ISSN. 0972 - 8406
The NEHU Journal Vol. XIX, No. 2 (July –December), 2021, pp. 55-65

Areca nut: Traditional processing, uses and products potential of the husk

Arigo R. W. Sangma and S. R. Joshi

Department of Biotechnology & Bioinformatics,
North-Eastern Hill University
Shillong 793 022, Meghalaya
Email: srjoshi2006@gmail.com

Abstract

*Areca nut (*Areca catechu *L.) belongs to the family Arecaceae. It is consumed in many parts of the world including India which is the largest producer in the world. Areca nut husk is considered as an agro-waste that can be used for obtaining different kinds of products. It contains compounds such as catechin, quercetin, phenolics, tannin and also has antimicrobial activity. The husk is used for enzyme production such as endoglucanase, manganese peroxidase and pectinase. It is also used for the production of xylose, ethanol and citric acid. Bio-adsorbent made from the husk can be used to remove different kinds of dye and chemicals such as brilliant green dye, methylene blue, phenol and* Pb^{2+}. *The present review is an effort to compile the available information on areca nut and its husks with respect to its uses as composite material, enzyme production, litter, compost, mushroom cultivation and in removal of dyes.*

Keywords: Areca nut, husks, enzymes, bioadsorbent, removal of waste.

Introduction

Areca nut (*Areca catechu* L.) belonging to the family Arecaceae is cultivated in 0.45 m ha in India with a production of 0.73 m tonnes in humid tropics and plains of South India, North-eastern region, and Andaman and Nicobar Islands (Anonymous, 2015). The plant is grown widely in North-eastern region. The fruit has a fibrous mesocarp, with endosperm deeply ruminated with a basal embryo. The husk constitutes about 60–80% of the total weight and volume of the fresh fruit. The husk fibre consisted of cellulose with different proportions of hemicellulose, lignin, pectin and protopectin (Ramachandra *et al*., 2004). Areca nut husk fibre contains 53.2% cellulose, 32.98% hemicellulose and 7.2% lignin (Hassan *et al*., 2010).

The North-eastern part of India is inhabited by ethnic tribes who are known to practise indigenous ways of livelihood. Their lifestyle is identified by distinct traditions and cultures among which consumption of areca nut along with betel leaf occupies an important place.

Traditional method of fermentation is an age-old practice in the region which not only enhances the taste and flavour of the processed products but also serves as a preservation strategy for foods, fruits, vegetables and meats. Along with foods and meats, the ethnic population is known to carry out fermentation of areca nut which is consumed locally. The areca nut are fermented for 3-5 months in soaking pits for enhancing the taste and flavour and also to preserve the nuts. In Assam, a pit of 2.5 feet is dug and leaflets of areca nut are placed surrounding the side and bottom of the pit. Some amount of cow dung is spread over it where the nuts are put, covered with jute bags along with some soil, and left for 3-4 months to ferment (Narzary *et al*., 2016). In Meghalaya, 6 to 8ft depth pits are constructed and the areca nuts are filled in bamboo baskets/gunny bags and soaked for 3-5 months for fermentation (Nandula, 2014). The fermentative process which involves decomposition and transformation of organic substrate goes through different phases: a mesophilic phase, characterized by the proliferation of the microbiota, a thermophilic phase with a high rate of biodegradation, the growth of thermophilic organisms and the inhibition of non- thermotolerant organisms, and the final phase that includes a period of cooling, stabilization and maturation, characterized by the growth of mesophilic organisms and humification of the compost (Ryckeboer *et al*., 2003). The time required for the maturation phase is a function of the substrate, environmental and operating conditions which can range from a few weeks to a year (Diaz *et al*., 2002). Apart from the traditional fermentation and consumption of areca nut, it holds great promise in its utilization for deriving different products from its husk.

Biological activity of areca nut

Antioxidant activities of extracts from areca (*Areca catechu* L.) flower, husk and seed was studied and was reported that the seed has the best antioxidant properties and the highest DPPH radical scavenging activity and reducing power (Zhang *et al.,* 2019).

An *in vitro* study was done on the effect of areca nut extracts (ANE) based on the bactericidal activity of crevicular polymorphonuclear neutrophils (cPMNs) in healthy subjects and chronic periodontitis (CP) patients by taking their gingival crevicular fluid (GCF) samples that were pre-treated with two varieties of areca nut extract: ripe and tender which revealed its potential activity. Hydrogen peroxide (H_2O_2) assays was also performed and a decrease in bactericidal activity and H_2O_2 production of cPMNs were reported in both healthy subjects and patients which implies that the areca nut influences the cPMNs, thus reducing their efficiency at eliminating bacteria from the periodontal environment (Shrivastava *et al.,* 2020).

Song *et al.* (2017) did a study on the identification of endophytic fungi from areca nut by using tissue block culture method and isolated 47 endophytic fungal strains from the root,

leaf and flower of areca nut. Naveenkumar *et al.* (2012) isolated lignolytic and phosphate solubilizing fungi from areca nut husk waste. Estimation of lignolytic and phosphate solubilzing efficiency of isolated fungi revealed the highest zone of clearance in lignolytic ability and phosphate solubilizing ability in *Gibberella fujikuroi* and *Aspergillus terreus* repectively.

Adsorbent

Girish and George (2017) used areca nut husk, an agricultural waste, as an adsorbent for removing phenol from wastewater by chemically treating it with phosphoric acid in a ratio 1:4 and it showed a promising adsorbent capacity of 25.746 mg/g. Dried areca nut / husks and luffa (*Luffa cylindrica*) sponge fibres were used as alternative and inexpensive natural matrices for microbial cell immobilization for the efficient degradation of hazardous organic compounds like phenol. The bacterial consortium were isolated by enriching a sludge sample from a petroleum refinery in high phenol concentrations and were immobilized on the lignocellulosic matrices and reported that the immobilized micro-organisms could be stored at 4°C for up to 6 weeks and could be reused for several successive batch degradation experiments up to 15 times (Bera and Mohanty, 2020). Baidya and Kumar (2021) used sodium hydroxide treated areca nut husk as a bioadsorbent to remove brilliant green dye from an aqueous solution where the adsorption process was strongly pH dependant and an optimum removal of 97% brilliant green dye was obtained at pH 7.0. The sodium hydroxide activation process where methylene blue was used in betel nut husk-based activated carbon showed a high adsorption capacity (Bardhan *et al*., 2020). In a study conducted by Ramesh *et al.* (2019), areca nut husk was used as an adsorbent, where the areca nut husk hydochar was used to remove Pb^{2+} since it showed maximum removal efficiency of 95.08% at 25 mg L^{-1} in the wastewaters.

According to a study done by Tabassum *et al.* (2020) betel nut husk used to produce activated hydrochar using sodium hydroxide (NaOH) was effectively used as an adsorbent for methylene blue adsorption. The adsorption efficiency improved over time, temperature, and pH. The thermodynamic data also revealed that the adsorption process was endothermic in character. The areca husk was pyrolyzed at 450°C for two hours to obtain biochar and their adsorption were investigated and found that the adsorption capacity increased with increase in initial iron concentration and contact time, but decreased with the adsorbent dosage (Subramani *et al.,* 2019). Akter *et al.* (2021) did a study on the pharmaceutical effluent for the reduction of COD from waste water using commercially activated carbon and areca nut husk treated activated carbon as adsorbents and found that areca nut husk treated activated carbon (ANHC) adsorbent can be used as a potentially low cost and environmental friendly adsorbent for the removal of organic

matter from pharmaceutical effluent.

Polymer composite

Studies have been carried out by alkali treatment using 5% sodium hydroxide on betel nut husk fibre and characterized for its chemical composition, tensile properties, morphology, and interfacial shear strength which showed higher Interfacial shear strength (IFSS) as compared to untreated BNH fibre due to the increase in fibre surface roughness and exposure of more reactive cellulose fibrils on BNH fibres surface due to alkali treatment (Lazim *et al.,* 2014). According to Yusriah *et al.* (2014), the physical, mechanical, thermal and morphological properties of betel nut husk fibre were investigated and it was found that the fibre length, diameter and density varied at each stage of the fibre maturity. Mechanical properties, the BNH fibre tensile properties were found to be comparable to coir and kenaf fibre.

Enzyme production

In a study by Sreena (2020), different kinds of agro-waste namely, areca nut husk, banana peduncle, jackfruit outer rind, pepper waste and tamarind husk were used as carbon source for producing endoglucanase enzyme. *Bacillus subtilis* treated areca nut husk gave the highest endoglucanase activity among different agro-waste. The endoglucanase production was enhanced by optimizing the medium via statistical method which led to an increase in endoglucanase activity. *Phanerochaete chrysosporium* and *Phanerochaete* sp. were used in solid state fermentation of manganese peroxidase (MnP) by using lignocellulosic biomass from areca nut husk as the substrate and the enzyme was partially purified by ammonium sulphate precipitation followed by ion exchange chromatography (Rajan *et al.,* 2010). In another study done by Nidhi *et al*. (2020), areca nut husk fibre was used as a substrate for the production of manganese peroxidase and was found to be effective by using *Fusarium* sp. in solid state fermentation. Narayanamurthy *et al.* (2008) in their study reported that when areca husk was used as a substrate for the production of citric acid under solid state fermentation (SSF) in the presence of 3% w/w methanol, it significantly increased the citric acid production by *Aspergillus niger*. Vardhan *et al.* (2020) studied the effect of acid and alkali pretreatment process on areca nut husk which showed that the areca husk fibre contained 29.17% hemicellulose which can be explored as a low-cost source of xylose. A study was conducted for the production of industrial fungal pectinase under submerged fermentation (SmF) by using efficient strains of fungal species from the areca nut husk waste. It was reported that out of 24 fungal strains, 20 strains showed the pectin degradation ability. Among them *Penicillium canescens* showed maximum pectinase activity and maximum exo–polygalacturonase activity was shown by *Rhizopus stolonifera* (Naveenkumar *et al.,* 2014).

Kumar *et al.* (2019) in their study found that using *Zymomonas mobilis* NCIM 2915 showed the maximum ethanol production after fermentation from areca nut husk by increasing the enzymatic hydrolysis and ethanol production through combinations of fungal pretreatment. Jackfruit seed and areca nut extracts were used to inhibit gut protease activity of *Spodoptera mauritia* as these proteinase inhibitors (PIs) inhibit the gut proteases of many insects. They reported that *Spodoptera mauritia* gut extract proteases cleaved casein and this proteolytic activity was inhibited by aqueous extracts of jackfruit seed and extract from areca nut up to 78% and 62 % respectively (Lakshmanan and Meethal, 2012).

Litter materials

Betel nut husks compared to rice hulls or dried leaves as litter material for broiler production on productive performance, carcass traits and internal organ characteristics was studied and it showed that the litter materials did not affect body weight gain, feed intake and feed conversion ratios during the experimental period (Azis *et al*., 2020). In Hunan province of China, the husk of *A. catechu* L. is being processed into commercially chewable stimulant named "Binglang". A quantitative analysis study of 5 alkaloids and 8 phenols in Binglang products was done for the first time and revealed the differences of contents of four areca alkaloids between the husk and seed products. Using traditionally unique processing methods of the raw husk for making binglang included roasting, steaming, boiling in water, and marinating in enzyme solution which lower the levels of areca alkaloids (Yuan *et al*., 2018).

Compost

Nagaraja *et al.* (2014) did a study on areca nut waste such as the husk, leaf and the leaf sheath for value added compost and found that the C/N ratio of areca nut husk was found to be very high initially but when treated and inoculated with *Phanerochaete chrysosporium* and *Pleurotous sajarcaju* showed significant reduction in C:N. Higher C:N ratios slow material decomposition, because low nitrogen limits microbial activity. Gurumurthy *et al.* (2018) also reported in their study by using areca nut husk and efficient microbial consortia consisting of cellulolytic and lignolytic fungi and by further enrichment with nitrogen fixer and phosphate solubilizing bacteria could result into production of nutrient enriched compost up to 90 days in areca nut husk residue. Vijayanand *et al.* (2016) used areca nut shell waste that was charred at different temperatures as biochar. The biochar prepared at higher temperature contains a higher proportion of the stable organic matter than that of lower temperatures. When the temperature was increased to a certain extend the stable organic matter yield was decreased and because of this biochar is more applicable for soil carbon sequestration.

Extraction and stability of pigment from areca nut

Han *et al.* (2010) reported in their study of the areca nut seeds used as raw material to extract a natural red pigment by organic solvent extraction, and the stability of the pigment obtained was evaluated. The results showed that the optimum extraction process of areca nut pigment was achieved by using 70% ethanol to extract areca nut seeds and the pigment had good stability under light illumination or acidic pH value, strong reduction resistance, but poor antioxidant capacity. Jose *et al.* (2018) in their study of antioxidant activities and free radical scavenging properties in mango leaves, husks of areca and coconut reported that all plant materials exhibited efficient free radical scavenging activity and the activity of areca husk was found to be relatively less. Analysis of phenolic compounds and immunomodulatory activity of areca nut extract was done against *Staphylococcus aureus* infection in Sprague-Dawley rats and found that areca nut extract could increase the number of WBCs and improve the activity and capacity of macrophages in rats infected with *S. aureus.* The antioxidant activity of areca nut might be attributed to the presence of catechin and quercetin (Sari *et al.,* 2020).

Quantitative determination of total phenolics and tannin in areca nut and its products reveal that the phenolic contents of dry unripe areca fruits were higher in betel nut than in unripe areca fruits and areca husk, and it was least in betel products (Zhang *et al.,* 2008). Tannin is obtained as a by-product from the process of preparing immature betel nuts for masticator purposes. It is being used for dyeing clothes, tanning leather, adhesive in ply board manufacture and as safe food colouring agent (TSS, 2018).

Antimicrobial properties

A study was done by Cyriac *et al.* (2012) on areca nut husk extracts on their antimicrobial properties against common oral pathogens like *Streptococcus mutans, Streptococcus salivarius, Streptococcus mitis, Lactobacillus acidophilus, Candida albicans, Prevotella intermedia* by agar well diffusion method and found that areca husk contains chemical components that has antifungal effect and would improve the oral health primarily through mechanical cleansing rather than antimicrobial activity. Anupama *et al.* (2021) studied the antimicrobial properties of areca nut against common bacterial pathogens viz., *Staphylococcus aureus* and *E.coli* and found that they were susceptible to the areca nut extract and 85-90% growth inhibition was reported. A study done on anthelmintic and antibacterial effects of extracts from Chinese honeysuckle seeds and areca nuts against ascarides, flukes, and *E. coli* strains showed that areca nut extracts were more effective against flukes and bacteria (Hai *et al.,* 2019). The activated carbon prepared from some biomasses were tested for its antibacterial capacity namely rubber wood, ramie fibre and areca nut husk against waterborne pathogen *Escherichia coli* and reported that areca husk

exhibited the highest killing effect of 43% when compared to other samples with different dosage concentrations (Das *et al.,* 2019).

Mushroom cultivation

A study was done on substrates for the cultivation of *Pleurotus ostreatus* on various substrates such as topsoil, areca nut husk, areca palm leaves, bamboo shoots, and its mixture with topsoil were used for cultivation and observed the highest mycelia growth in topsoil followed by areca nut husk (Sharmila *et al.,* 2015).

Conclusion

Consumption and use of areca nut are quite significant in the Northeast especially in Meghalaya. Certain varieties of the raw nut are put to fermentation for change of flavour and taste of the nut. This traditionally practiced process has not been studied and the diversity and dynamics of microbes prevalent during the process is still unreported. Meghalaya being the 5th highest producer of areca nut in India (Nandula, 2014) has a lot of potential make use of the agrowaste produced by betel nut. Thus, betel nut husk can be explored for producing different kinds of product which can be very useful as this agro-waste is not being utilized properly after processing of the areca nuts.

References

Akter, S., Sultana, F., Kabir, M. R., Brahma, P. P., Tasneem, A., Sarker, N. and Uddin, M. K. 2021. A comparative study of cod removal efficacy from pharmaceutical wastewater by areca nut husk produced and commercially available activated carbons. *Asian Journal of Environment and Ecology*, 14:47-56.

Anupama, M., Puspita, D. and Rajesh, K. 2021. Studies on antimicrobial properties of areca nut areca catechu. *Journal of Pharmacognosy and Phytochemistry*, 10(1): 961-963.

Azis, A., Zubaidah, Z. and Afriani, A. 2020. Betel nut husks as an alternative litter materials for broiler production. *International Journal of Poultry Science*, 19(2): 81-85.

Baidya, K. S. and Kumar, U. 2021. Adsorption of brilliant green dye from aqueous solution onto chemically modified areca nut husk. *South African Journal of Chemical Engineering,* 35: 33-43.

Bardhan, M., Novera, T. M., Tabassum, M., Islam, M. and Jawad, A. H. 2020. Adsorption of methylene blue onto betel nut husk-based activated carbon prepared by sodium hydroxide activation process. *Water Science and Technology*, 82(9): 1932-1949.

Bera, S. and Mohanty, K. 2020. Areca nut (*Areca catechu*) husks and luffa (*Luffa*

cylindrica) sponge as microbial immobilization matrices for efficient phenol degradation. *Journal of Water Process Engineering*, 33: 100999.

Cyriac, M. B., Pai, V., Varghese, I., Shantaram, M. and Jose, M. 2012. Antimicrobial properties of areca catechu (areca nut) husk extracts against common oral pathogens. *International Journal of Research in Ayurveda and Pharmacy*, 3(1): 81-8.

Diaz, L.F., Savage G.M. and Golueke, C.G. 2002. Composting of municipal solid wastes. In: Tchobanoglous G., Kreith F. (Eds.), *Handbook of Solid Waste Management.* McGraw-Hill Inc., New York, 12.1-70.

Das, J., Debnath, C., Nath, H. and Saxena, R. 2019. Antibacterial effect of activated carbons prepared from some biomasses available in North East India. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 1-11.

Girish, C. R. and George, G. M. 2017. Phenol removal from wastewater using areca nut husk (*Areca catechu*) as adsorbent. *International Journal of Mechanical Engineering and Technology*, 8(12): 1-9.

Gurumurthy, S. B., Patil, S. V., Shankarappa, T. H. and Prashantha, A. 2018. Bioconversion of areca nut husk: residue to compost via microbial consortia. *International Journal of Current Microbiology and Applied Science*, 7(8): 2883-2888.

Hai, N., Atsushi, M., Nguyen, H. T. T. and Nguyen, T. V. 2019. A study on anthelmintic and antibacterial effects of extracts from Chinese honeysuckle (*Quisqualis Indica* L) seeds and areca (*Areca catechu*) nuts. *Asian Journal of Pharmaceutical and Clinical Research*, 12(6): 88-92.

Han, L., Zhang, H. D., Wan, J., Jiang, L. J. and He, J. 2010. Extraction and stability of pigment from areca nut (*Areca catechu* L.) Seeds. *Food Science*, 4: 23-29.

Jose, M., Varghese, V. I., Jayakar, V., Lokapur, V., Srinivasa, K. and Shantaram, M. 2018. Evaluation of antioxidant activities and free radical scavenging properties in mango leaves, husks of areca and coconut. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 9(4): 1616.

Kumar, K. J. N., Thippeswamy, B. and Krishnappa, M. 2016. Bioethanol Fermentation from fungal pretreated lignocellulosic areca nut (*Areca catechu* L.) husk using yeasts and *zymomonas mobilis* NCIM 2915. *International Journal of Current Microbiology and Applied Sciences*, 5(10): 571-82.

Lakshmanan, A. P. and Meethal, K. V. 2012. Jackfruit seed and areca nut extracts inhibit gut protease activity of *Spodoptera mauritia* Boisd (Lepidoptera: Noctuidae). *Acta Biologica Indica*, 1(1): 129-131.

Lazim, Y., Salit, M. S., Zainudin, E. S., Mustapha, M. and Jawaid, M. 2014. Effect of

alkali treatment on the physical, mechanical, and morphological properties of waste betel nut (*Areca catechu*) husk fibre. *BioResources*, 9(4): 7721-7736.

Nagaraja, R., Gurumurthy, B. R. and Shivanna, M. B. 2014. Biosoftening of areca nut waste areca husk, leaf and leaf sheath for value-added compost. *International Journal of Research in Applied Natural and Social Sciences*, 2: 105-112.

Nandula, P. 2014. Areca nut subsector in Meghalaya: A review. Meghalaya Basin Development Authority (MBDA). A report, 16-17.

Narayanamurthy, G., Ramachandra, Y. L., Rai, P. S., Manohara, Y. N. and Kavitha, B. T. 2008. Areca husk: an inexpensive substrate for citric acid production by *Aspergillus niger* under solid-state fermentation. *Indian Journal of Biotechnology*, 7: 99-102.

Narzary, Y., Brahma, J., Brahma, C. and Das, S. 2016. A study on indigenous fermented foods and beverages of Kokrajhar, Assam, India. *Journal of Ethnic Foods*, 3(4): 284-291.

Naveenkumar, K. J., Thippeswamy, B. and Krishnappa, M. 2014. Production and partial purification of fungal pectinases from areca nut (*Areca catechu* L.) husk waste under submerged fermentation. *International Journal of Advanced Biotechnology and Research,* 5(2): 188-201.

Naveenkumar, K.J., Thippeswamy, B., Banakar, S.P., Thirumalesh, B.V. and Thippeswamy, B. 2012. Lignolytic and phosphate solubilizing efficiency of fungal species isolated from areca nut husk waste. *Journal of Research in Biology*, 2(1): 143-151.

Nidhi, K. V., Varsha, B. S., Prajwal, M., Sai, P. S. G., Ananda, H. V. and Prakruthi, G. 2020. A biotechnological approach on screening and production of manganese peroxidase by *Fusarium* sp. from areca nut husk. *European Journal of Pharmaceutical and Medical Research,* 7: 310-314.

Rajan, A., Kurup, J. G. and Abraham, T. E. 2010. Solid-state production of manganese peroxidases using areca nut husk as substrate. *Brazilian Archives of Biology and Technology*, 53(3): 555-562.

Ramachandra, T. V., Kamakshi, G. and Shruthi, B. V. 2004. Bioresource status in Karnataka. *Renewable and Sustainable Energy Reviews*, 8(1): 1-47.

Ramesh, S., Sundararaju, P., Banu, K. S. P., Karthikeyan, S., Doraiswamy, U. and Soundarapandian, K. 2019. Hydrothermal carbonization of areca nut husk biomass: fuel properties and sorption of metals. *Environmental Science and Pollution Research*, 26(4): 3751-3761.

Ryckeboer, J., Mergaert, J., Vaes, K., Klammer, S., DeClercq. D., Coosemans, J. and Swings, J. 2003. A survey of bacteria and fungi occurring during composting and

self-heating processes. *Annals of Microbiology*, 53(4): 349-410.

Sari, L. M., Hakim, R. F., Mubarak, Z. and Andriyanto, A. 2020. Analysis of phenolic compounds and immunomodulatory activity of areca nut extract from Aceh, Indonesia, against *Staphylococcus aureus* infection in Sprague-Dawley rats. *Veterinary World*, 13(1): 134.

Sharmila, S., Rebecca, J. L., Tissopi, T. and Kowsalya, E. 2015. Effect of substrates on the cultivation of *Pleurotus ostreatus* and its nutritional analysis. *Der Pharmacia Lettre*, 7(8): 193-196.

Shrivastava, D., Srivastava, K. C., Dayakara, J. K., Sghaireen, M. G., Gudipaneni, R. K., Al-Johani, K. and Khurshid, Z. 2020. Bactericidal activity of crevicular polymorphonuclear neutrophils in chronic periodontitis patients and healthy subjects under the influence of areca nut extract: an in vitro study. *Applied Sciences*, 10(14): 5008.

Song, W., Niu, X., Yu, F., Zhu, H., Tang, Q. and Qin, W. 2017. Isolation and preliminary identification of endophytic fungi from areca nut (*Areca catechu)*. *Acta Agriculturae Jiangxi*, 29(6): 66-74.

Sreena, C. P. 2020. Areca nut husk: A potential feedstock for enhanced production of endoglucanase by *Bacillus subtilis* MU S1. *Environmental Technology and Innovation*, 19, 100989.

Subramani, B. S., Shrihari, S., Manu, B. and Babunarayan, K. S. 2019. Evaluation of pyrolyzed areca husk as a potential adsorbent for the removal of Fe^{2+} ions from aqueous solutions. *Journal of Environmental Management*, 246: 345-354.

Tabassum, M., Bardhan, M., Novera, T. M., Islam, M. A., Jawad, A. H. and Islam, M. A. 2020. NaOH-activated betel nut husk hydrochar for efficient adsorption of methylene blue dye. *Water, Air, and Soil Pollution*, 231(8): 1-13.

The Totgars Co-operative Sale Society Limited, Sirsi (TSS) 2018. Uses of areca and its components. Retrived from https://www.tssindia.in/index.php/other1/about-areca nut-menu/uses-of-areca-and-components.

Vardhan, H., Mahato, R. B., Sasmal, S. and Mohanty, K. 2020. Production of xylose from pre-treated husk of areca nut. *Journal of Natural Fibers*, 7:1-14.

Vijayanand, C., Kamaraj, S., Sriramajayam, S. and Ramesh, D. 2016. Biochar production from areca nut waste. *International Journal of Farm Science,* 6(1): 43-48.

Yuan, H., Cao, M., Yi, P., Xie, Q., Jian, Y., Li B. and Wang, W. 2018. Determination of alkaloids and phenols in the chewable husk products of *Areca catechu* L. Using HPLC-UV and UHPLC-MS/MS. *Journal of Liquid Chromatography and Related*

Technologies, 41(10): 612-620.

Yusriah, L., Sapuan, S. M., Zainudin, E. S. and Mariatti, M. 2014. Characterization of physical, mechanical, thermal and morphological properties of agro-waste betel nut (*Areca catechu*) husk fibre. *Journal of Cleaner Production*, 72: 174-180.

Zhang, C. J., Lv, F. J., Tai, J. X., Wang, Z. N. and Fu, Q. 2008. Quantitative determination of total phenolics and tannin in areca nut and its products. *Food Research and Development*, 29(6): 119-121.

Zhang, W., Li, B., Han, L. and Zhang, H. 2009. Antioxidant activities of extracts from areca (*Areca catechu L.*) flower, husk and seed. *African Journal of Biotechnology*, 16:3887-3892.