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CELLULOSIC PADS AS MATRIX SACHET ANTIMICROBIAL: A REVIEW

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ABSTRACT

The advancement of active packaging technology has contributed to the need for customer assurance of the quality and protection of fresh foods and agricultural products. An example of active packaging to maintain food quality and improve product protection is the use of antimicrobial pads. Antimicrobial pads are a type of active packaging that releases active agents into the headspace food packaging in order to prevent, inhibit or destroy the growth of microorganisms.. Antimicrobial pads are very easy to apply to food products by placing them on the bottom of the product or inserting them into the packaging material. This literature study discusses the characterization of cellulose as a major component in the manufacture of pads, techniques for the incorporation of antimicrobial compounds into pads, and suitable applications for the inhibition of microorganisms in food products. Apart from that, this literature study also discusses the advantages and disadvantages of antimicrobial pads as active packs.

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INTRODUCTION

For humans, food protection and harm are a significant concern. Food damage is caused by physical, chemical and microbial pollutants that affect the quality of food products, from harvesting to storage until marketing (Mohammadi and Jafari 2020). Microbial contamination is one of the biggest causes of food damage such as meat, fish and other foodstuffs (Otoni et al. 2016, Aragüez et al. 2020). Contamination of microorganisms makes food products rot quickly so that it undergoes a change in quality into the hands of consumers. Therefore, it is necessary to maintain quality and improve product protection, including by using active packaging (Otoni et al. 2016, Zhang et al. 2017, Aragüez et al. 2020).

Active packaging is a packaging that modifies certain physiological or environmental conditions by means of agents or active substances interacting between food products with certain mechanisms (Bodbodak and Rafiee 2016). It helps to enhance the product's shelf life and consistency or to achieve the desired characteristics (Biji et al. 2015). By releasing active compounds or adding compounds to the headspace or to packaged foods, the active packaging method works (Yildirim and Röcker 2018). Examples of active packaging are antimicrobial packaging, oxygen scavengers, ethylene scavengers, active emitters, preservative releasers and regulating functions (Biji et al. 2015, Otoni et al. 2016, Kuswandi and Jumina 2019). One form of active packaging that is developing today is antimicrobial packaging.

Antimicrobial packaging is a form of active packaging which has antimicrobial agents to prevent and inhibit the growth of microbes in food packaging as a barrier function (Camo et al. 2008). The surface of a multilayer structure or certain objects such as labels, pads, sachets and tablets

can be antimicrobial packaging (Arvanitoyannis and Kotsanopoulos 2012, Gavara et al. 2015, Murgic et al. 2015). Antimicrobial pads, which are one example of cellulose-based antimicrobial packaging, are very likely to be an antimicrobial carrier agent in food that the consistency of foods is more maintained (Agrimonti et al. 2019). Nanocellulose is one example of a polymer to release antimicrobial agents gradually (Sartika 2020). The amended of nanocellulose to pads can improve the barrier, physical and mechanical characteristic of good composite products (Adnan et al. 2018). Consequently, this literature review purposed to analyze the newest developments of food packaging systems that focus on cellulose the main component of pad production, The Process of Making Cellulosic Matrix Pads as Antimicrobial Food Pads, Release of antimicrobial agents on Cellulosic pads products, The advantages and disadvantages of these concepts are also reviewed.

DISCUSSION

Cellulose As The Main Component For Pad Production

Cellulose is a glucose polymer with a β -1,4-D-glycosides in a straight chain. Linear structure causes cellulose to become crystalline and insoluble (Fahma et al. 2010). The basic ingredient of cellulose constituents is selobiosa, where the repeat unit is two units of sugar. Cellulose molecules are randomly appeared and seem to form intra- and inter-molecular hydrogen bonds, as well as providing a structure of the molecular chain connected to layers linked by a weak van der Waals force. The layer is a parallel chain of units of anhydroglucopyranosis linked together by intermolecular hydrogen bonds (Rowell 2012). Crystalline and amorphous arrangements consist of the molecular structure of cellulose. The chemical intake of cellulose is found in Figure 1.

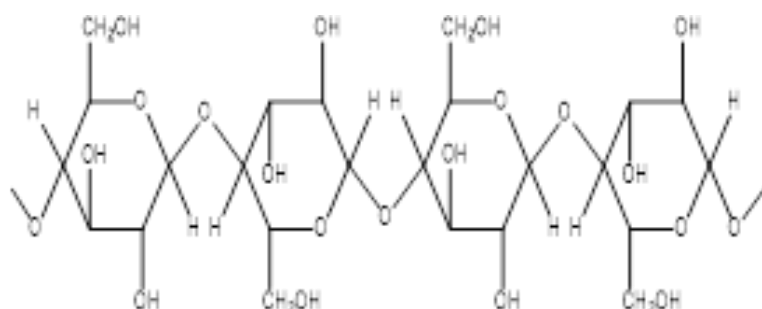


Fig 1. Chemical Structure of Cellulose (Rowell 2012)

The arrangement of crystals in each cellulose fiber differs according to the source of the raw material, so the mechanical properties of the fibers affect the polymer to be made. The amount of cellulose in fiber affects its quality and application. Fibers that have a high concentration of cellulose are more suitable for use in the textile and paper industries. The organization of crystals and the degree of crystalline strongly influence the mechanical properties of cellulose fibers (Fahma et al. 2014).

Cellulose is the main ingredient in the manufacturing of pads. (Fernández et al. 2009, 2010, Bovi et al. 2018). In various applications such as absorbent pads, cellulose itself has been commonly used (Kocak et al. 2005, Teunissen and Lagro-Janssen 2009, Griebing 2013), filter pads (Mao et al. 2008, Paig-Tran et al. 2013) hydrogel pads (Yang et al. 2010) and antimicrobial food pads (Fernández et al. 2010, Bovi et al. 2018). Pad components are typically combined with other polymers such as nanocellulose or CMC for better material properties (Qian et al. 2008, Papkov et al. 2013, Adnan et al. 2018). According to (Moon et al. 2011, Muthuraj et al. 2018) stated cellulose has retention properties and absorption is quite good when compared to competitor products.

Cellulose is very potential to be used as a moisture absorber for food packaging applications with CMC additional ingredients (Pinming et al. 2016). Previous reports have shown that CMC demonstrates cellulose paper characteristics to be a better product of physical, barrier and mechanical properties (Qian et al. 2008). (Boruvkova and Wiener 2011) stated cellulose carboxymethyl (CMC) which is a cellulose derivative product that can absorb almost eight times more than ordinary cotton. The downside of using CMC is its poor insect resistance and fast decomposition (Jannatyha et al. 2020).

Currently, cellulose has been developed in nano-sizes. Nanocellulose is a natural fiber that can be extracted from cellulose and has a nano size. Nanocellulose contains 100% of the chemical composition of cellulose with both crystalline and amorphous regions (Moon et al. 2011). Nanocellulose fibers are generally less than 100 nm in diameter. Nanocellulose production begins with size reduction pretreatment, the addition of enzymes or chemicals, and post-treatment with sonication (Dungani et al. 2018).

Cellulose-based paper packaging combined with chitosan and propolis as well as the addition of micro fibril cellulose (MFC) was successful by releasing the active polyphenol agent gradually and reducing 1 log cycle in beef cuts (Rollini et al. 2017). In addition, the use of nanocellulose can be used as a controlled release of some active compounds in hydrogel nanocomposites (Nascimento et al. 2018). As reported in previous studies, nano biopolymer composites can improve composite components mechanically, physically and barrier (Moon et al. 2011).

According to (Tarrés et al. 2016) the merging of nanocellulose can improve the physical properties produced due to its higher specific surface, improve the relative bonding area and improve the physical properties of the sheet of paper. Furthermore, (Martins et al. 2013) the fusion of nanocellulose in nanocomposite materials such as paper has been acquainted to improve surface strength and qualities. In addition, (Adnan et al. 2018) reported that the addition of nanocellulose decreases specific volume (bulk) marginally by up to 10 percent and improves the properties of folding endurance, tensile strength and tear strength significantly. Besides, the air permeability of paper can be decreased by more than 50 percent in the properties of barrier paper. This suggests that the paper is more likely to be used in pharmaceutical and food packaging as the reduction in air permeability will slow down the growth of microbes in order to extend the product's shelf life.

The Process of Making Cellulose Pads Matrix as Antimicrobial Food Pads

One of the most innovative and flexible applications of today's active packaging systems is cellulose pads. The form of this packaging generally consists of sheets of upper and lower film layers and the middle layer of the nucleus consisting mostly of cellulose and active ingredients that absorb excess fluid (droplet loss) or inhibit the growth of microbes contained in the packaging. Cellulose pads are classified into two major categories: absorbers for water contact and absorbers for non-contact. For packaging meat products, such as fish, beef and pork, water contact absorbent pads are commercially used (Fang et al. 2017). The structure of the antimicrobial food pads layer is contained in Figure 2. However, the weakness of cellulose pads only absorbs water in meat products, so that the growth of these microbes continues to grow if there is no active

antimicrobial agent (Fernández et al. 2009, Otoni et al. 2016, Bovi et al. 2018, Agrimonti et al. 2019).

Cellulose is normally processed using one of two techniques, sulfite or pulp-making pre-hydrolysis kraft (sulfate method). For about 80 percent of the world's cellulose production, Kraft pulp making techniques are the most common (Fahma et al. 2014). In retail food packaging and coatings, cellulose pads are commonly used to absorb moisture and liquid from meat, poultry and fish, keep items looking new, protect packaging systems from unhealthy meat mucus, and produce esthetically attractive packaging. This unhealthy mucus, even if not absorbed inside the pads, can cause an unwanted smell, spoil food or encourage the spread of pathogens carried by food. A conventional component of absorbent pads, natural cellulose has been reported as a promising nanoreactor and stabilizer for silver nanoparticles. (He et al. 2003).

According to (Fernández et al. 2009) Cellulose is a powerful carrier for antimicrobial materials such as Silver Nanoparticles (Fernández et al. 2010); Essential Oils (Oral et al. 2009), and Fructose (Bovi et al. 2018). This is because cellulose can bind to electropositive metal transition atoms through electrostatic interactions (Fahma et al. 2014, Zhang et al. 2017). If these two issues are resolved, cellulose pads can work to release their active agents. The first is to use the

top and bottom layers to cover the adsorbent material. In certain cases, waterproof thermoplastic materials or cellulose materials form these layers (Fernández et al. 2009, Bovi et al. 2018). Here's a summary of the layer structure and the active ingredients in the food antimicrobial pads contained in Table 2.

Release of Antimicrobial Active Agents from Cellulose Pads

Current consumer demand is looking for preservative-free products and added only when their presence is required, namely where most of the damage occurred (Han 2005, Realini and Marcos 2014). Antimicrobial food pads are one of the active packaging innovations. In the form of antimicrobials, microbial growth is prevented by being applied to the subsurface of food. Antimicrobial food pads are manufactured in the form of multi-layer mixtures or composite polymers (Ogunsona et al. 2020).

Polymer nanomaterials can be combined in a matrix to create antimicrobial composite sheets in order to maintain the storability of product. In a typical multilayer package, there are five layers (Fig. 2) in which agents active antimicrobial can be integrated into the matrix layer (Bovi et al. 2018). As a consequence, antimicrobial multilayer packaging can give mechanical and barrier qualities which is better than the antimicrobial monolayer package.

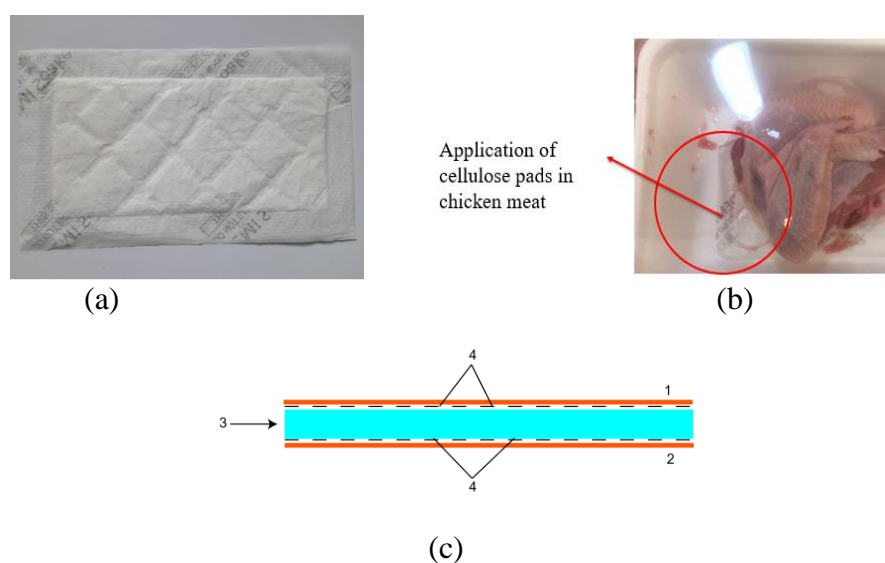


Figure 2. Layer Structure of Antimicrobial Food Pads Components (a) Top view of Image of Antimicrobial Food Pads, (b) Image Application of antimicrobial food pads on chicken meat (c) Structure of antimicrobial food pads components: 1-upper layer film, 2-bottom layer film, 4- microperforated plastics, 3-cellulosic pads + active agents (Bovi et al. 2018).

Table 2. Layer structure along with active ingredients in food antimicrobial pads

Layer arrangement on the Pad	The Main Structure of Pad	Agen Active	Reference
The cellulose fibers in the middle are then served with a top and bottom polyethylene plastic layer.	Fiber Cellulose	Silver Nanotechnology	(Fernández et al. 2009)
The top layer is PE film, the middle layer is cellulose sheet and the bottom layer is nonwoven.	Sheet of cellulose	Composite of Super Absorbent Polymer granules with binders or plasticizers, starch-based superabsorbent materials	(Jensen and Versteylen 2012)
The top layer is a film, namely PE, PP, Polyester, or a combination of both. The bottom layer is a nonwoven material such as polyolefin, polyester or polyamide. It may also be made of the same material as the top layer.	One or more structure layers. The absorbent material can also be the slurry of the cellulosic material, binder fibers, airlaid, nonwovens, superpolymer adsorbent, thermoplastic polymer fibers, or a combination.	Packaging system: CO2 generator, oxygenated, desiccant, ethylene absorbent or antimicrobial. Active agent: organic acids (such as lactic acid, sorbic acid, citric acid, or a combination thereof) quaternary ammonium compounds, inorganic acids or a combination thereof.	(Vertesylen 2015)
The first layer of the perforated micro PP, the second layer of the perforated micro PP, the third layer of the cellulose pad with the active agent, the fourth layer of the perforated micro PP and the fifth layer of the film	Fiber cellulose	Fructose	(Bovi et al. 2018)

Tabel 3. Example of application of pads using an antimicrobial agent

Antimicrobial Agent	Carrier/ Modified	Aplikasi	Target Bacteria	Hasil Penelitian	Referensi
Chitosan	Paper Nanosheets Composites	Antibacterial paper	E. Coli	<ul style="list-style-type: none"> • Chitosan can inhibit 90% of the viability of E. Coli 	(Zemljic et al. 2017)
Silver Nanotechnology	<i>Coating on the pad surface</i>	The melon pieces are packed in a tray with Absorbent Pads added	E. Coli	<ul style="list-style-type: none"> • The addition fruitpad will maintain total mesophilic and psychrotrophic aerobic microorganisms for 10 days with an average of 3 log₁₀ CFU/g • Besides, absorbent Pads can slow the aging of melon pieces, very low yeast count, lower ° Brix value, and a fresher appearance after 10 days of storage 	(Fernández et al. 2010)
Fructose	Cellulose pads are combined with fructose concentrations	Moisture Absorbent Pads for package of strawberry	Weigh loss, Water absorbed, Condensed water dan Water loss	<ul style="list-style-type: none"> • FruitPad with 30% fructose concentration showed the highest water absorption (0.94 g water/g pad) at relative humidity 100 and temperature 20 °C • Increase shelf life from 3 days to 5 days 	(Bovi et al. 2018)
Pinosylvin	Using a coating containing pinosylvin-cyclodextrin	Antimicrobial absorbent pads	<i>C. coli ATCC 33559</i> and <i>C. jejuni ATCC 33560</i>	<ul style="list-style-type: none"> • Can inhibit <i>C. jejuni</i> ATCC 33560 and <i>C. coli</i> ATCC 33559 by 99% to 100% 	(Bovi et al. 2018)
ZnO nanoparticle, CuO nanoparticle and Silver Nanoparticle	Immobilized in cotton fibers	Antibacterial cotton pads	<i>S. Epidermis</i> , <i>L. monocytogenes</i> , <i>S. aureus</i> , and <i>E. coli</i>	<ul style="list-style-type: none"> • Both cotton pads using nanoparticles of ZnO, CuO and Silver demonstrated significant inhibitory activity on E.coli, L.monocytogenes, S. aureus, and S. Epidermis microbes with varying activity levels 	(Shankar and Rhim 2017)
Oregano essential oil	<i>Spray coating</i>	<i>Absorbent pads</i>	<i>Enterobacteriaceae</i> , yeast, and lactic acid bacteria	<ul style="list-style-type: none"> • Absorbent pads combined with essential oregano oil will extend the shelf life of meat for three to five days. 	(Oral et al. 2009)

Antimicrobial Agent	Carrier/ Modified	Aplikasi	Target Bacteria	Hasil Penelitian	Referensi
Oregano, thyme and cinnamon essential oil	<i>Pads enriched with essential oil</i>	<i>Cellulosic Pad</i>	<i>Specific bacterial species of meat and some common foodborne pathogens (C. jejuni, S. enterica, and S. aureus).</i>	<ul style="list-style-type: none"> Cellulosic pad added with oregano, thyme and cinnamon essential oils will increase the shelf life of hamburgers and minced beef to 4 ° C for 16 and 12 days. 	(Agrimonti et al. 2019)
Lemon essential oil/vermiculite	<i>Encapsulated and blended in electrospun</i>	<i>Anti-bacteriostatic pad /polyvinyl alcohol (PVA)</i>	<i>Escherichia coli, Total Plate Counts</i>	<ul style="list-style-type: none"> Compared to without adding pad products, it can increase the shelf life of chilled pork products by up to 3 days. Anti-bacteriostatic pad proven to inhibit TPC and E. Coli bacteria 	(Li et al. 2021)
<i>Cinnamaldehyde</i>	<i>Crosslinking nonwovens polyethylene terephthalate with β-cyclodextrin</i>	<i>Nonwoven polyethylene terephthalate altered with a cinnamaldehyde active agent and modified with β-cyclodextrin</i>	<i>Escherichia coli and Staphylo-coccus aureus</i>	<ul style="list-style-type: none"> Antibacterial pads with active cinnamaldehyde compound control release will prolong the life of cold fresh pork by 80% from its original shelf life.. 	(Zhou et al. 2020)

Fresh food production requires several operational processes such as size reduction, milling, cutting, peeling, sifting, drying slicing which shortens the shelf life of food due to browning, loss of moisture content, surface dehydration, and the reproduction of spoilage-related microorganisms. Microbial growth is related to the fruit characteristic, such as fruit composition, water activity, pH, redox potential, the amount of O₂ in the pack, etc., but also storage temperature, the composition of the air in the package, and relative humidity (Martins et al. 2013, Bovi et al. 2018). The cellulose pads with the contents of the object should also pay attention to the air headspace on to product. It will allow mucus to build up in the container if the air headspace is very wide than the product packaging, it will also ruin the appearance of fresh-cut goods, and it is best to use absorbent agents to extract moisture and liquid. Consequently, absorbent pads based on cellulose are commonly used in retail food packaging. However, slimy fluids that cannot be absorbed by the pads may cause unwanted odors, impair food quality or encourage the spread of food-borne pathogens (Otoni et al. 2016, Bovi et al. 2018, Silva et al. 2018).

A strong antimicrobial carrier is a cellulose. It is a naturally occurring carbohydrate with a linear molecular chain formed by β 1,4 glycosidic bonds connected by anhydroglucose units. Cellulose, by electrostatic interactions, is also able to bind electropositive transition metal atoms. AgNPs is an instance of an antimicrobial agents (Fernández et al. 2010). As a consequence, micro-cellulose adsorbs silver ions during immersion in silver nitrate. The porous cellulose framework then serves as a nanoreactor and stabilizes silver nanoparticles (AgNPs) from their normal shape (He et al. 2003). When mixed with cellulose, trace amounts of silver are very effective as broad-spectrum decontamination agents. An example of the application of antimicrobial food pads using active ingredients of antimicrobial agents combined with cellulose is shown in Table 3.

The effectiveness of nanocomposites consisting of AgNP-Chitosan has been shown to inhibit various microorganisms (Rhim et al. 2006, An et al. 2008). One of the uses of silver nanoparticles is fruit and meat products (Fernández et al. 2009). In addition there is the application of the incorporation of precious metal nanoparticles into cellulose pore fibers (He et al.

2003). On the other hand, the use of ingredients such as salt, sugar and protein in the matrix of food products can extend the shelf life in food technology.

The advantages of antimicrobial food pads are that they are easy to apply in packaged products (Bovi et al. 2018), inhibit microbial growth (Fernández et al. 2009), maintain product quality and shelf life (Silva et al. 2018). In addition, antimicrobial food pads can control the release of antimicrobial active agents into food products so that they can maintain longer shelf life (Gaikwad et al. 2019). The disadvantage of antimicrobial food pads is that they have to adjust the headspace of the product with the pads so that the process of releasing the antimicrobial agent runs well (Otoni et al. 2016).

CONCLUSION

One of the most effective revolutionary active food packaging systems is the application of Cellulose Pads as antimicrobials. Fructose, pinosylvine, metal nanoparticles, antimicrobials, essential oils and other active compounds are the antimicrobial compounds incorporated in the cellulose pads. With consumer demand for less synthetic, preservative-free, natural compounds are constantly being produced. It is also recommended to embrace bio-based and/or biodegradable materials as environmentally friendly alternatives to cellulose pad materials. Different literature suggests that microbial growth is effectively prevented by cellulose pads paired with antimicrobial compounds.

The development of antimicrobial food pads is continuously encouraged to optimize and make the production of cellulose pads an effective antimicrobial. Overall, the investigators are concerned about the controlled release of the antimicrobials into the product either in vitro or in vivo. The resulting controlled release of nanocomposites has potential applications to extend shelf life and make fresher food products last longer, help overcome barriers faced by consumers, and make commercial applications easier.

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REFERENCES

- Adnan, S., A. H. Azhar, L. Jasmani, and M. F. Samsudin. 2018. Properties of paper incorporated with nanocellulose extracted using microbial hydrolysis assisted shear process. *IOP Conference Series: Materials Science and Engineering* 368.
- Agrimonti, C., J. C. White, S. Tonetti, and N. Marmioli. 2019. Antimicrobial activity of cellulosic pads amended with emulsions of essential oils of oregano, thyme and cinnamon against microorganisms in minced beef meat. *International Journal of Food Microbiology* 305:108246.
- An, J., M. Zhang, S. Wang, and J. Tang. 2008. Physical, chemical and microbiological changes in stored green asparagus spears as affected by coating of silver nanoparticles-PVP. *LWT - Food Science and Technology* 41:1100–1107.
- Aragüez, L., A. Colombo, R. Borneo, and A. Aguirre. 2020. Active packaging from triticale flour films for prolonging storage life of cherry tomato. *Food Packaging and Shelf Life* 25:100520.
- Arvanitoyannis, I. S., and K. Kotsanopoulos. 2012. *Modified Atmosphere and Active packaging Technologies*. Page CRC Press, USA.
- Biji, K. B., C. N. Ravishankar, C. O. Mohan, and T. K. Srinivasa Gopal. 2015. Smart packaging systems for food applications: a review. *Journal of Food Science and Technology* 52:6125–6135.
- Bodbodak, S., and Z. Rafiee. 2016. Recent trends in active packaging in fruits and vegetables. Page *Eco-Friendly Technology for Postharvest Produce Quality*. Elsevier Inc.
- Boruvkova, K., and J. Wiener. 2011. Water absorption in carboxymethyl cellulose. *Autex Research Journal* 11:110–113.
- Bovi, G. G., O. J. Caleb, E. Klaus, F. Tintchev, C. Rauh, and P. V. Mahajan. 2018. Moisture absorption kinetics of FruitPad for packaging of fresh strawberry. *Journal of Food Engineering* 223:248–254.
- Camo, J., J. A. Beltrán, and P. Roncalés. 2008. Extension of the display life of lamb with an antioxidant active packaging. *Meat Science* 80:1086–1091.
- Dungani, R., P. Aditiawati, S. Aprilia, K. Yuniarti, T. Karliati, I. Suwandhi, and I. Sumardi. 2018. Biomaterial from Oil Palm Waste: Properties, Characterization and Applications. *Palm Oil*.
- Fahma, F., N. Hori, T. Iwata, and A. Takemura. 2014. Preparation and characterization of polychloroprene nanocomposites with cellulose nanofibers from oil palm empty fruit bunches as a nanofiller. *Journal of Applied Polymer Science* 131:1–6.
- Fahma, F., S. Iwamoto, N. Hori, T. Iwata, and A. Takemura. 2010. Isolation, preparation, and characterization of nanofibers from oil palm empty-fruit-bunch (OPEFB). *Cellulose* 17:977–985.
- Fang, Z., Y. Zhao, R. D. Warner, and S. K. Johnson. 2017. Active and intelligent packaging in meat industry. *Trends in Food Science and Technology* 61:60–71.
- Fernández, A., P. Picouet, and E. Lloret. 2010. Cellulose-silver nanoparticle hybrid materials to control spoilage-related microflora in absorbent pads located in trays of fresh-cut melon. *International Journal of Food Microbiology* 142:222–228.
- Fernández, A., E. Soriano, G. López-Carballo, P. Picouet, E. Lloret, R. Gavara, and P. Hernández-Muñoz. 2009. Preservation of aseptic conditions in absorbent pads by using silver nanotechnology. *Food Research International* 42:1105–1112.
- Gaikwad, K. K., S. Singh, and A. Aji. 2019. Moisture absorbers for food packaging applications. *Environmental Chemistry Letters* 17:609–628.

- Gavara, R., G. López Carballo, P. Hernández Munoz, R. Catalá, V. Muriel Galet, J. Cerisuelo, and I. Domínguez. 2015. Practical Guide to Antimicrobial Active Packaging. Page Pira.
- Griebing, T. L. 2013. Re: Efficacy of an improved absorbent pad on incontinence-associated dermatitis in older women: Cluster randomized controlled trial: Editorial comment. *Journal of Urology* 189:1819–1820.
- Han, J. H. 2005. Innovation in Food Packing. Elsevier Academic Press, USA.
- He, J., T. Kunitake, and A. Nakao. 2003. Facile In Situ Synthesis of Noble Metal Nanoparticles in Porous Cellulose Fibers. *Chemistry of Materials* 15:4401–4406.
- Jannatyha, N., S. Shojaee-Aliabadi, M. Moslehishad, and E. Moradi. 2020. Comparing mechanical, barrier and antimicrobial properties of nanocellulose/CMC and nanochitosan/CMC composite films. *International Journal of Biological Macromolecules* 164:2323–2328.
- Jensen, R., and S. Versteylen. 2012. Food package for cut produce. USA.
- Kocak, D., M. Akalin, I. Usta, and N. Merdan. 2005. New Approach To Produce Absorbent Pads For New End Uses. Page Medical Textiles and Biomaterials for Healthcare: Incorporating Proceedings of MEDTEX03 International Conference and Exhibition on Healthcare and Medical Textiles. Woodhead Publishing Limited, London.
- Kuswandi, B., and Jumina. 2019. Active and intelligent packaging, safety, and quality controls. Page Fresh-Cut Fruits and Vegetables: Technologies and Mechanisms for Safety Control. Elsevier Inc., London.
- Li, X., N. Xiao, G. Xiao, W. Bai, X. Zhang, and W. Zhao. 2021. Lemon essential oil/vermiculite encapsulated in electrospun konjac glucomannan-grafted-poly (acrylic acid)/polyvinyl alcohol bacteriostatic pad: sustained control release and its application in food preservation. *Food Chemistry*:129021.
- Mao, J., B. Grgic, W. H. Finlay, J. F. Kadla, and R. J. Kerekes. 2008. Wood pulp based filters for removal of sub-micrometer aerosol particles. *Nordic Pulp and Paper Research Journal* 23:420–425.
- Martins, N. C. T., C. S. R. Freire, C. P. Neto, A. J. D. Silvestre, J. Causio, G. Baldi, P. Sadocco, and T. Trindade. 2013. Antibacterial paper based on composite coatings of nanofibrillated cellulose and ZnO. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 417:111–119.
- Mohammadi, Z., and S. M. Jafari. 2020. Detection of food spoilage and adulteration by novel nanomaterial-based sensors. *Advances in Colloid and Interface Science* 286:102297.
- Moon, R. J., A. Martini, J. Nairn, J. Simonsen, and J. Youngblood. 2011. Cellulose nanomaterials review: Structure, properties and nanocomposites. Page Chemical Society Reviews. The Royal Society of Chemistry, Wisconsin USA.
- Murgic, Z. H., A. Rescek, A. P. Sirocic, L. K. Krehula, and Z. Katancic. 2015. Nanoparticles in active polymer food packaging. Page Pira. Shropshire.
- Muthuraj, R., M. Misra, and A. K. Mohanty. 2018. Biodegradable compatibilized polymer blends for packaging applications: A literature review. Page Journal of Applied Polymer Science. Journal of Applied Polymer.
- Nascimento, D. M., Y. L. Nunes, M. C. B. Figueirêdo, H. M. C. De Azeredo, F. A. Aouada, J. P. A. Feitosa, M. F. Rosa, and A. Dufresne. 2018. Nanocellulose nanocomposite hydrogels: Technological and environmental issues. *Green Chemistry* 20:2428–2448.

- Ogunsona, E. O., R. Muthuraj, E. Ojogbo, O. Valerio, and T. H. Mekonnen. 2020. Engineered nanomaterials for antimicrobial applications: A review. *Applied Materials Today* 18:100473.
- Oral, N., L. Vatansever, Ç. Sezer, B. Aydin, A. Güven, M. Gülmez, K. H. C. Başer, and M. Kürkçüoğlu. 2009. Effect of absorbent pads containing oregano essential oil on the shelf life extension of overwrap packed chicken drumsticks stored at four degrees Celsius. *Poultry Science* 88:1459–1465.
- Otoni, C. G., P. J. P. Espitia, R. J. Avena-Bustillos, and T. H. McHugh. 2016. Trends in antimicrobial food packaging systems: Emitting sachets and absorbent pads. *Food Research International* 83:60–73.
- Paig-Tran, E. W. M., T. Kleinteich, and A. P. Summers. 2013. The filter pads and filtration mechanisms of the devil rays: Variation at macro and microscopic scales. *Journal of Morphology* 274:1026–1043.
- Papkov, D., Y. Zou, M. N. Andalib, A. Goponenko, S. Z. D. Cheng, and Y. A. Dzenis. 2013. Simultaneously strong and tough ultrafine continuous nanofibers. *ACS Nano* 7:3324–3331.
- Pinming, C., N. Sukgorn, T. Suhatcho, B. Saetang, P. Kerdkhong, T. Maboonthuay, K. Chalapat, and K. Siraleartmukul. 2016. Humidity sensor using carboxymethyl cellulose hydrogel membrane. 2016 13th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology, ECTI-CON 2016:2–4.
- Qian, L., Y. Guan, B. He, and H. Xiao. 2008. Synergy of wet strength and antimicrobial activity of cellulose paper induced by a novel polymer complex. *Materials Letters* 62:3610–3612.
- Realini, C. E., and B. Marcos. 2014. Active and intelligent packaging systems for a modern society. *Meat Science* 98:404–419.
- Rhim, J. W., S. I. Hong, H. M. Park, and P. K. W. Ng. 2006. Preparation and characterization of chitosan-based nanocomposite films with antimicrobial activity. *Journal of Agricultural and Food Chemistry* 54:5814–5822.
- Rollini, M., E. Mascheroni, G. Capretti, V. Coma, A. Musatti, and L. Piergiovanni. 2017. Propolis and chitosan as antimicrobial and polyphenols retainer for the development of paper based active packaging materials. *Food Packaging and Shelf Life* 14:75–82.
- Rowell, R. M. 2012. Moisture properties. *Page Handbook of Wood Chemistry and Wood Composites, Second Edition*. CRC Press LLC, Florida.
- Sartika, D. 2020. Rancangan matriks saset antimikroba dari bead komposit alginat-selulosa nanokristal untuk slow-release senyawa aktif eugenol dewi sartika. IPB University.
- Shankar, S., and J. W. Rhim. 2017. Facile approach for large-scale production of metal and metal oxide nanoparticles and preparation of antibacterial cotton pads. *Carbohydrate Polymers* 163:137–145.
- Silva, F., F. C. Domingues, and C. Nerín. 2018. Control microbial growth on fresh chicken meat using pinosylvin inclusion complexes based packaging absorbent pads. *Lwt* 89:148–154.
- Tarrés, Q., H. Oliver-Ortega, M. Llop, M. À. Pèlach, M. Delgado-Aguilar, and P. Mutjé. 2016. Effective and simple methodology to produce nanocellulose-based aerogels for selective oil removal. *Cellulose* 23:3077–3088.
- Teunissen, T. A. M., and A. L. M. Lagro-Janssen. 2009. Sex differences in the use of absorbent (incontinence) pads in independently living elderly people: Do men receive less care? *International Journal of Clinical Practice* 63:869–873.
- Vertesylen. 2015. (12) Patent Application Publication (10) Pub . No .: US 2015 /

- 0258769 A1 lifted-off layer Patent Application Publication. USA.
- Yang, Z., H. Peng, W. Wang, and T. Liu. 2010. Crystallization behavior of poly(ϵ -caprolactone)/layered double hydroxide nanocomposites. *Journal of Applied Polymer Science* 116:2658–2667.
- Yildirim, S., and B. Röcker. 2018. Active packaging. *Nanomaterials for Food Packaging: Materials, Processing Technologies, and Safety Issues*:173–202.
- Zemljic, L. F., J. V. Valh, and T. Kreže. 2017. Preparation of antimicrobial paper sheets using chitosan. *Cellulose Chemistry and Technology* 51:75–81.
- Zhang, H., J. Jung, and Y. Zhao. 2017. Preparation and characterization of cellulose nanocrystals films incorporated with essential oil loaded β -chitosan beads. *Food Hydrocolloids* 69:164–172.
- Zhou, Z., Y. Liu, Z. Liu, L. Fan, T. Dong, Y. Jin, M. D. A. Saldaña, and W. Sun. 2020. Sustained-release antibacterial pads based on nonwovens polyethylene terephthalate modified by β -cyclodextrin embedded with cinnamaldehyde for cold fresh pork preservation. *Food Packaging and Shelf Life* 26.

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Journals

Adam, M., Corbeels, M., Leffelaar, P.A., Van Keulen, H., Wery, J., Ewert, F., 2012. Building crop models within different crop modelling frameworks. *Agric. Syst.* 113, 57–63. doi:10.1016/j.agsy.2012.07.010

Arifin, M.Z., Probawati, B.D., Hastuti, S., 2015. Applications of Queuing Theory in the Tobacco Supply. *Agric. Sci. Procedia* 3, 255–261. doi:10.1016/j.aaspro.2015.01.049

Books

Agrios, G., 2005. *Plant Pathology*, 5th ed. Academic Press, London.