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.

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 (Preferred 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

<table>
<thead>
<tr>
<th>No.</th>
<th>SNI title</th>
<th>SNI Number</th>
<th>Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Base paper for plastic laminated</td>
<td>14-6519–2001</td>
<td>Primary packaging: food-coated surfaces with plastic.</td>
</tr>
<tr>
<td></td>
<td>wrapping paper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Tea bag made of kraft paper</td>
<td>14-7038-2004</td>
<td>Primary packaging: the inner part of the product is covered with aluminum foil.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>3</td>
<td>Duplex cardboard</td>
<td>0123:2008</td>
<td>Secondary packaging</td>
</tr>
<tr>
<td>4</td>
<td>Glazing paper</td>
<td>6021:2009</td>
<td>Primary packaging</td>
</tr>
<tr>
<td>5</td>
<td>Salute paper</td>
<td>0154:2010</td>
<td>Secondary packaging: primary packaging for dry food products or coated with water/oil repellent</td>
</tr>
<tr>
<td>6</td>
<td>Salute cardboard</td>
<td>7723:2011</td>
<td>Secondary packaging: primary packaging for dry food products or coated with water/oil repellent</td>
</tr>
</tbody>
</table>
Table 2. compared to the characteristics of commercial paper and SNI

<table>
<thead>
<tr>
<th>Water content (%)</th>
<th>pH</th>
<th>Gramm age (g/m²)</th>
<th>Brightness (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial paper</td>
<td>6.09</td>
<td>7.55</td>
<td>83.00</td>
</tr>
<tr>
<td>SNI</td>
<td>≤ 8</td>
<td>6-9</td>
<td>255-500</td>
</tr>
</tbody>
</table>

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., 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 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 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
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).

### Table 4. Chemical composition of coconut coir.

<table>
<thead>
<tr>
<th>Cellulose (%)</th>
<th>Lignin (%)</th>
<th>Hemicellulose (%)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>44</td>
<td>33</td>
<td>12</td>
<td>Wu et al., 2019</td>
</tr>
<tr>
<td>36-50</td>
<td>30-46</td>
<td>10.20</td>
<td>Ho et al., 2021</td>
</tr>
<tr>
<td>20-40</td>
<td>25-50</td>
<td>3.15</td>
<td>Bronzato et al., 2019</td>
</tr>
<tr>
<td>32.69-36.3</td>
<td>31.9-53</td>
<td>22.56</td>
<td>Aziz et al., 2019</td>
</tr>
<tr>
<td>40-45</td>
<td>30-40</td>
<td>24</td>
<td>Samanta et al., 2018</td>
</tr>
</tbody>
</table>
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


