detachment force required for single fibre separation from husk. Shimadzu AGX series universal testing machine (UTM) (50kN capacity) was used for force measurement. A jaw was specially fabricated to hold soaked husk. It consisted of two pieces of rubber, which were clamped together by a pair of bolt and nut on upper end at a distance of 2 cm from the edge. Other ends of rubber pieces were clamped together in the lower jaw of UTM. Metal jaw of testing machine could not hold a single fibre from soaked husk. Hence, a wooden block of dimensions (52 × 26 × 62 mm)(L × W × H), with mid slit of 2 mm width and 38 mm depth, was developed to hold free end of fibre. A pair of heavy duty bolts and nuts was fixed at a distance of 12 mm from the edge of block with a distance of 26 mm between them. The block was clamped in the upper jaw of UTM. Soaked husks from experimental sample were randomly selected for force measurement test. A soaked husk was clamped in lateral orientation between rubber pieces with tightening of nut and bolt. Care was taken to keep that portion of husk free from where a fibre was

Fig. 3b. Chemical treatment of husks.

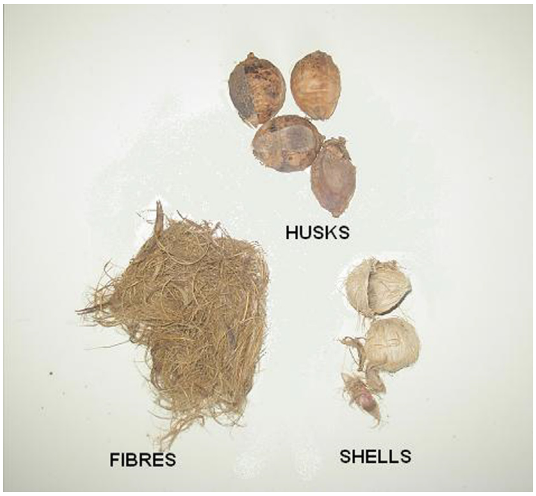

Fig. 4. Arecanut husk constituents.

Fig. 5a. Measurement of detachment force for bunch of fibres separation.

pulled. The free end of fibre from pedicel of husk was inserted and clamped in the wooden block slit in the upper jaw of UTM. The test was carried out with a cross-head speed of 1 mm/min and force application of 0.5 N/s with 5 replications from each experimental sample. Value of maximum force was recorded (Fig. 5a).

2.2.4.3. Measurement of detachment force required for separation of a bunch of fibres from husk. The test method, as mentioned in Section 2.2.4.2 for measurement of detachment force required for single fibre, was followed, except tips of five fibres were inserted together and clamped in wooden block. Randomly selected husks were tested with a cross-head speed of 1 mm/min with 5 replications from each experiment. Maximum force value was recorded.

2.2.4.4. Fibre tensile strength. Tensile strength of fibre was measured by following ASTM D3379, 1975 which was followed by Yusriah et al. (2012a) for arecanut husk fibre characterisation. Fibre tensile strength was measured with Shimadzu UTM (AGX series, 50kN capacity). Dried fibres obtained from fibre recovery study were used for tensile strength test. Tensile testing of fibre was carried out by clamping it in two wooden blocks, which in turn were clamped in the upper and lower jaws of UTM (Fig. 5b). Middle portion of 20 mm of test fibre was marked. One end of fibre was inserted and clamped in the slit of upper side wooden block up to the marking. Similarly other marked end of fibre was clamped in the slit of lower side wooden block. The fibre was tested with a cross-head speed of 1 mm/min and force application of 0.5 N/s. Maximum tensile breaking force value was recorded. A total of 40 fibres from each experimental sample were tested.

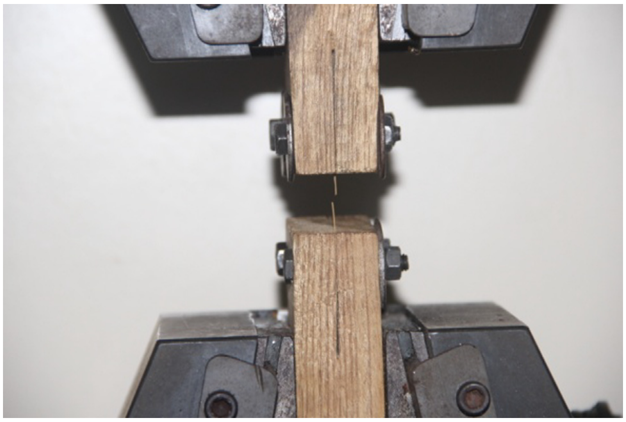

Fig. 5b. Measurement of tensile strength of fibre.

3. Results and discussion

3.1. Fibre recovery

Fibre recovery from husks obtained using different combinations of pretreatments is presented in Table 1. Maximum fibre recovery of 57.34% was obtained in pressed husks soaked in water for 24 h, which was significantly higher than the fibre recovery of 52.77% obtained from pressed husks soaked in 2.5% KOH for 24 h. Minimum fibre recovery of 43.35% was observed in untreated husks soaked in 2.5% KOH for 24 h. Maximum fibre recovery was less than the actual fibre content of 80.20% obtained from husks of cultivar Shreevardhini (Deshmukh et al., 2016). ANOVA of results showed that mechanical and chemical treatments had significant influence on fibre recovery from arecanut husks as an individual treatment at 5% level of significance (LoS), but the combined effect of both treatments on fibre recovery was found to be statistically non-significant.

Pressing of husks between two rollers resulted in compaction of the husks. The ovoid shape of husks was changed to plain sheet. Damage of physical structure resulted in breaking of shells. The fibres attached were initially compressed with shell, but swung back to actual size due to resilience. Fibres became free at pedicel for pulling. At apex region, fibre bonding with shell was broken and loosened fibres could be pulled easily. This resulted in higher fibre recovery from pressed husks soaked both in water and alkali. Compared to pressed husks, less fibre recovery was obtained in busted husks because in this operation only puncturing or piercing of husks took place. Although piercing of husks had improved soaking into husks layers, but partial damage of shells had no resultant effect on easy and high fibre separation. This was due to the fact that the fibres were firmly attached to shells; similar to untreated husks. Only separable fibres were extracted in the experiment. Naik et al. (2014) reported that crushing of husks removed dust, reduced weight of husks and helped in fibre extraction from husks. Fibre recovery resulted from busted husks and untreated husks were at par indicating that busting of husk has no significant effect over untreated husk. Soaking of husks for 24 h resulted in penetration of solution in husk, which caused swelling of husk. In water soaked husks, manual separation of fibre became easy. But same was not observed in husks soaked in alkali. Alkali penetrated deep inside husks and even though the husks were washed thoroughly with water remove alkali from the surface of husks, but it was not possible

Table 1
Effect of mechanical and chemical treatment on fibre recovery, detachment force required for single fibre and bunch of fibres separation, and fibre strength.

Mechanical treatment	Chemical treatment	Fibre recovery, %	Mean of mechanical treatment	Detachment force (Single Fibre), N	Mean of mechanical treatment	Detachment force (Bunch of Fibres), N	Mean of mechanical treatment	Fibre strength, N	Mean of mechanical treatment
Pressing	Soaking in water for 24 h	57.34	55.05^a	8.03	6.57	15.48	14.38^b	34.19	35.52
	Soaking in 2.5% KOH for 24 h	52.77		5.12		13.27		36.85	
Busting	Soaking in water for 24 h	49.45	46.79^b	10.58	8.93	17.32	17.33^b	34.10	35.12
	Soaking in 2.5% KOH for 24 h	44.14		7.29		17.34		36.16	
Untreated	Soaking in water for 24 h	47.50	45.43^b	10.63	9.12	24.19	23.71^c	32.47	34.30
	Soaking in 2.5% KOH for 24 h	43.35		7.61		23.23		36.13	
	SE	±1.2991		±1.2612		±2.1762		±2.4031	
	CD(at 5%)	4.09	2.8946	3.72	2.6309	8.80	4.5396	6.76	ns
Mean of Chemical Treatments	Soaking in water for 24 h	51.43^a	2.3634 (CD)	9.74^a	2.1481 (CD)	18.99	2.1481 (CD)	33.58	ns
	Soaking in 2.5% KOH for 24 h	46.75^b		6.67^b		17.94		36.38	

Means followed by different letters are significantly different.

to remove alkali completely from subsurface of husks. Hence during manual separation of fibre, husks; fibres; and shells became slippery which resulted into lower fibre recovery. The effect of alkali could have been neutralised with acid treatment of husks. Present study confirmed earlier findings that mechanical pressing has significant positive effect on fibre recovery from husks. Past laboratory studies carried out extraction of arecanut husks fibre by soaking in water with varying periods (2–15 days). But no study has been done to ever confirm the combined effect of mechanical and chemical treatments of arecanut husks on fibre recovery.

3.2. Detachment force required for separation of single fibre

Effect of pretreatments of arecanut husk on detachment force required for separation of single fibre is presented in Table 1. Minimum detachment force to separate single fibre from husks is desirable. Lowest detachment force of 5.12 N was observed in pressed husks soaked in 2.5% KOH for 24 h, which was at par with busted husks (7.29 N) and untreated husks (7.61 N) – both alkali treated. Water soaked husks (8.03–10.63 N) had significantly higher detachment force required for single fibre separation. ANOVA of results showed that chemical treatment of husks had statistically significant effect (5% LoS) on detachment force required for single fibre separation. But mechanical treatment of husks and interaction of mechanical and chemical treatments of husks had statistically non-significant effect on detachment force required for single fibre separation. Alkali penetrated deep into hard shells of husks and weakened bond between shells and fibres and thereby resulted in less detachment force. Water had penetrated inside the shell but did not weaken the bond between shell and fibre, hence water soaked husks showed high detachment force. Pressing of husks resulted into least detachment force (6.57 N) among mechanical treatments, followed by busted husks (8.93 N) and untreated husks (9.12 N). This is in good agreement with highest fibre recovery obtained in pressed husks due to damage of shell and thereby loosening of fibres attached to shell. Chemical treatment had positive effect on reduction in detachment force required for single fibre separation.

3.3. Detachment force required for separation of bunch of fibres

Minimum value of detachment force for bunch of fibres separation is desirable to have high and easy fibre extraction from designed machine. From Table 1, it is observed that minimum detachment force (13.27 N) required for separation of bunch of fibres was observed in pressed husks soaked in 2.5% KOH for 24 h, followed by pressed husks soaked in water for 24 h (15.48 N) and busted husks soaked in water for 24 h (17.32 N), which were all at par. Highest detachment force (24.19 N) was observed in untreated husk soaked in water for 24 h. Mechanical treatments had statistically significant effect on detachment force required for separation of bunch of fibres at 5% LoS. So mechanical treatment was found to be effective in reduction of force required to detach bunch of fibres and hence total fibre separation. Chemical treatment of husk and interaction of mechanical and chemical treatments of husk were proved to be statistically non-significant on detachment force required for separation of bunch of fibre. As a corollary to the minimum detachment force observed in pressed husks, the maximum fibre recovery was obtained from pressed husks. This was attributed to weakening of bond between the shell and fibre due to pressing and resulted into minimum detachment force. Soaking in water or alkali swelled the husks by liquid absorption. The loosened fibres were easily pulled, thereby resulted in less detachment force. Although non-significant effect on detachment force, in general alkali treatment of husks lowered detachment force for bunch of fibre separation. This was due to the partial removal of lignin from fibre and shell.

3.4. Fibre tensile strength

Maximum fibre tensile strength is desirable for uses of fibres in reinforcement applications. Table 1 presents mean values of fibre strength observed due to the combined effect of mechanical and chemical treatments of husks. Maximum fibre strength of 36.85 N was observed in fibres from pressed husks soaked in 2.5% KOH for 24 h. It was observed that tensile strength of fibre varied between 32.47 and 36.85 N. These values can be compared with 0.22–9.25 N (Debnath, 1982), 19.06 N for VTL 3 - tk and 24.88 N for VTL 17 - tk (Anon., 1999) reported earlier for fibres of different arecanut varieties. The pre-treatments did not have significant effect on tensile strength. But fibres of 2.5% KOH soaked husks had higher tensile strength as compared to fibres of water soaked husks. Yusriah et al. (2014) reported that tensile strength of untreated fibres reduced from 128.79 to 30.73 MPa for dried arecanut husk fibres due to alkali treatment. Mohan Kumar (2008) reported that alkali treatment improved overall mechanical performance of fibre. Rajan et al. (2005) observed that increased tensile strength of biosoftened (microbial treated) fibres from 92.7 Nmm^{-2} for untreated fibres to 125.2 Nmm^{-2} for microbial treated fibres. Hence, there are contradictions in the past studies on effects of alkali treatment on fibres. In the present study husks were directly treated with solution of potassium hydroxide and the results are in general in agreement with the findings of Mohan Kumar (2008) for improvement of fibre tensile strength. Alkali treatment might have caused consolidation of lingo-cellulose matrix resulting into high resistance to break. Lignin was the component which imparted brittleness to the fibre. Partial removal of lignin caused other components of the fibres like cellulose to become more compact and thereby increased the strength and flexibility of the arecanut husk fibre (Rajan et al., 2005).

4. Conclusions

- Investigation was undertaken to evaluate mechanical and chemical pretreatments of arecanut husk for mass scale extraction of fibres from husks with their effect on husk and fibre characteristics.
- The experiments conducted resulted in development of mechanical and chemical pre-treatments suitable for mass extraction of fibres.
- Pressing of dried arecanut husks along with soaking resulted in maximising fibre recovery and hence strongly recommended for fibre extraction.
- Pressing of husks with 2.5% KOH alkali pretreatment of arecanut husks resulted in least detachment force required for separation of single fibre as well as bunch of fibres from husks.
- Fibre tensile strength was not significantly affected by any pretreatments (pressing, busting, alkali soaking) carried out on arecanut husks compared to control treatments (untreated, water soaking).
- Anticipated benefits of alkali treatment of husks for fibre separation were not observed. It is recommended to impart optional alkali treatment to fibres separately to change fibre properties.
- The information generated will be useful for design and development of suitable machinery for mass extraction of fibres from arecanut husks for enabling commercial exploitation.

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