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REVIEW ARTICLE

A REVIEW: POTENTIAL OF *DURIO ZIBETHINUS* L. (DURIAN) WASTE

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ABSTRACT

The fresh arils of durian fruits contained approximately one-third of the fruit's total weight; the remainder of the fruit, including the rinds and seeds, is considered waste. As a result, researchers investigated and studied the potential for these wastes to be processed into products or value-added products in various industries. This review aimed to discuss the potential for waste products of *D. zibethinus* to be converted into value-added products in a variety of areas. An extensive literature study was done on various search engines. Related previous research was selected for discovering the potential of *D. zibethinus* waste. This review found four fields of studies that gained interest in the invention of value-added products by using *D. zibethinus* waste, including activated carbon precursor, bio-composite product, bio-based polymer product, and bioethanol production. As Malaysia is growing in the food waste industry, more study needs to be done to successfully invent new value-added products from *D. zibethinus* waste such as rind and seed. The effort of this study could help in reducing unused *D. zibethinus* waste.

KEYWORDS

Durio zibethinus, Rind, Seed, Waste

1. INTRODUCTION

The world recognizes *Durio zibethinus* (Durian) as the King of Fruit. It is indigenous to Southeast Asian countries such as Malaysia, Indonesia, Thailand, and the Philippines. Thorny fruits, distinct and strong aroma and fresh arils of the fruits contribute to the popularity and high demand of *D. zibethinus* as a tropical fruit (Poerwanto et al., 2008; Raihana et al., 2015). Moreover, *D. zibethinus* fruits contain a high amount of carbohydrates, protein, and various fatty acids (Berry 1980; Leontowicz et al., 2011; Husin et al., 2018; Jennings 2019). Current research is focusing on the potentials of *D. zibethinus* in various fields of study by identifying various bioactive compounds of the fruits, which can be further explored for their potentials in pharmaceutical industries (Leontowicz et al., 2008; Toledo et al., 2008; Haruenkit et al., 2010; Charoenkiatkul et al., 2015; Adegoke et al., 2019).

The most intriguing studies on their medicinal properties have been those on their antioxidant contents, antimicrobial properties; antipyretic effects and therapeutic effects (Brown, 1997; Siriphanich, 2011; Ho and Bhat, 2015; Waay-Juico, et al., 2017; Suprianto et al., 2018; Chigurupati et al., 2017; Theapparat et al., 2018; Aruan et al., 2019; Evary et al., 2019; Kam et al., 2019; Adeniyi and Olatunji 2019). Most current modern research are started after gaining knowledge on indigenous people's culture. Indigenous people utilized *D. zibethinus* as part of their daily life in various applications as fever reduction fertility treatment as well as in pregnancy, and postpartum care (Husin et al., 2018; Jasamai et al., 2018; Sah et al., 2014; Sah et al., 2014; Husin et al., 2018; Ansari 2016; Syamsiah et al., 2016). Furthermore, some researchers identified the potential for *D. zibethinus* to be used in future medicine for illness prevention and enhanced food security (Shamin-Shazwan et al., 2021b; 2021c). However, more research is needed to confirm the benefits scientifically.

Thailand, Indonesia, and Malaysia are the top three exporters of *D. zibethinus* to the rest of the world, particularly China. Malaysia has been reported to be one of the best countries for producing high-quality durian fruits that are suited to consumers' taste buds (Teh et al., 2017; Neo, 2020). Durian is sold in the market as a paste or pulps in fresh or processed durian fruits, primarily for export purposes. In 2018, only 5.8 per cent of Malaysia's durian production (17,000 tonnes) was exported, with the remainder sold on the domestic market (Bloomberg 2019; Hasnan 2019). Due to the fact that Malaysia's durian production is geared toward the domestic market, the fruit's waste production will also increase significantly. Nowadays, research on fruits' functional properties is not only limited to their consumable components but also their residues or wastes.

Agricultural wastes comprise production and processing residues of raw agricultural products such as fruits, vegetables, meat, poultry, dairy products, and crops (Obi et al., 2016). Agricultural waste management (AWM) for ecological agriculture and sustainable production has recently piqued policymakers' interest (Hai and Tuyet, 2010). Additionally, waste management has become a critical issue for food industries, which process millions of tons of feedstock annually (Donato et al., 2011; Donato et al., 2014). Agricultural wastes can be a valuable resource for increasing food security; however, if not properly treated, maintained, or disposed of, they are likely to cause environmental pollution or even harm human health (Sabiiti, 2011). Hence, this review discussed several prospects and potentials for converting durian biomasses into value-added products in conjunction with the global effort to maximize fruit yield utilization to promote zero wastes.

2. INNOVATIONS OF *D. ZIBETHINUS* WASTES

Malaysia, the world's leading producer of durian, produced 377,251 tons in 2019 (Hirschmann, 2021). In Malaysia, durian varieties typically contained only approximately one-third edible fresh aril, with the

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remainder being inedible parts consisting of 67-70 per cent rinds and 20-25 per cent seeds (Amid and Mirhosseini, 2012; Ho and Bhat, 2015; Shamin-Shazwan et al., 2021a). This means that Malaysia has already produced 300,000 tons of durian biomasses in 2019. This concern is almost identical to that of Indonesia, where fruit waste totals 556,360 tons on average, owing to the fact that unutilized fruit parts accounted for up to 79 per cent of total fruits (Kusumaningtyas and Syah, 2020). *D. zibethinus* wastes (rinds and seeds) should be fully utilized in industries by extracting the goods from them; previous research demonstrated the presence of valuable phytochemical components from rind (Table 1) and seed (Table 2) that can be used as value-added products.

Table 1: Phytochemical Content of D. Zibethinus Rind

Component	Amount	References
Cellulose	30.00 – 57.00%	Unhasirikul et al., 2013; Aimi et al., 2014; Hirunpraditkoon et al., 2014; Lubis et al., 2018
Hemicellulose	13.00 – 22.00%	Unhasirikul et al., 2013; Aimi et al., 2014; Hirunpraditkoon et al., 2014; Lubis et al., 2018
Lignin	7.00 – 13.50 %	Charoenvai et al., 2011; Aimi et al., 2014; Hirunpraditkoon et al., 2014; Unhasirikul et al., 2013; Lubis et al., 2018; Obeng et al., 2018
Moisture content	3.00 – 14.00%	Unhasirikul et al., 2013; Hirunpraditkoon et al., 2014; Manshor et al., 2014; Masrol et al., 2015; Lubis et al., 2018
Protein	3.15%	Unhasirikul et al., 2013
Ash	4.00 – 5.50%	Charoenvai et al., 2011; Unhasirikul et al., 2013; Obeng et al., 2018
Fat	0.26%	Unhasirikul et al., 2013
Crude fiber	27.81%	Unhasirikul et al., 2013
Total carbohydrate	57.85%	Unhasirikul et al., 2013
Glucan	42.00 – 45.00%	Obeng et al., 2018
Xylan	12.00 – 13.00%	Obeng et al., 2018
Galactan	1.20 – 1.30%	Obeng et al., 2018
Arabinan	2.90 – 3.20%	Obeng et al., 2018
Pectin	6.00 – 9.00%	Wai et al., 2009

Table 2: Phytochemical Content of D. Zibethinus Seed

Component	Amount	References
Moisture Content	12.00 – 15.00%	Tongdang, 2008; Ginting et al., 2016; Ginting et al., 2017
Carbohydrate	81.00%	Ginting et al., 2016; Ginting et al., 2017
Protein	0.80 – 3.40 %	Tongdang, 2008; Srianta et al., 2012; Ginting et al., 2016; Ginting et al., 2017
Ash	0.13 – 1.58%	Tongdang, 2008; Srianta et al., 2012; Ginting et al., 2016; Ginting et al., 2017
Fat	0.07%	Ginting et al., 2016; Ginting et al., 2017
Starch	10.00 – 20.00%	Tongdang, 2008; Ginting et al., 2016; Ginting et al., 2017
Amylose	22.00 – 24.00%	Ginting et al., 2016; Ginting et al., 2017
Amylopectin	54.00%	Ginting et al., 2016; Ginting et al., 2017

According to the tables above, it evidenced that more research was conducted on rinds than seeds. The rinds have been studied either on fresh rind samples or processed samples (flour). The research interest on rinds is primarily focused on two aspects: high cellulose and hemicellulose contents and the presence of activated carbon. Several intriguing efforts to develop value-added products from durian wastes are underway, including (1) activated carbon, (2) bio-composite, (3) bio-based polymer, and (4) bioethanol.

2.1 Potentials in Activated Carbon Productions

Activated carbon is widely used in various industrial sectors for the adsorption of gaseous and liquid pollutants, including pharmaceutical, petroleum, mining, nuclear, automobile, and vacuum manufacturing (Chandra et al., 2009). It is an amorphous carbonaceous material with high surface porosity and a large surface area of more than 800 m^2/g, as well as a high chemical inertness (Liew et al., 2018). As a result of large pore properties in durian biomass, *D. zibethinus* biomass may be used as a new alternative activated carbon source as in Figure 1 (Chandra et al., 2009). Additionally, researchers make a novel effort to reduce the cost of adsorbent production by utilizing whole fruit wastes. Another study examines the use of *Tamarindus indica* L. (tamarind) seeds as an activated carbon precursor for the absorption of heavy metals from industrial wastewater (Mopoung et al., 2015). A group researcher discovered that activated carbon derived from *T. indica* seeds could efficiently absorb Fe (III) and absorb in an alkaline solution (Mopoung et al., 2015).

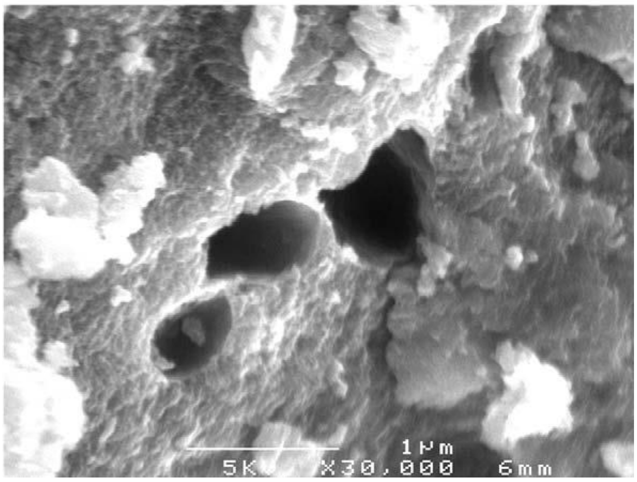

Figure 1: Surface Morphology of Activated Carbon from Durian Biomass (Chandra et al., 2009).

Due to the presence of cellulose, hemicellulose, and lignin, *D. zibethinus* rinds and seeds have been identified as a new promising alternative for activated carbon precursors by previous researcher (Foo and Hameed, 2012a, b; Hirunpraditkoon et al., 2014; Ngabura et al., 2018b; Lestari et al., 2019). Additionally, several studies on *D. zibethinus* biomass have been conducted to determine its suitability as an alternative physical or chemical adsorbent for air pollution, oil removal for water treatment, wastewater treatment, and hazardous dyes removal from aqueous solutions such as (Yahya et al., 2015; Wang et al., 2017; Kusrini et al., 2019; Tham et al., 2011; Husin et al., 2012; Hameed and Hakimi, 2008; Adam et al., 2012; Mohammed et al., 2012; Ahmad et al., 2014; Ahmad et al., 2015; Pimpa and Pimpa, 2014; Anisuzzaman et al., 2015). Besides the relatively high cellulose, hemicellulose, and lignin levels in the rinds, as shown in Table 1, discovered another application of activated carbon derived from *D. zibethinus* rinds: a high-quality bio briquette (Saudah et al., 2019). They proposed using durian rinds as an alternative fuel source for briquette production by incorporating charcoal durian rinds into janeng flour. The application of janeng flour is also beneficial for this endeavor, as the flour is readily available at a low cost.

The presence of cellulose has become a significant advantage for *D. zibethinus* in terms of potentials as bio briquette and biosorption materials. The biosorption capacity of fruit waste for removing heavy metals has been investigated using the metal bonds in biological materials technique. This is a novel method for removing heavy metals from aqueous effluents (Lestari et al., 2019). The biosorption capacity of *D. zibethinus* rinds has been evaluated for its potential as a bio sorbent for heavy metals such as Zn (II), iron, Pb (II), gold; Au (III), cadmium; Cd (II) and chromium; Cr (VI) (Kurniawan et al., 2011; Wai et al., 2010; Lestari et al., 2015; Ngabura et al., 2018a; Lestari et al., 2019; Firdaus et al., 2018; Abidin et al. 2011; Saikaew and Kaewsarn, 2009).

However, additional research is required to exploit the bio sorbent potential of *D. zibethinus* fully. Fruit biomass is frequently used to create value-added products in this era of advanced technology. For example, successfully produced enhanced microwave absorbers from jackfruit carbon biomass incorporated with nickel hydroxide (Guan et al., 2018). A new alternative absorber produced from fruit biomass has been developed; it is renewable, easy to mass-produce, and has a straightforward fabrication method. One of the difficulties associated with utilizing durian biomass is the presence of polysaccharides (such as pectin) that are soluble in water and difficult to separate from aqueous solution (Mirhosseini et al., 2010). A group researchers first discovered that modified durian rind pectin improved heavy metal absorption and potentially be developed into new nutraceutical products (Wong et al., 2008). A group researchers successfully extracted the Ca-alginate immobilized durian seed gel, overcoming the solubility issue of polysaccharides gum (Lestari et al., 2019). They immobilized durian seeds in order to use them in industrial applications, and they evaluated durian seed's bio sorbent potential for absorbing Zn (II) in a solution.

2.2 Potentials in Bio-Composite Productions

Bio-composite is a general term that refers to composite materials produced from biological raw materials such as plant fibers, recycled wood, or by-products of food crops (Ilyas and Sapuan, 2020). The concept of incorporating *D. zibethinus* rinds into bio-composite products stems from the global effort to reduce fruit biomass. This can be done by converting undesirable plant parts into value-added products. Moreover, *D. zibethinus* has high fiber content, implying that it can be extracted and processed into a filler and integrated into a polymer matrix to increase the strength and stiffness of the composite while using a lesser required polymer (Lee et al., 2018; Gowman et al., 2019).

Cellulose fibers are frequently used as reinforcement to improve the mechanical properties of bio-composites. A group researchers obtained data on the physical and chemical properties, as well as the thermal stability of *D. zibethinus* rind fiber, indicating that it may be one of the best raw materials for textile production (Lubis et al., 2018). Recent research has also piqued interest in the *D. zibethinus* rinds, as it has a cellulose content that is almost identical to that of oil palm, kenaf, and banana (Lubis et al., 2018; Sembiring et al., 2018). Despite the fact that research on the characterization of bio-composite properties from *D. zibethinus* has been conducted, new bio-composite products from *D. zibethinus* are still lacking. A research group at the International Islamic University Malaysia recently developed a biodegradable food container and 3-D printing filament from durian skins. However, additional research is needed to improve the bio-composite materials used in this product and lower its manufacturing costs (International Islamic University Malaysia 2020). Additionally, the bio-composite from *D. zibethinus* can be used to manufacture a variety of other products, including (1) replacing synthetic fibers, which significantly reduces the carbon footprint, (2) application on construction sites for load-bearing parts and glass fiber composites, and (3) medical devices and implants (Campilho, 2017).

2.3 Potentials in Biobased Polymer Productions

Nowadays, the world is concerned about food packaging waste, such as waste bags, food packaging, and agricultural mulch films, which created an environment where toxic plasticizers had a negative impact on the environment (Ilyas and Sapuan, 2020). As a result, bio-based polymer production has emerged as a viable alternative to synthetic materials used in the manufacture of food packaging. Biopolymer and bioplastic are bio-based polymers that have been extensively researched for years due to their biodegradability and biocompatibility (Kosseva et al., 2020).

In general, a biopolymer is a polymer produced by combining several repeating units containing carbon used in or originate from living organisms. Fruit biomass application in *D. zibethinus* may also be a viable alternative for biopolymer production, thereby increasing the value of agricultural biomass waste. Previous research by indicated that the high cellulose content and high tensile strength of *D. zibethinus* rinds could be converted into a new biopolymer (Pimpa et al., 2012; Rachtanapun et al., 2012; Suriyatem et al., 2019). This could be achieved by adding a film-forming agent, binding agent, sustained release agent, and gelling agent, as well as a metal absorber during the manufacturing process. For instance, recently applied *D. zibethinus* cellulose to an unstable existing rice-starch (RS)-film (Suriyatem et al., 2019). Their research discovered that a high amount of carboxymethyl cellulose (CMC) and tensile strength extracted from *D. zibethinus* rind improves the properties of RS-films for use in a variety of industries including postharvest coating, packing, and pharmaceuticals. Some researchers investigated the addition of CMC from other plant species to starch film and observed a positive effect on the film's physical and mechanical properties (Ghanbarzadeh et al., 2010).

Bioplastic is biodegradable plastic derived from sustainable materials derived from natural sources. It has gained considerable interest in recent years due to its capacity to reduce synthetic plastic waste harmful to the environment. Starch is the primary component required for the manufacture of bioplastics. *D. zibethinus* seeds (Table 2), which contain between 10% and 20% starch, should be investigated for their potential use as a bioplastic substitute. Handayani and Wijayanti transformed *D. zibethinus* seeds into bioplastic products (Wijayanti, 2015). They concluded that seeds could serve as an excellent raw material for producing biodegradable plastic, which would help the world meet its goal of reducing its reliance on synthetic plastic. It is stated that bioplastic derived from *D. zibethinus* seeds can degrade in as little as 15 days and has been proven to be environmentally friendly. Bioplastic production is not limited to *D. zibethinus* biomass alone; successfully improved the mechanical properties of bioplastic products from cocoa pod husk by extracting jackfruit seed starch combined with microcrystalline cellulose from cocoa pod husk (Lubis et al., 2017).

2.4 Potentials in Bioethanol Productions

Biofuel (such as biodiesel and bioethanol) has been a popular topic of discussion for years to replace fossil fuels. Agricultural biomass could be manufactured for use as a biofuel source; not only plant-based biomass has demonstrated its utility in a variety of industries due to its low cost, ease of acquisition, and ability to mitigate adverse environmental impacts. Each country's primary source of raw materials for bioethanol production is unique, such as wine surplus (France), sugar cane (Brazil), and wheat, sugar beet, and corn (the United States and European Union) (Bušić et al., 2018). A group researchers classified raw materials for bioethanol production into three categories: sugar-containing raw materials, starch-containing feedstock, and lignocellulosic biomass (Bušić et al., 2018). By referring to Tables 1 and 2, *D. zibethinus* biomass can be classified as category 2 or 3. Previous research has demonstrated that a significant amount of carbohydrates, cellulose, and starch can be obtained from the rinds and seeds of *D. zibethinus*.

In Thailand, research has established that the rinds of *D. zibethinus* can be a good source of sugar for ethanol production as an alternative to reducing environmental issues (Unhasirikul et al., 2013). This research was supported by other studies reporting on an alternative method for producing fuel from the rind of *D. zibethinus* and bioethanol production (O'Gara et al., 2004; Purnomo et al., 2016; Obeng et al., 2018). The research on raw materials and innovation in plant-based biomass for bioethanol production is not limited to *D. zibethinus*. There are studies of this kind on other plants' biomasses such as oil palm (kernel shell, frond, trunk, empty fruit bunch, mesocarp fibre, palm oil mill effluent), paddy (husk, straw), pineapple (leaf crown, fruit peel), and banana (pseudo stem, peels, and spoiled fruits) are also being investigated (Aditiya et al., 2016). Thus, it is established that research on bioethanol production has been conducted extensively using various plant species. Future research on the potential of *D. zibethinus* as a material for bioethanol production should be conducted by comparing optimizations performed on other plants.

3. Conclusion

According to this review, *D. zibethinus* has demonstrated significant potentials in a variety of biomass innovation applications. Durian biomass has been found to be capable of being developed into value-added products such as activated carbon materials, bio-composite, biopolymer, bioplastic, and bioethanol production. However, small-scale recycling cannot keep up with the volume of agricultural waste generated daily in the current agronomic process. In accordance with sustainable development goals aimed at environmental protection, numerous stakeholders, including government agencies, the private sector, and research institutions, should take additional action to improve agriculture waste management. Thus, comprehensive studies on the potentials of durian fruit waste as a high-value product should be expanded. Numerous researchers have recently reported and documented the value of durian fruit waste. However, there are still numerous aspects to explore and investigate in order to minimize fruit waste and conserve nature for future generations. As a result, the findings from this study may provide valuable information and findings for future research.

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References

Abidin, M.A.Z., Jalil, A.A., Triwahyono, S., Adam, S.H., Kamarudin, N.H.N., 2011. Recovery of gold(III) from an aqueous solution onto a *Durio zibethinus* husk. Biochem Eng J., 54, Pp. 124-131.

Adam, S.H., Jalil, A.A., Triwahyono, S., 2012. Novel removal of water-insoluble dispers dye onto a low-cost adsorbent prepared from tropical fruit waste. Desalin Water Treat., 40 (1-3), Pp. 337-347.

Adegoke, A.S., Jerry, O.V., Ademola, O.G., 2019. GC-MS analysis of phytochemical constituents in methanol extract of wood bark from *Durio zibethinus* Murr. Int. J., Med. Plants Nat., 5 (3), Pp. 1-11.

Adeniyi, S.A., Olatunji, G.A., 2019. Evaluation of macro and micro elements in *Durio zibethinus* Murr and their biological roles on human physiology. Glob. Sci., J., 7 (10), Pp. 1114-1122.

Aditiya, H.B., Chong, W.T., Mahlia, T.M.I., Sebayang, A.H., Berawi, M.A., Nur, H., 2016. Second generation bioethanol potential from selected malaysia's biodiversity biomasses: A review. Waste Manag., 47, Pp. 46-61. http://dx.doi.org/10.1016/j.wasman.2015.07.031

Ahmad, M.A., Ahmad, N., Bello, O.S., 2014. Adsorptive removal of malachite green dye using durian seed-based activated carbon. Water Air Soil Pollut., 225 (2057), Pp. 1-18. 10.1007/s11270-014-2057-z

Ahmad, M.A., Ahmad, N., Bello, O.S., 2015. Adsorption kinetic studies for the removal of synthetic dye using durian seed activated carbon. J. Dispers Sci. Technol., 36 (5), Pp. 670-684. 10.1080/01932691.2014.913983

Aimi, N.N., Anuar, H., Manshor, M.R., Nazri, W.B., Sapuan, S.M., 2014. Optimizing the parameters in durian skin fiber reinforced polypropylene composites by response surface methodology. Ind. Crops Prod., 54, Pp. 291-295.

Amid, B.T., Mirhosseini, H., 2012. Optimization of aqueous extraction of gum from durian (*Durio zibethinus*) seed: A potential, low cost source of hydrocolloid. Food Chem., 132, Pp. 1258-1268.

Anisuzzaman, S.M., Joseph, C.G., Krishnaiah, D., Bono, A., Ooi, L.C., 2015. Parametric and adsorption kinetic studies of methylene blue removal from simulated textile water using durian (*Durio zibethinus* Murray) skin. Water Sci. Technol., 72 (6), Pp. 896-907.

Ansari, R., 2016. Potential use of durian fruit (*Durio zibenthinus* Linn) as an adjunct to treat infertility in polycystic ovarian syndrome. J. Integr Med., 14, Pp. 22-28.

Aruan, D.G.R., Barus, T., Haro, G., Simanjuntak, P., 2019. Toxicity and antioxidant activities of extract of N-Hexane, H2o, and ethyl acetate from the leaves of durian. *Durio zibethinus* L, Rasayan J. Chem., 12 (2), Pp. 947-950.

Berry, S.K., 1980. Cyclopropene fatty acids in some Malaysian edible seeds and nuts: I. durian (*Durio zibethinus* Murr.). J. Lipids., 15, Pp. 452-455.

Bloomberg. 2019. Malaysian durian sales may spike on china's nod to thorny fruit. In: The Star Online. https://www.thestar.com.my/business/business-news/2019/06/03/malaysian-durian-sales-may-spike-on-chinas-nod-to-thorny-fruit/. Accessed 1 October 2021

Brown, M.J., 1997. Durian – A bibliographic review. International Plant Genetic Resources Institute.

Bušić, A., Marđetko, N., Kundas, S., Morzak, G., Belskaya, H., Šantek, M.I., Komes, D., Novak, S., Šantek, B., 2018. Bioethanol production from renewable raw materials and its separation and purification: A review. Food Technol Biotechnol, 56 (3), Pp. 289-311.

Campilho, R., 2017. Recent innovations in biocomposite products. In: Ray D (ed.) Biocomposites for High-Performance Applications, Woodhead Publishing, United Kingdom, Pp. 275-306.

Chandra, T.C., Mirna, M.M., Sunarso, J., Sudaryanto, Y., Ismadji, S., 2009. Activated carbon from durian shell: Preparation and characterization. J. Taiwan Inst. Chem. Eng., 40, Pp. 457-462.

Charoenkiatkul, S., Thiyajai, P., Judprasong, K., 2015. Nutrients and bioactive compounds in popular and indigenous durian (*Durio zibethinus* Murr.). Food Chem, 193, Pp. 181-186.

Charoenvai, S., Khedari, J., Hirunlabh, J., Asasutjarit, C., 2011. Development of durian fiber-based composite material, The Second TSME International Conference on Mechanical Engineering.

Chigurupati, S.E., Mohammad, J.I., Vijayabalan, S., Vaipuri, N.D., Selvarajan, K.K., Nemala, A.R., 2017. Quantitative estimation and antimicrobial potential of ethanol extract of *Durio zibethinus* Murr. Leaves. Asian J. Pharm. Clin. Res., 10 (9), Pp. 251-254.

Donato, P.D., Finore, I., Anzelmo, G., Lama, L., Nicolaus, B., Poli, A., 2014. Biomasss and biopolymer production using vegetable wastes as cheap substrates for extremophiles. Chem. Eng. Trans., 38, Pp. 163-168.

Donato, P.D., Fiorentino, G., Anzelmo, G., Tommonaro, G., Nicolaus, B., Poli, A., 2011. Re-use of vegetable wastes as cheap substrates for extremophile biomass production. Waste Biomass Valorization, 2, Pp. 103-111.

Evary, Y.M., Nugroho, A.E., Pramono, S., 2019. Comparative study on DPPH free radical scavenging and alpha-glucosidase inhibitory activities of ethanolic extracts from different parts of durian plant (*Durio zibethinus* Murr.). Food Res., 3 (5), Pp. 463-468.

Firdaus, F.E., Redella, A., Nursabila, S., 2018. The effectiveness biosorption of durian (*Durio zibhetinus*) rind pectin on handling liquid waste containing heavy metal (Pb II). MATEC Web of Conference, 248, Pp. 04003.

Foo, K.Y., Hameed, B.H., 2012a. A cost effective method for regeneration of durian shell and jackfruit peel activated carbons by microwave irridiation. Chem. Eng., 193-194, Pp. 404-409.

Foo, K.Y., Hameed, B.H., 2012b. Textural porosity, surface chemistry and adsorptive properties of durian shell derived activated carbon prepared by microwave assisted NaOH activation. Chem. Eng., 187, Pp. 53-62.

Ghanbarzadeh, B., Almasi, H., Entezami, A.A., 2010. Physical properties of edible modified starch/carboxymethyl cellulose films. Innov. Food Sci. Emerg. Technol., 11, Pp. 697–702.

Ginting, M.H.S., Hasibuan, R., Lubis, M., Tanjung, D.S., Iqbal, N., 2017. Effect of hydrochloric acid concentration as chitosan solvent on mechanical properties of bioplastics from durian seed starch (*Durio Zibethinus*) with filler chitosan and plasticizer sorbitol. IOP Conf. Series: Materials Science and Engineering, 180, Pp. 012126.

Ginting, M.H.S., Kristiani, M., Amelia Y., Hasibuan, R., 2016. The effect of chitosan, sorbitol, and heating temperature bioplastic solution on mechanical properties of bioplastic from durian seed starch (*Durio zibehinus*). Int. J. Eng., 6 (1), Pp. 33-38.

Gowman, A.C., Picard, M.C., Lim, L., Misra, M., Mohanty, A.K., 2019. Fruit waste valorization for biodegradable biocomposite applications: A review. BioResources, 14 (4), Pp. 10047-10092.

Guan, H., Wang, H., Zhang, Y., Dong, C., Chen, G., Wang, Y., Xie, J., 2018. Microwave absorption performance of $Ni(OH)_2$ decorating biomass carbon composites from jackfruit peel. Appl. Surf., Sci. 447, Pp. 261-268.

Hai, H.T., Tuyet, N.T.A., 2010. Benefits of the 3R approach for agricultural waste management (AWM) in Vietnam: Under the Framework of joint Project on Asia Resource Circulation Policy Research Working Paper Series. Institute for Global Environmental Strategies supported by the Ministry of Environment, Japan.

Hameed, B.H., Hakimi, H., 2008. Utilization of durian (*Durio zibethinus* Murray) peel as low cost sorbent for the removal of acid dye from aqueous solutions. Biochem. Eng. J., 39, Pp. 338-343.

Handayani, P.A., Wijayanti, H., 2015. Pembuatan film plastik biodegradable dari limbah biji durian (*Durio zibethinus* Murr). Jurnal Badan Alam Terbarukan, 4 (1), Pp. 21-26.

Haruenkit, R., Poovarodom, S., Vearasilp, S., Namiesnik, J., Sliwka-Kaszynska, M., Park, Y., Heo, B., Cho, J., Jang, H.G., Gorinstein, S., 2010. Comparison of bioactive compounds, antioxidant and antiproliferative activities of mon thong durian during ripening. Food Chem., 118, Pp. 540-547.

Hasnan, L., 2019. Durian: The New Gold. The ASEAN Post.

Hirschmann, R., 2021. Production volume of durians in Malaysia from 2013 to 2020. https://www.statista.com/statistics/1000876/malaysia-durian-production/. Accessed 31st December 2020.

Hirunpraditkoon, S., Intharit, S., Srisumran, S., Wongvirojtana, P., 2014. Combustion properties of briquette charcoal from durian peel. Appl. Mech. Mater., 666, Pp. 41-45.

Ho, L.H., Bhat, R., 2015. Exploring the potential nutraceutical values of durian (*Durio zibethinus* L.) – An exotic tropical fruit. Food Chem., 168, Pp. 80-89.

Husin, N.A., Rahman, S., Karunakaran, R., Bhore, S.J., 2018. A review on the nutritional, medicinal, molecular and genome attributes of durian (*Durio zibethinus* L.), the King of fruits in Malaysia. Bioinformation, 14 (6), Pp. 265-270.

Husin, N.I., Boudville, R., Hussain, N.H., 2012. Durian (*Durio zibethinus* L.) shell and banana pseudostem fibers: Microsorbent for the removal of oil from aqueous solution. IEEE Symposium on Humanities, Science and Engineering Research, Pp. 71-76.

Ilyas, R.A., Sapuan, S.M., 2020. Biopolymers and biocomposites: Chemistry and technology. Curr. Anal. Chem., 16, Pp. 1-4.

International Islamic University Malaysia. 2020. Durian skin biocomposite for take-out containers and 3-D printing. https://phys.org/news/2020-01-durian-skin-biocomposite-take-out-d.html. Accessed 5 April 2020.

Jennings, K., 2019. Durian fruit: Smelly but incredibly nutritious. Healthline. 31 May 2019. https://www.healthline.com/nutrition/durian-fruit. Accessed 15 November 2019.

Kam, W.J., Abas, F., Hussain, N., Mirhosseini, H., 2019. Comparison of crude extract from *Durio zibethinus* M. (Durian) leaf waste via ultrasound-assisted extraction and accelerated solvent extraction: Antioxidant activity and cytotoxicity. Nat. Prod. Res., 34 (13), Pp. 1937-1941.

Kosseva, M.R., Zhong, S., Li, M., Zhang, J., Tjutju, N.A.S., 2020. Chapter 11-Biopolymers produced from food wastes: a case study on biosynthesis of bacterial cellulose from fruit juices. In Kosseva MR and Webb C (eds.), Food Industry Wastes. 2nd edition: Academic Press. Pp. 225-254.

Kurniawan, A., Sisnandy, V.O.A., Trilestari, K., Sunarso, J., Indraswati, N., Ismadji, S., 2011. performance of durian shell waste as high capacity biosorbent for Cr(VI) removal from synthetic wastewater. Ecol Eng., 37, PP. 940-947.

Kusrini, E., Usman, A., Sani, F.A., Wilson, L.D., Abdullah, M.A.A., 2019. simultaneous adsorption of lanthanum and yttrium from aqueous solution by durian rind biosorbent. Environ Monit Assess, 191 (488), Pp. 1-8.

Kusumaningtyas, R.D., Syah, A.F.A., 2020. Conversion of durian shell agroindustrial waste into various valuable products to support the food security during the Covid-19 new normal era. Review, 13 (2), Pp. 111-117.

Lee, M.C., Koay, S.C., Chan, M.Y., Pang, M.M., Chou, P.M., Tsai, K.Y., 2018. Preparation and characterization of durian husk fiber filled polylactic acid biocomposites. MATEC Web of Conferences, 152, Pp. 02007.

Leontowicz, H., Leontowicz, M., Haruenkit, R., Poovarodom, S., Jastrzebski, Z., Drzewiecki, J., Ayala, A.L.M., Jesion, I., Trakhtenberg, S., Gorinstein, S., 2008. Durian (*Durio zibethinus* Murr.) cultivars as nutritional supplementation to rat's diets. Food and Chem. Toxicol., 46, Pp. 581-589.

Leontowiez, H., Leontowicz, M., Jesion, I., Bielecki, W., Poovarodom, S., Veorasilp, S., Gonzalez-Aguilar, G., Robles-Sanchez, M., Trakhtenberg., S., and Gorinstein, S., 2011. Positive effects of durian fruit at different stages of ripening on the hearts and livers of rats' fat diets high in cholesterol. Eur. J. Integr. Med., 3, Pp. 169-181.

Lestari, I., Kurniawati, D., Zein, R., and Aziz, H., 2019. Biosorption of Zn (II) Metal Ion by Ca-Alginate Immobilized durian (*Durio zibethinus*) seed. J. Chem. Nat. Resour., 1 (2), Pp. 60-68.

Lestari, I., Sy, S., Harmiwati, Kurniawati, D., Alif, A., Munaf, E., Zein, R., Aziz, H., 2015. Equilibrium and kinetics modeling biosoption of Zn(II) in aqueous solution using durian (*Durio zibethinus*) seed as low-cost biosorbent. J. Chem. Pharm., 7 (9S), Pp. 111-122.

Liew, R.K., Chong, M.Y., Osazuwa, O.U., Nam, W.L., Phang, X.Y., Su, M.H., Cheng, C.K., Chong, C.T., Lam, S.S., 2018. Production of activated carbon as catalyst support by microwave pyrolysis of palm kernel shell: A comparative study of chemical versus physical activation. Res. Chem Intermed., 44 (6), Pp. 3849-3865.

Lubis, M., Gana, A., Maysarah, S., Ginting, M.H.S., Harahap, M.B., 2017. Production of bioplastic from jackfruit seed starch (*Artocarpus heterophyllus*) reinforced with microcrystalline cellulose from cocoa pod husk (*Theobroma cacao* L.) using glycerol as plasticizer. IOP Conf. Series: Materials Science and Engineering, 309 (1), Pp. 012100.

Lubis, R., Sarapig, S.W., Wirjosentono, B., Eddyanto, E., 2018. Characterization of durian rinds fiber (*Durio zibethinus*, murr) from North Sumatera. AIP Conference Proceedings, 2049 (1), Pp. 020069.

Manshor, M.R., Anuar, H., Aimi, M.N.N., Fitrie, M.I.A., Nazri, W.B.W., Sapuan, S.M., El-Shekeil, Y.A., Wahit, M.U., 2014. Mechanical, thermal and morphological properties of durian skin fibre reinforced PLA biocomposites. Mater Des., 59, Pp. 279-286.

Masrol, S.R., Ibrahim, M.H.I., Adnan, S., 2015. Chemi-mechanical pulping of durian rinds. Procedia Manuf., 2, Pp. 171-180.

Mirhosseini, H., Tan, C.P., Naghshineh, M., 2010. Influence of pectin and CMC content on physicochemical properties of orange beverage emulsion. J. Food Agric. Environ., 8 (2), Pp. 134-139.

Mohammed, S.A., Najib, N.W.A.Z., Muniandi, V., 2012. Durian rind as a low cost adsorbent. Int. J. Civ. Environ. Eng., 12 (4), Pp. 51-56.

Mopoung, S., Moonsri, P., Palas ,W., and Khumpai, S., 2015. Characterization and properties of activated carbon prepared from tamarind seeds by KOH activation for Fe(III) adsorption from aqueous solution. Sci. World. J., (1), Pp. 1-9.

Neo, P., 2020. King of Imports: China's durian market continues to be top target for exporting countries. William Reed Business Media Ltd. https://www.foodnavigator-asia.com/Article/2020/02/01/King-of-imports-China-s-durian-market-continues-to-be-top-target-for-exporting-countries. Accessed 5 April 2020.

Ngabura, M., Hussain, S.A., Ghani, W.A.W.A., Jami, M.S., Tan, Y.P., 2018a. Utilization of renewable durian peels for biosorption of zinc from wastewater. J. Environ. Chem. Eng., 6 (2), Pp. 1-48.

Ngabura, M., Hussain, S.A., Ghani, W.A.W.A., Jami, M.S., and Tan, Y.P., 2018b. Optimization and activation of renewable durian husk for biosorption of lead (II) from an aqueous medium. J Chem Technol Biotechnol., 94 (5), Pp. 1-50.

O'Gara, E., Guest, D.I., Hassan, N.M., 2004. Botany and production of durian (*Durio zibethinus*) in Southeast Asia., in Diversity and Management of *Phytophthora* in Southeast Asia, Drenth A. and Guest D.I., Editors. ACIAR Monograph: Canberra, Australia. Pp. 180-186.

Obeng, A.K., Premjet, D., Premjet, S., 2018. Fermentable sugar production from the peels of two durian (*Durio zibethinus* Murr.) cultivars by phosphoric acid treatment. Resources, 7 (60), Pp. 1-15.

Obi, F.O., Ugwuishiwu, B.O., Nwakaire, J.N., 2016. Agricultural waste concept, generation, utilization and management. Niger J. Technol., 35 (4), Pp. 957 – 964.

Pimpa, W., Pimpa, C., 2014. Characterization of durian seed starch/pvoh composite hydrogel as a potential adsorbent for removal of hazardous dyes. Adv Mat Res., 931-932, Pp. 286-290.

Pimpa, W., Pimpa, C., Junsangsree, P., 2012. Development of biodegradable films based on durian seed starch. Adv. Mat. Res., 506, Pp. 311-314.

Poerwanto, R., Efendi, D., Widodo, W.D., Susanto, S., Purwoko, B.S., 2008. Off-Season production of tropical fruits. Acta Horticular., 772 (772), Pp. 127-133.

Purnomo, A., Yudiantoro, Y.A.W., Putro, J.N., Nugraha, A.T., Irawaty, W., Ismadji, S., 2016. Subcritical water hydrolysis of durian seeds waste for bioethanol production. Int. J. Chem. Eng., 7, Pp. 29-37.

Rachtanapun, P., Luangkamin, S., Tanprasert, K., Suriyatem, R., 2012. Carboxymethyl cellulose film from durian rind. LWT- Food Sci. Technol., 48, Pp. 52-58.

Raihana, A.R.N., Marikkar, J.M.N., Amin, I., Shuhaimi, M., 2015. A review on food values of selected tropical fruits's seeds. Int. J. Food Prop., 18 (11), Pp. 2380-2392.

Sabiiti, E.N., 2011. Utilizing agricultural waste to enhance food security and conserve the environment. Afr. J. Food Agric. Nutr. Dev., 11 (6), Pp. 1-9.

Saikaew, W., Kaewsarn, P., 2009. Cadmium ion removal using biosorbent derived from fruit peel wastes. Songklanarin J. Sci. Technol., 31 (5), Pp. 547-554.

Sah, B.P., Pathak, T., Sankar, S., Suresh, B., 2014. Phytochemical investigations on the fruits of Durio zibenthinus Linn. for antimicrobial activity. Int. J. Pharm Sci. Res., 5 (12), Pp. 878-891.

Saudah, Irhamni, Diana, Ernilasari, Suzanni, M.A., 2019. Pati Janeng adhesive durian shellbiobriquette (*Durio zibethinus* Murr). J. Phys. Conf. Ser., 1232 (1), Pp. 012004.

Sembiring, T., Kristiarawati, and Sinuhaji, K.S.P., 2018. Characterization of biocomposite materials based on the durian fiber (*Durio Zibethinus* Murr) reinforced using polyester resin. J. Phys. Conf. Ser., 1116, Pp. 1-7.

Shamin-Shazwan, K., Razali, N.I.A., Shahari, R., Amri. C.N.A.C., Go, R., 2021a. Fruit morphology of *Durio zibethinus* L. in Jelebu, Negeri Sembilan, Malaysia. Indian J. Agric Res., 55 (6), Pp. 1-6.

Shamin-Shazwan, K., Shahari, R., Amri, C.N.A.C., Go, R., 2021b. Propagation methods, agronomic practices and fruit production of *Durio zibethinus* L. in Malaysia: A review. Malay Nat. J., 73 (1), Pp. 99-104.

Shamin-Shazwan, K., Shahari, R., Amri, C.N.A.C., Nordin, M.S., Go, R., 2021c. A review on medicinal uses of genus *Durio*. Med Plants – Int J. Phytomed Relat Ind., 13 (3), Pp. 388-395.

Siriphanich, J., 2011. Durian (*Durio zibethinus* Merr.). Postharvest Biology and Technology of Tropical and Subtropical Fruits: Cocona to Mango., Pp. 80-114.

Srianta, I., Hendrawan, B., Kusumawati, N., Blanc, P.J., 2012. Study on durian seed as a new substrate for angkak production. Int. Food Res. J., 19 (3), Pp. 941-945.

Suprianto, A., Diba, F., Prayogo, H., 2018. Studi etnobotani pemanfaatan tumbuhan durian (*Durio* Spp) di Desa Labian Ira'ang Kecamatan Batang Lupar Kabupaten Kapuas Hulu. Jurnal Hutan Lestari, 6 (3), Pp. 673-687.

Suriyatem, R., Auras, R.A., Rachtanapun, P., 2019. Utilization of carboxymethyl cellulose from durian rind agricultural waste to improve physical properties and stability of rice starch-based film. J. Polym. Environ., 27 (2), Pp. 286-298.

Syamsiah, Hiola, S.F., Mu'nisa, A., Jurnadi, O., 2016. Study on medicinal plants used by the Ethnic Mamuju in West Sulawesi, Indonesia. J. Trop Crop Sci., 3 (2), Pp. 42-48.

The, B.T., Lim, K., Yong, C.H., Ng, C.C.Y., Rao, S.R., Rajasegaran, V., Lim, W.K., Ong, C.K., Chan, K., Cheng, V.K.Y., Soh, P.S., Swarup, S., Rozen, S.G., Nagarajan, N., Tan, P., 2017. The draft genome of tropical fruit durian (*Durio zibethinus*). Nat. Genet., 49 (11), Pp. 1633-1644.

Tham, Y.J., Latif, P.A., Abdullah, A.M., Shamala-Devi, A., Taufiq-Yap, Y.H., 2011. Performances of toluene removal by activated carbon derived from durian shell. Bioresour Technol., 102, Pp. 724-728.

Theapparat, Y., Khongthong, S., Rodjan, P., Lertwittayanon, K., Faroongsarng, D., 2018. Physicochemical properties and in vitro antioxidant activities of pyroligneous acid prepared from brushwood biomass waste of mangosteen, durian, rambutan, and langsat. J. For. Res., 30 (3), Pp. 1139-1148.

Toledo, F., Arancibia-Avila, P., Park, Y., Jung, S., Kang, S., Heo, B.G., Drzewiecki, J., Zachwieja, Z., Zagrodzki, P., Pasko, P., Gorinstein, S., 2008. Screening of the antioxidant and nutritional properties, phenolic contents and proteins of five durian cultivars. Int. J. Food Sci. Nutr., 59 (5), Pp. 415-427.

Tongdang, T., 2008. Some properties of starch extracted from three Thai aromatic fruit seeds. Starch, 60, Pp. 199-207.

Unhasirikul, M., Narkrugsa, W., Naranong, N., 2013. Sugar production from durian (*Durio zibethinus* Murray) peel by acid hydrolysis. Afr. J. Biotechnol., 12 (33), Pp. 5244-5251.

Waay-Juico, M.C., Cortuna, G.E., Evangelista, S.H.M., Gatal, R.R.D., Licuana, C.I.K.S., Tapia, F.J.C., 2017. Ethnobotanical practices of Tagabawa Tribe on selected medicinal plants at Barangay Jose Rizal, Sta. Cruz, Davao del Sur, Philippines. J. Complement Altern Med. Res., 4 (3), Pp. 1-12.

Wai, W.W., Alkarkhi, A.F.M., Easa, A.M., 2009. Optimization of pectin extraction from durian rind (*Durio zibethinus*) using response surface methodology. J. Food Sci., 74 (8), Pp. 637-641.

Wai, W.W., Alkarkhi, A.F.M., Easa, A.M., 2010. Comparing biosorbent ability of modified citrus and durian rind pectin. Carbohydr Polym., 79, Pp. 584-589.

Wang, Y., Zhu, L., Zhu, F., You, L., Shen, X., Li, S., 2017. Removal of organic solvent/oils using carbon aerogels derived from waste durian shell. J. Taiwan Inst. Chem., Eng., 13 (21), Pp. 1-8.

Wong, W.W., Abbas, F.M.A., Liong, M.T., Azhar, M.E., 2008. Modification of durian rind pectin for improved biosorbent ability. Int. Food., Res. J., 15 (3), Pp. 363-365.

Yahya, M.A., Al-Qodah, Z., Ngah, C.W.Z., 2015. Agricultural bio-waste materials as potential sustainable precursors used for activated carbon production: A review. Renew Sust Energy Rev, 46., Pp. 218-235.