Journal of Applied Food Technology

Home page: https://ejournal2.undip.ac.id/index.php/jaft

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Active Food Packaging Based on Coconut Coir Pulp with the Addition of Antimicrobial Oleoresin Substance from Ginger Dregs

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Abstract

The development of food packaging innovations is ongoing, from materials to varied shapes and designs. Paper packaging is one of the various types of packaging that are widely used as an alternative to plastic packaging. However, the high use of paper can damage the environment, such as deforestation and reduction of green land. Alternative raw materials for making paper need to be studied further, and the addition of active ingredients will be an added value compared to ordinary paper packaging. This narrative review will examine the potential of active food packaging from coconut fiber and the addition of ginger pulp oleoresin. Coconut coir is waste from coconut production that is underutilized, while 25% of one coconut is produced from waste in the form of coconut coir. Coconut coir can replace wood's cellulose fibers to manufacture biodegradable, environmentally friendly paper. Ginger flesh contains oleoresin as an antimicrobial agent. Oleoresin is a mixture of essential oils and resins obtained by extraction. Adding these antimicrobial substances will produce active packaging that effectively handles and prevents contamination and microbial growth in food. Therefore, paper made from coconut coir pulp with the addition of oleoresin has the potential to be developed into active food packaging as an effort to conserve the environment and utilize waste.

Article information:
Received: 16 August 2022
Accepted: 5 December 2022
Available online: 12 December 2022

Keywords:
Antimicrobial
Coconut fiber
Food packaging
Ginger pulp
Oleoresin

doi: 10.17728/jaft.15558

Introduction

Nowadays, speed and practicality are demands that must exist in all aspects, including the handling and processing food products. Food packaging is needed to wrap food in order to avoid various damages, such as physical, chemical, and microorganism damage. The common raw materials to make food packaging is from plastic and paper. Both types of packaging are considered more economical and practical. However, this damages the environment and the ecosystem. Indonesia is estimated to produce 64 million tons of waste annually, 14% from plastic waste and 9% from paper waste (Nurhidayat and Adiluhung, 2021).

Plastic waste is an inorganic material that comes from materials with carbon chains that are very difficult to decompose. On the other hand, paper is a material made from cellulose fibers mainly obtained from wood. The increasing use of paper poses serious problems, especially the depletion of raw materials for wood which causes deforestation and the risk of natural disasters. In addition, paper packaging is generally easily moldy and contaminated with other objects. Therefore, it is necessary to study more alternative materials that are environmentally friendly for paper making and add value to the paper. Using active paper packaging (a type of packaging material that incorporates active substances or technologies to enhance the quality and shelf life of packaged products) from coconut fiber with ginger pulp oleoresin is one food packaging innovation that is environmentally friendly, safe to use and can prevent microbial damage. Using coconut coir can replace the role of trees in the manufacture of pulp so that it is expected to reduce the risks and environmental problems caused by using paper, such as landslides. Coconut coir is a waste from coconut production that is abundant but cannot be utilized optimally. One coconut (525 grams) contains 25% coconut coir (±132 grams) (Rumbayan and Sudarno, 2020). The main components of this coir are cellulose, hemicellulose and lignin (Nascimento et al., 2021). Lignin is the main by-product and is suitable for use as raw material for paper pulp. The high lignin content makes the paper less brittle and more ductile.

The addition of antimicrobial substances in the form of oleoresin in food packaging can be an alternative to active packaging, especially amid the current pandemic. The ginger oleoresin is a lipid-based extract that contains many active phytochemicals. Ginger dregs are a waste of ginger essential oil refining and are known to contain oleoresin. In contrast to essential oils, oleoresins consist of volatile and non-volatile compounds. This extract is more complete because it shows a profile of aroma, taste, color, and spiciness (Procopio et al., 2022). In addition, oleoresin is also used as an antibacterial agent, which prevents microbiological contamination (Oriani et al., 2018). The main compounds of this oleoresin are gingerols and shogaols, namely 6, 8, 10-gingerol and 6-shogaol (Shukla et al., 2020). Oleoresin in ginger dregs can be applied for food packaging to prevent food from microbial damage. Therefore, this review aims to elaborate on the potential of coconut coir and the addition oleoresin from ginger dregs as an active food packaging. It is expected to produce alternative, environmentally friendly packaging options, good quality products, and can guarantee food hygiene and the risk of microorganism contamination.

Methods

This systematic review used the PRISMA (Preference Reporting Items for Systematic Review and Meta-analyses) method by collecting data or sources related to a particular topic from various references such as articles and journals. The data search was done by combining keywords compiled with a Boolean strategy using AND, OR, and NOT operators. The literature search was carried out from ScienceDirect and Google Scholar with the keywords: active food packaging, oleoresin, ginger dregs, and antibacterial from ginger.

The inclusion and exclusion criteria were used as a constraint to select the literature that had been reviewed. Inclusion criteria were articles or journals reviewed for research on active food packaging raw materials published in 2018-2022. The exclusion criteria used were the elimination of identical journals and their suitability with the author's discussion. Literature selection was made by reviewing the titles, abstracts, and contents of articles or journals that met the inclusion criteria and did not meet the exclusion criteria.

Results and Discussion

Characteristics of Active Food Packaging

The use of food packaging has now become a common thing to do along with the many types of food products, especially fast food. The function of food packaging today is not only as a container or wrapper but can prevent food's physical, chemical, and microorganism contamination. Food packaging made of plastic, mica, paper, and styrofoam is increasingly popular today (Mulyanto and Adi, 2020). The selection of packaging materials may differ depending on the handled food products. However, the primary packaging criteria must be resistant to air and light to maintain the quality of food products (Rahmawaty, 2021). According to the Regulation of the Head of Badan Pengawas Obat dan Makanan (BPOM) concerning Food Packaging Materials (HK.03.1.23.07.11.6664 of 2011), paper is one of the essential ingredients in the manufacture of food packaging. Several types of paper packaging have also been specified for their usefulness in the SNI given in Table 1.

The types of paper for food packaging, in general, can be distinguished into two categories: single-layer paper and composite paper. Composite paper is paper made from more than one type of pulp, such as polymers and natural fibers of coconut fiber, which are made to increase the use value of the paper. This composite paper can be an alternative solution to overcome the problem of illegal logging and the potential for waste in the environment (Lestari et al., 2021). Paper packaging has limited applications, especially for food packaging, due to its water resistance (Hosen et al., 2022). Paper packaging made of softwood fibers also has low mechanical strength (Chungsiriporn et al., 2022). Paper packaging needs to meet the standards of physical and chemical properties regulated in Standar Nasional Indonesia (SNI) with several parameters, including water content (dry oven method SNI ISO 287:2010), pH (SNI ISO 6588-1.2010), age of grams (SNI ISO 536: 2010) and brightness (SNI ISO 2470:2010). A comparison of the physical and chemical characteristics of commercial paper with SNI standards can be seen in Table 2.

Commercial food packaging that has been widely circulated is only limited to protecting food from dust, dirt, and the risk of physical damage but cannot

Tabel 1. Paper Specifications and Usage

No.	SNI title	SNI Number	Utilization
1.	Base paper for plastic laminated wrapping paper	14-6519–2001	Primary packaging: food-coated surfaces with plastic.
2.	Tea bag made of kraft paper	14-7038-2004	Primary packaging: the inner part of the product is covered with aluminum foil. Kraft paper is used for packaging flour, sugar, dried fruits, vegetables, sandwich wrappers, biscuit bags, chewing gum wrappers, frozen and unfrozen candy wrappers, salt, pepper, sugar wraps and tea bags.
3.	Duplex cardboard	0123:2008	Secondary packaging
4.	Glazing paper	6021:2009	Primary packaging
5.	Salute paper	0154:2010	Secondary packaging: primary packaging for dry food products or coated with water/oil repellent
6.	Salute cardboard	7723:2011	Secondary packaging: primary packaging for dry food products or coated with water/oil repellent

Table 2. compared to the characteristics of commercial paper and SNI

Paper	Water content (%)	pH	Gramm age (g/m^2)	Brightness (%)
Commercial paper	6.09	7.55	83.00	22.82
SNI	≤ 8	6-9	255-500	-

Source: Agustina and Susanti (2018)

effectively prevent reactions that occur in food, especially those caused by microorganism contamination. Active packaging is an innovative approach with a positive interaction system between the environment and packaging to extend shelf life while ensuring quality (Qian et al., 2021).

In addition, several active packaging systems can improve food safety and quality, such as oxygen or carbon dioxide scavengers, carbon dioxide or ethanol and SO2 emitting systems, ethylene, light and moisture absorption systems, and antimicrobial or antioxidant release and storage systems (Ahmed et al. al., 2022). Recent research on active packaging is shown in Table 3. Several factors influence the characteristics of active paper packaging, such as chemical mechanisms, storage and distribution conditions, physical and mechanical properties of packaging, sensory properties, and antimicrobial toxicity properties.

The existence of poor resistance of food paper packaging which is not suitable for long-term storage needs to be improved or modified by coating or adding some active compounds. Paper can be formed as active packaging because of its pore structure. Several active packaging systems will increase the activity of paper materials, such as vapor and gas permeability, physical properties, optical properties, surface properties and antimicrobial activity (de Oliveira-Filho et al., 2022). One of the activities of the paper material is tensile resistance, which is the maximum tensile force per unit width that paper and cardboard can withstand just before breaking. The addition of oleoresin affects the tensile resistance of active paper packaging. The higher the addition of oleoresin, the lower the tensile resistance of the paper. Based on SNI 8218:2015 regarding paper and cardboard for food packaging, the minimum tensile resistance is 1.6 kN/m. The tensile strength is also affected by the homogeneity of the adhesive. Pulp and adhesive will produce fiber bonds and fill empty gaps so that the tensile resistance will be higher if the mixture is more homogeneous (Sundari et al., 2020). The adhesive prevents the paper from breaking easily when stretched and pulled on the opposite side, while the cellulose in the pulp will affect the tear strength. High cellulose fibers can increase the tear strength of paper because cellulose fibers can bind to each other to form strong paper (Asngad and Syalala, 2018). The adhesive and cellulose will bond to each other until homogeneous, so the paper sheet becomes strong and does not tear easily. However, the thinner the paper thickness causes the paper strength to tear more easily.

The potential of Coconut Coir as Raw Material for Active Food Packaging

Coir is a by-product of the coconut plantation industry and the most significant part of the coconut fruit (Tyas and Zulaikha, 2018). Coconut coir is often not appropriately used and is thrown away as waste. Indonesia has the largest coconut plantation in the world, with an area of about 31.2% of the total area of coconut plantations in the world, with a total production of 3.2 million tons of coconut (Santosa et al., 2019). Unfortunately, the large coconut production also produces much waste in the form of coconut fiber. Coconut consists of four main parts: coconut husk or coir, shell, coconut meat and coconut water.

Coconut coir is the part with the most extensive composition, which is 0.4 kg of one coconut with 30% in the form of fiber. The chemical components of coconut coir can be seen in Table 4. The high cellulose and lignin composition indicate that coco fiber has the potential to be used as a material for making paper pulp for packaging (Dewi et al., 2021).

Paper made with coconut fiber as raw material can be used for various things, one of which is as bio-packaging. Based on the research of Noor et al. (2020), paper made from raw materials in the form of a combination of coconut fiber and paper waste can be utilized as bio-packaging. The bio-packaging can accommodate a load of more than 1 kg and can be destroyed using water so that it is environmentally friendly. Jeetah and Jaffur (2021) found that coconut coir waste can be processed into biodegradable paper with the advantage of low cost and abundant availability. Paper made from coconut fiber can be used as food packaging. According to Deshwal et al. (2019), 31% of the packaging used globally is made of paper and paperboard, the most widely used materials for food packaging. The amount of wood that must be used to make paper can threaten the future of life on earth, so the innovation of making paper with raw material for coconut coir waste can be a solution for environmental improvement.

Paper from coconut fiber can be made by mechanical or chemical pulping. The chemical pulping process is a method that is more often used for papermaking. The chemical solution used in the chemical pulping method can reduce the lignin content to produce paper with strong fiber bonds (Mboowa, 2020). The paper produced in the mechanical pulping process tends to be brownish due to a high lignin content (Ainun et al., 2018). According to Haile et al. (2021), the chemical pulping process produces a yield of 40-50%, with the resulting paper product having high-strength quality compared to paper from mechanical pulping. However yield resulting from the chemical pulping process is quite low, which becomes a drawback of this method. According to Abd El-Sayed et al. (2020), the anthraquinone pulping method can overcome the problem of low yields because this method is known to increase the yield by up to 5%. Ulfa and Isnaini (2020), in their research, applied one type of chemical pulping method, namely soda pulping, which uses sodium hydroxide (NaOH) as an agent in charge of degrading lignin in the paper making with coconut fiber as raw

Tabel 3. Recent research of active packaging

Material	Active Component	Method	Mode of Action	Obtained Characteristics	Reference
Chitosan, MMT nanoclays, Ginger Essential Oil (EO), Rosemary EO.	Phenolic diterpenes	Chitosan film-forming dispersion (FFD)	Can absorb bacteria from solution and immobilize them on its surface, significantly reducing meat pathogenic organisms	Obtain thicker film, larger solid content per unit surface, maintain good meat appearance	Pires et al., 2018.
Cellulose nanofibrils from coconut coir fibers (CCF) and their reinforcements in biodegradable composite films	2,2,6,6-tetramethylpiperidine-1-oxyl (TEMPO)	Chemical pretreatment, mild TEMPO-mediated oxidation, and ultrasonic separation	The stronger the hydrogen bond network, the more stable the composite film structure against thermal decomposition.	Good thermal stability but the addition of too much or too little CCF will result in weak hydrogen bonds.	Wu et al., 2019
Chitosan, gum Arabic, polyethylene glycol, and ginger essential oil	α-zingiberene, β-cedrene, α-curcumene, β-bisbolene, βsesquiphellandrene, E-β-Famesene, and β-panasinsene	Solvent casting	Destruction to the cytoplasmic membrane.	Increased roughness and the appearance of more cavities without cracks, high tensile strength, and high heat stability.	Amalraj et al., 2020
Torch ginger inflorescence extract (TGI), starch powder	96% D-limonene, 2,6% -mirsen, oktan, -pinena, -linalool, sikloheksena, dan decana.	Chitosan film-forming dispersion (FFD)	Increases antioxidant activity, causes protein denaturation and cell death, triggers leakage of cellular content, and results in bacterial cell death.	More brittle and difficult to decompose, increase film thickness, increase tensile strength (TS), can withstand a minimum temperature of 280°C.	Moon et al., 2020
Ginger starch-based edible films incorporated with coconut shell liquid smoke (CSLS)	2-methoxyphenols (guaiacol), phenol, 4-ethyl-2-methoxyphenol (EMP), syringol, carbonyls, and organic acids	Ultrasound treatment and application for ground beef	Phenolics can increase cell membrane permeability and leakage of intracellular components. Carbonyl inhibits bacteria by penetrating cell walls and inactivating enzymes	Compact and uniform structure with good flexibility, resulting in higher water vapor barrier properties, and increased thermostability.	Rahmasari and Yemis, 2022

material.

Based on this research, increasing the temperature, time, and concentration of NaOH will decrease pulp yield and lignin in coir fiber.

Oleoresin Antibacterial Properties of Ginger Dregs

Packaging innovations made from natural materials with the addition of antimicrobial substances can prevent contamination of microorganisms in food so that food will remain sterile and safe until just before consumption and extend shelf life. One of the antimicrobial substances that can be used is oleoresin. Oleoresin is a concentrated liquid from plants which contains essential oils and is obtained by extraction using a solvent and accompanied by the removal of the solvent at the end of the process (Hanif et al., 2020).

The content of oleoresin is usually taken from herbs and spices, one of them are spice plants, such as ginger. The oleoresin component in ginger is a non-volatile component consisting of gingerol, shogaol, zingerone, and paradols (Promdam and Panichayupakaranant, 2022). Gingerol is an oleoresin compound found in the most significant amount in ginger. The content of gingerol in ginger can change into the form of its derivative component, shogaol, due to storage or heating (Oriani et al., 2018). The shogaol component has more biologically active abilities than gingerol, such as the ability to ward off free radicals (Johnson et al., 2021).

Tabel 4. Chemical composition of coconut coir.

Cellulose (%)	Lignin (%)	Hemicellulose (%)	Reference
44	33	12	Wu et al., 2019
36-50	30-46	10-20	Ho et al., 2021
20-40	25-50	3-15	Bronzato et al., 2019
32,69-36,3	31,9-53	22,56	Aziz et al., 2019
40-45	30-40	24	Samanta et al., 2018

The content of gingerol and shogaol in ginger oleoresin has the ability to be antimicrobial. Gingerol and shogaol as phenolic components can denature proteins in bacterial cells. These phenolic components will cause disruption of membrane permeability and transport processes in bacteria, resulting in swelling and cell rupture (Beristain-Bauza et al., 2019). Phenolic components can cause protein denaturation at low concentrations, while at high concentrations, it will cause protein coagulation (Pratiwi and Salimah, 2020). The mechanism of action of gingerol as an antibacterial can also damage the cytoplasm. Cytoplasmic damage will result in leakage of cells that can kill cells (Putra et al., 2021). Gingerol and shogaol as phenol derivative compounds can interact with bacterial cells through the hydrogen bonds' adsorption process. Through these interactions, bonds are formed between phenols and proteins in bacterial cells that can cause cell membranes to lyse (Rumanti et al., 2021).

The herbal medicine industry in Indonesia produces many ginger dregs as a by-product which has not been utilized properly. Ginger dregs from the beverage industry or herbal medicine are usually used as fertilizer or biofuel, even though the bioactive content in ginger dregs is still relatively high (Yulianto et al., 2022). The oleoresin yield produced in ginger pulp extraction using ethanol solvent was 1.86% (Hastuti et al., 2018). Meanwhile, in dry ginger extraction using ethanol solvent, the oleoresin yield was 2.6-9.8% (Shukla et al., 2019). The oleoresin content in ginger pulp is still relatively high and can be used as an antibacterial agent to manufacture active packaging.

Conclusion

The innovation of paper packaging for food made from coconut fiber with the addition of antimicrobial oleoresin can be an alternative to using paper packaging for food commonly used in the community. The high cellulose content in coconut fiber produces paper sheets with strong resistance. Adding oleoresin from ginger pulp produces antimicrobial paper, which is very good for food packaging.

References

Abd El-Sayed, E.S., El-Sakhawy, M., El-Sakhawy, M.A.M. 2020. Non-wood fibers as raw material for pulp and paper industry. Nordic Pulp and Paper Research Journal 35(2):215-230. DOI: 10.1515/npprj-2019-0064.

Agustina, E.S. W., Susanti V.H.E. 2018. Natural wrapping paper from banana (*Musa paradisiaca Linn*) peel waste with additive essential oils. Journal of Physics: Conference Series. 1022:1-8. DOI: 10.1088/1742-6596/1022/1/012032.

Ahmed, M.W., Haque, M.A., Mohibbullah, M., Khan, M.S.I., Islam, M.A., Mondal, M.H.T., Ahmmed, R., 2022. A review on active packaging for quality and safety of foods: Current trends, applications, prospects and challenges. Food Packaging and Shelf Life 33:1-12. DOI: 10.1016/j.fpsl.2022.100913.

Ainun, Z.M.A., Muhammad, K.I., Rasmina, H., Hazwani, H.A., Sharmiza, A., Naziratulasikin, A.K., Latifah, J. 2018. Effect of chemical pretreatment on pulp and paper characteristics of bamboo gigantochloa scorthechinii kraft fibers. The Wood and Biofiber International Conference: 1-6. DOI: 10.1088/1757-899X/368/1/012044.

Amalraj, A., Raj, K.K.J., Haponiuk, J.T., Thomas, S., Gopi, S. 2020. Preparation, characterization, and antimicrobial activity of chitosan/gum arabic/polyethylene glycol composite films incorporated with black pepper essential oil and ginger essential oil as potential packaging and wound dressing materials. Advanced Composites and Hybrid Materials 3:485-497. DOI: 10.1007/s42114-020-00178-w.

Asngad, A., Syalala, Y. 2018. Tensile strength and tear strength of paper from reeds through organosolv process with ethanol solvent and different cooking time. Proceedings of the National Seminar on Biology and Science Education III: 99-106.

Aziz, N.A., Latip, A.F.A., Peng, L.C., Latif, N.H.A., Brosse, N., Hashim, R., Hussin, M.H. 2019. Reinforced lignin-phenol-glyoxal (LPG) wood adhesives from coconut husk. International Journal of Biological Macromolecules 141:185-196. DOI: 10.1016/j.ijbiomac.2019.08.255.

Beristain-Bauza, S.D.C., Hernández-Carranza, P., Cid-Pérez, T.S., Ávila-Sosa, R., Ruiz-López, I.I., Ochoa-Velasco, C.E. 2019. Antimicrobial activity of ginger (*Zingiber officinale*) and its application in food products. Food Reviews International 35(5):1-20. DOI: 10.1080/87559129.2019.1573829.

Bronzato, G.R.F., dos Reis, V.A.C.A., Borro, J.A., Leão, A.L., Cesarino, I. 2019. Second generation ethanol made from coir husk under the biomass Cascade approach. Molecular Crystals and Liquid Crystals 693(1):107-114. DOI: 10.1080/15421406.2020.1723890.

Chungsiriporn, J., Khunthongkaew, P., Wongnoipla, Y., Sopajarn, A., Karrila, S. Iewkittayakorn, J., 2022. Fibrous packaging paper made of oil palm fiber with beeswax-chitosan solution to improve water resistance. Industrial Crops and Products 177:1-9. DOI: 10.1016/j.indcrop.2022.114541.

de Oliveira-Filho, J.G., de Deus, I.P.B., Valadares, A.C.F., Fernandes, C.C., Estevam, E.B.B., Egea, M.B. 2020. Chitosan film with citrus limonia essential oil: physical and morphological properties and antibacterial activity. Colloids and Interfaces 4(2):1-10. DOI: 10.3390/colloids4020018.

Deshwal, G. K., Panjagari, N. R., Alam, T. 2019. An overview of paper and paper based food packaging materials: health safety and environmental concerns. Journal of Food Science and Technology: 1-13. DOI:10.1007/s13197-019-03950-z.

Dewi, I.A., Ihwah, A., Setyawan, H.Y., Kurniasari, A.A.N., Ulfah, A. 2021. Optimization of NaOH concentration and cooking time in delignification of mature coconut (*Cocus nucifera* L.) coir. International Conference on Green Agro-industry and Bioeconomy: 1-8. DOI: 10.1088/1755-1315/733/1/012034.

Haile, A., Gebino, G., Tesfaye, T., Mengie, W., Ayele, M., Abuhay, A., Yilie, D. 2021. Utilization of non-wood biomass for pulp manufacturing in paper industry: case of Ethiopia. Biomass Conversion and Biorefinery 1:1-19. DOI: 10.1007/s13399-021-01424-x.

Hanif, A., Widyasanti, A., Putri, S.H., 2020. Effect of duration in the extraction of rendemen from mangga kuweni peel (Mangifera odorata Griff) using MAE method. Agroindustrial Technology Journal 4(2):95-107. DOI: 10.21111/atj.v4i2.4916.

Hastuti, D., Rohadi, R., Putri, A.S. 2018. The ratio of n-hexane-ethanol to physical and chemical characteristics of oleoresin press cage ginger (*Zingiber majus Rumph*) variety emprit. Journal Food Technology and Agricultural Product 13(1):41-56.

Ho, K.H., Nguyen, P.X.T., Do, N.H.N., Le, K.A., Le, P.K. 2021. Green fabrication of bio-based aerogels from coconut coir for heat insulation and oil removal. Chemical Engineering Transactions 88:709-714. DOI: 10.3303/CET2188118.

Hosen, M.D., Hossain., M.S., Islam, M.A., Haque, A.N.M.A., Naebe, M. 2022. Utilization of natural wastes: Water-resistant semi-transparent paper for food packaging. Journal of Cleaner Production 364:1-9. DOI: 10.1016/j.jclepro.2022.132665.

Jeetah, P., Jaffur, N. 2021. Coconut husk, a lignocellulosic biomass, as a promising engineering material for non-wood paper production. Journal of Natural Fibers: 1-15. DOI: 10.1080/15440478.2021.1889428.

Johnson, J.B., Mani, J.S., White, S., Brown, P., Naiker, M. 2021. Quantitative profiling of gingerol and its derivatives in australian ginger. Journal of Food Composition and Analysis 104:1-8. DOI: 10.1016/j.jfca.2021.104190.

Lestari, A. P., Apriani, M., Sophia, A.V. 2021. Analysis of the effect of cassava peel binder on tear resistance properties of composite paper from corn cobs and beef rumen contents. Conference Proceeding on Waste Treatment Technology: 107-111.

Mboowa, D. 2020. A review of the traditional pulping methods and the recent improvements in the pulping processes. Biomass Conversion and Biorefinery 1:1-12. DOI: 10.1007/s13399-020-01243-6.

Moon, S.H., Waite-Cusic, J., Huang, E. 2020. Control of Salmonella in chicken meat using a combination of a commercial bacteriophage and plant-based essential oils. Food Control 110:1-25. DOI: 10.1016/j.foodcont.2019.106984.

Moon, S.H., Waite-Cusic, J., Huang, E., 2020. Control of Salmonella in chicken meat using a combination of a commercial bacteriophage and plant-based essential oils. Food Cont. 110, 106984 DOI: 10.1016/j.foodcont.2019.106984.

Mulyanto, T., Supriyono, Gunawan, R. A. 2020. Design of styrofoam waste processing machine with heating belt method. Scientific Journal of Engineering and Innovation 2(2):107-114. DOI: 10.35814/asiimetrik.v2i2.1406.

Nascimento, R.J.M., Pereira, K.R.A., Avelino, F. 2021. Parametric and modeling studies of Rhodamine-B adsorption using coconut coir-based materials as eco-friendly adsorbents. Journal of Environmental Chemical Engineering. 9(5): 1-15. DOI: 10.1016/j.jece.2021.105943.

Noor, A., Afriani, F., Puriza, M.Y., Tiandho, Y. 2020. Bio-packaging based on a composite of paper waste and coconut fiber. 2nd International Conference on Green Energy and Environment: 1-4. DOI: 10.1088/1755-1315/599/1/012051.

Nurhidayat, M., Adiluhung, H. 2021. Exploration paperboard in waterproof packaging. SISTEMIK: Scientific Journal of Engineering Scienc. 2): 22-27. DOI: 10.53580/sistemik.v9i02.60.

Oriani, V.B., Alvim, I.D., Paulino, B.N., Procópio, F.R., Pastore, G.M., Hubinger, M.D. 2018. The influence of the storage temperature on the stability of lipid microparticles containing ginger oleoresin. Food Research International 109:472-480. DOI: 10.1016/j.foodres.2018.04.066.

Pires, J.R.A., de Souza, V.G.L. and Fernando, A.L. 2018. Chitosan/montmorillonite bionanocomposites incorporated with rosemary and ginger essential oil as packaging for fresh poultry meat. Food packaging and shelf life 17: 142-149. DOI: 10.1016/j.fpsl.2018.06.011.

Pratiwi, A., Salimah, I. 2020. Antioxidant and antibacterial activity of kembang leson essensial oil. Al-kauniyah: Journal Biology 13(2):139-146. DOI: 10.15408/kauniyah.v13i2.9966.

Procopio, F.R., Ferraz, M.C., Paulino, B.N., Sobral P. J. A., Hubinger, M.D. 2022. Spice oleoresins as value-added ingredient for food industry: Recent advances and perspectives. in Food Science & Technology. 122:123-139. DOI: 10.1016/j.tifs.2022.02.010.

Promdam, N., Panichayupakaranant, P. 2022. Gingerol: a narrative review of its beneficial effect on human health. Food Chemistry Advances 1:1-10. DOI: 10.1016/j.focha.2022.100043.

Putra, R.H.P., Widyaningrum, I., Fadli, M.Z. 2021. The activity of a combination of ethyl acetate extract rhizome of red ginger and red galangal. Journal Complementary Bio Medicine 8(2):1-8.

Qian, M., Liu, D., Zhang, X., Yin, Z., Ismail, B.B., Ye, X. and Guo, M., 2021. A review of active packaging in bakery products: applications and future trends. Trends in Food Science & Technology 114: 59-471. DOI: 10.1080/10408398.2020.1783199.

Rahmasari, Y., Yemis, G.P. 2022. Characterization of ginger starch-based edible films incorporated with coconut shell liquid smoke by ultrasound treatment and application for ground beef. Meat Science. 188:1-10. DOI: 10.1016/j.meatsci.2022.108799.

Rahmawaty, D. 2021. The influence of product packaging design, product materials, shop service on buying decisions Al Insan Elementary Scholl Bekasi City. Journal of Educational Research and Learning 5(2b):903-910. DOI:

10.35568/naturalistic.v5i2b.1220.

Rumanti, R.M., Suprianto, S., Tarigan, J., Ramadani, A.M.S. 2021. Antibacterial potential of combinant *Zingiber officinale var. Rubrum* with Cinnamomum burmannii against *Staphylococcus aureus*. Journal of Indah Science and Clinic. 2(1):6-10. DOI: 10.52622/jisk.v2i1.8.

Rumbayan, R., Sudarno. 2020. Compressive strength, flexural strength and water absorption for bricks with the addition of coco fiber. 2(3): 48-57. DOI: 10.47600/jtst.v2i3.255.

Samanta, A.K., Basu, G., Mishra, L. 2018. Role of major constituents of coconut fibres on absorption of ionic dyes. Industrial Crops and Products 117:20-27. DOI: 10.1016/j.indcrop.2018.02.080.

Santosa, I., Sulistiawati, E., Kumalasari, I., dan Suhendra, S. 2019. Technology development for organic production of high quality virgin coconut oil. Proceedings of the 2019 Ahmad Dahlan International Conference Series on Engineering and Science (ADICS-ES 2019): 41-44. DOI: 10.2991/adics-es-19.2019.11.

Shukla, A., Das, C., Goud, V.V. 2020. Design of a carrier system for gingerols enriched oleoresin tailored for food applications. Food and Bioproducts Processing. 124:296–306. DOI: 10.1016/j.fbp.2020.09.007.

Sundari, E. M., Apriani, W., and Suhendra. 2020. Tensile strength test of recycled paper mixed sugarcane dregs, coconut fiber, and waste paper. Scientific Journal of Mechanical Engineering. 6(1):28-33. DOI: 10.32832/ame.v6i1.2871.

Tyas, E.W., Zulaikha, E. 2018. Development of coconut coir fiber material for home decor. ITS Journal of Science and Arts 7(2):108-112. DOI: 10.12962/j23373520.v7i2.36573.

Ulfa, M., Isnaini, K. 2020. The effect of soda pulping variables on coir fiber's pulp properties. Acta Chimica Asiana 3(2):170-173. DOI: 10.29303/aca.v3i2.47.

Wu, J., Du, X., Yin, Z., Xu, S., Xu, S., Zhang, Y. 2019. Preparation and characterization of cellulose nanofibrils from coconut coir fibers and their reinforcements in biodegradable composite films. Carbohydrate Polymers 211:49-56. DOI: 10.1016/j.carbpol.2019.01.093.

Yulianto, M.E., Paramita, V., Amalia, R., Wahyuningsih, N., Nyamiati, R.D. 2022. Production of bioactive compounds from ginger (*Zingiber officianale*) dregs through subcritical water extraction. Materials Today: Proceedings: 188-194. DOI: 10.1016/j.matpr.2022.02.216.