Global Scientific JOURNALS

GSJ: Volume 8, Issue 2, February 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

LAURIC ACID ON EDIBLE FILMS: A REVIEW

Irfa Nursyabani[1], Emma Rochima[1]AsepAgus Handaka[1], Camellia Panatarani[2] I Made Joni[2]

[1]Department of Fisheries, Faculty of Fisheries and Marine Science, Padjadjaran University
[2]Department of Physics, Faculty of Mathematics and Natural Sciences, Padjadjaran University
Jl. Raya Bandung-Sumedang KM 21, Jatinangor 45363, West Java, Indonesia

*E-mail address: irfa.nursyabani@gmail.com

ABSTRACT

Severe environmental pollution cause by plastic food packaging has raise considerable interest in edible and biodegradable films made from renewable natural polymers. Several strategies have been used to produced edible films with better performances. One of those strategies is incorporating fatty acids into edible films as film forming materials, plasticizer or additives. Lauric acid is a medium-length chain fatty acid derived from natural renewable resources with numerous applications in various fields. Lauric acid has been shown to have an antimicrobial effects and good water barrier protection for films. This review discusses the application of lauric acid in the field of edible film for food protection. The properties effected by lauric acid content on the films are also discussed.

Keywords: *edible film,lauric acid, antimicrobial properties, barrier properties*

1. INTRODUCTION

Concerns about environmental impact and exhausting natural resources caused by non-biodegradable, petrochemical-based plastic packaging has raised interest in the use of alternatives originating from renewable sources[1]. In this regard, food biopolymers such as proteins, polysaccharides and lipids have received considerable attention as alternatives and are frequently used to formulate edible film and coating, thus playing a vital role to improve the shelf-life of food[2]. Edible films and coatings offer extra advantages such as edibility, biocompatibility, esthetic appearance, barrier to gasses properties, non-toxic, non-polluting and its low cost[3].

Edible films are used to protect foods from unfavourable conditions while keeping them safe and fresh during shelf life. Edible films have varry usage purpose according to requirement of foods during their storage. Also, natural characteristic of film forming materials may limit protective features due to their migration mechanisms of moisture and gases[4]. Characteristics of edible films affected by several parameters such as the kind of film forming material composition, the condition under which films are prepared like, type of solvent, pH of medium, temperature and the type and concentration of additives (plasticizers, antimicrobials, antioxidants, cross-linking agents or emulsifiers)[1][5][6][7]. Hydrocolloid films (protein and polysaccharide based) possess good gas barrier properties (oxygen, carbon dioxide) even lower than plastic films and adequate barrier properties to lipids but not to water vapor[6]. Therefore, several strategies have been used to improve the physical properties of biopolymer based films. Among them, promising results in increasing the hydrophobicity have been obtained by addition of neutral lipids, fatty acids waxes[8][9] and clay[10].

Fatty acid is an aliphatic compound having carboxyl groups. Based on its chain length, it can be divided into 3 categories. First, is short chain fatty acid (SCFA) having less than 8 carbon atom, then medium chain fatty acid (MCFA) with 8–2 carbon atoms, and long chain fatty acid (LCFA) have more than 12 carbon atoms. While based on the double bond existence, there are unsaturated fatty acid and saturated fatty acid[11]. In recent years, many studies have been published reporting the effect of incorporating different fatty acids, such as caproic, capric, lauric, myristic, palmitic, stearic, and oleic acid on edible film properties [12][13][14][15]. However, this article will focus on lauric acid content in edible films and its effect on the properties of the films.

2. LAURIC ACID ON EDIBLE FILMS

2. 1. Lauric Acid

Lauric acid, a medium length- long chain fatty acid is found in the form of glycerides in a number of natural's fats, coconut oil and palm-kernel oil. It offers advantages in food processing as it acts as a kind of preservative, staving off oxidation and spoiling. Lauric acid has been shown to have an antimicrobial effect against gram positive bacteria and yeasts [16][17]. Lauric acid, which is the major form of fatty acid in VCO, have recently shown to induce apoptotic changes in various colorectal cancer cells mediated by reactive oxygen species[18].

2. 2. Edible Film

The term "edible film" has two main considerations. First part is "edible", means that films may be consumed together with in contact so they need to cover all properties of safe food ingredients according to Food and Drug Administration (FDA) having Generally Recognized As Save (GRAS) status[4]. Second part is "films" means covering material should have packaging properties which protect the inner part from outer environment and limit gas and water vapor transportation between food material and outside. Formerly, edible film was used to protect food materials by functioning as a barrier to gas, and moisture migration. Recently, edible films can be used with more functional features such as encapsulation of aroma volatiles, vitamins, flavouring agents, antimicrobials and antioxidants[4][5].

A typical edible film has three major components, film forming materials, plasticizer and additives. Proteins, polysaccharides, lipids and combination or mixture of these are major film forming materials[5]. Functional additives such as plasticizers, antioxidants, vitamins, antimicrobial agents, essential oils, pigments and chemical preservatives are used to improve protective properties of edible films[5][19. Additionally, edible films need a suitable solvent in order to prepare a film forming dispersion (FFD). Mostly water, alcohol or aqueous alcohols are used as solvents according to natural solubility characteristics of film forming materials[20].

2. 3. Preparation of Edible Film Containing Lauric Acid

Hydrophobic materials such as lipid, wax and fatty acid, have been directly incorporated into gelatin-based films to improve their water resistance and water vapor barrier properties[21][22][23]. However the direct addition of hydrophobic substance to gelatin film forming solutions might not permanently alter the properties of gelatin film since those substances could migrate from the film matrix. Protein/lipid films can be formed using two methods. One method to form emulsions and films is to prepare an emulsion of protein–lipid complexes by a physical treatment (for example, homogenising) and then to create the film by coating and drying. Another method is to form an edible film under different phases[24].

In recent papers, lauric acid has been incorporated in starch for preparing the amylose-lipid inclusion complexes[25][26]. Wang et al. (2019)[27] has investigated different treatment methods to create potato starch-lauric acid complex and it effects on film properties. The treatment methods used on the study were simple mixing (Control), ultrasonic treatment (UT), dimethyl sulfoxide heating (DSH), and pullulanase debranching (PD). The DSH, UT and PD methods facilitated swollen starch to release amylose molecules. The PD method had highest complexing index, showed that the method was more effective at forming PS-LA complexes than the Control, DSH, and UT methods. The composite films prepared by the PD method exhibited better mechanical and moisture barrier properties than films prepared by Control, DSH and UT methods.

Lauric acid mostly incorporated into polysaccharides/protein-based films as the only fatty acid content, but several studies have done different thing. Bertan et al. (2005)[28] incorporated lauric acid into gelatin, triacetin and blend of stearic and palmitic acid film. It is quiet interesting that lauric acid and two different fatty acids contained in one film. The film forming solution prepared by hydrating 10 g gelatin for 1 h and warmed at 90°C per 10 min. Triacetin (15% w/w dry gelatin) plus stearic-palmitic acid blend (10% each one; w/w dry gelatin) and lauric acid (1, 2.5, 5, 10% w/w dry gelatin) were heated. Then the solutions were mixed and stirred using a magneting stirrer.

2. 4. Effect of Lauric Acid on Edible Film Properties

Fatty acids are embedded in the amylose hydrophobic cavity to form a single helical complex, which is stabilized through

hydrophobic interactions[29][30]. Starch is one of the most popular film forming material. In recent papers, lauric acid has been incorporated in starch for preparing the amylose-lipid inclusion complexes. Lauric acid was more strongly bound with amylose than other fatty acids with longer carbon chain length[31]. Meng et al. (2014)[32] found that the corn starch with long carbon chain fatty acids had lower complexing index values than corn starch with lauric acid due to their poor dispersivity in gelatinized starch.
Several studies about incorporating lauric acid on edible films and its effects on the film properties shown in Table 1.

Table 1. Summary of research studied lauric acid on edible films

System Of Application	Effects (Improvements/ Reducements)	Reference
Unriped banana starch	· Lower water vapor permeability · Higher opacity · Lower luminosity · Higher tensile strength	Sartori&Menegalli (2016)[33]
Wheat starch, chitosan	· More effective antimicrobial ability	Salleh& Muhamad (2007) [34]
Rice starch, ι-carrageenan	· Smoother and uniform surface · Lower solubility · Lower water vapor permeability · Higher opacity · Higher tensile strength	Thakur et al. (2017) [15]
Native cassava starch, poly (butylene adipate-co-terephthalate) (PBAT)	· Homogenous and compact structure · Increase elongation · Decrease water vapor permeability	Nobrega et al. (2011) [35]
Gelatin, wheat gluten	· Lower water vapor permeability · Higher opacity · Slightly higher solubility · Lower intensity phase transition	Fakhouri et al. (2018) [12]
Gelatin, triacetin, a blend of stearic and palmitic acid	· Decrease water vapor permeability · Decrease tensile strength · Increase elongation · Increase solubility · Increase opacity	Bertan et al. (2005) [28]
Methyl cellulose (MC), polyethylene glycol (PEG)	· Improvement of water barrier properties · Increase CO_2 transmission	Ayranchi&Tunc (2001) [13]

Main purpose of incorporating lauric acid into edible films mostly to improve moisture and water barrier properties of the films. Wong et al[] studying the effect of addition of fatty acids in chitosan films produced by casting method, showed that the incorporation of lauric acid reduced the water vapor permeability to 49% when compared to control. According to Nobrega et al.[35], who studied how the incorporation of fatty acids affected the mechanical and barrier properties of cassava starch films, the addition of short-chain fatty acids like lauric acid facilitates fatty acid incorporation into a polymeric film matrix and decreases the WVP considerably at relative humidity values ranging from 33 to 64%. Similar results was reported on other studies that incorporation of lauric acid into edible films could decrease water vapor permeability of the films due to hydrophobicity of the fatty acid[12][28][33].

The addition of lauric acid increased the film opacity [12][15][28][33] with a tendency to increase with increasing concentration of lauric acid. This may be attributed to the physical state of the fatty acid (solid) at room temperature. The incorporation of lipids to the hydrocolloid mixture resulted a decrease in the transparency values probably due to the differences in the refractive index of the dispersed and continuous phase. The results of this study are similar to those reported previously which found that incorporation of fatty acids lowered the transparency of films[36].

Incorporated lauricacid into rice starch-carageeenan based films tend to reduced the solubility of films. Solubility value of LA films was 50.31±1.41%, lower than control films (without fatty acid) and films that contain other fatty acid (stearic, palmitic, butyric, and fatty acid ester). Low solubility value of LA could be attributed to formation of strong stable helices formed between amylose and lipid content whic formed an insoluble film on the starch granule surface and delayed the transportation of water into the granule [15].

Incorporating lauric acid and chitosan into starch based film showed more effective antimicrobial ability against *B. subtilis* and *E. coli* [34]. and the film had synergistic antimicrobial effect when chitosan and lauric acid were combined. The starch-based film incorporated with lauric acid and chitosan showed better flexibility than when purely starch-based film was formulated. The solution of starch and chitosan with different mixing ratios (w/w) 8:2 and 9:1 were the most effective ratio with greater inhibition on both *B.subtilis* and *E. coli* than other solution in agar plate and liquid culture test. The control (pure wheat starch) and antimicrobial (AM) film (incorporated with chitosan and lauric acid) were produced by casting method. A wide clear zone on solid media was observed for *B. subtilis* growth inhibition whereas inhibition for *E. coli* was not as effective as *B. subtilis*. From the liquid culture test, the AM films clearly demonstrated a better inhibition against *B*. *subtilis* than *E*. *coli*.

3. CONCLUSIONS

Many researchers studied different properties of edible films affected by lauric acid (preparation methods, physical, mechanical, water barrier, antimicrobial properties). Their results show that lauric acid is a promising material for edible films that it tends to lower the water vapor permeability and have antimicrobial ability against food pathogen bacterial. It can be useful for preserving and extending the shelf life of foods. However, it tends to produced more opaque films that could limit it uses as food packaging.

References

[1] T. Janjarasskul, J.M. Krochta. Edible packaging materials. *Annual Review of Food Science and Technology,* 1 (2010) 415-448.

[2] A. Nawab, F. Alam, M.A. Haq, Z. Lutfi, A. Hasnain. Mango kernel starch-gum composite films: Physical, mechanical and barrier properties. *International Journal of Biological Macromolecules,* 98 (2017) 869-876.

[3] J.H. Han. *Food Technology* 54 (2000) 56-65.

[4] O. Erkmen, T.F. Bozoglu. Food Microbiology: Principle into Practice. John Wiley and Sons Ltd, Chicester, UK. (2016) p. 458.

[5] J.H. Han. Innovation in food packaging. (2014). In: J.H. Han, Edible films and coatings: A review. Academic Press, London. P. 231-255.

[6] T. Bourtoom. Review article edible films and coatings: Characteristics and properties. *International Food Research Journal,* 15 (2008) 237-248.

[7] V. Falguera, J.P. Quintero, A. Jiménez, J.A. Muñoz, A. Ibarz. Edible films and coatings: Structures, active function and trends in their use. *Trend in Food Science and Technology,* 22 (2011) 291-303.

[8] V. Morillon, F. Debeaufort, G. Blond, M. Capelle, A. Voilley. Factors affecting the moisture permeability of lipid-based edible films: A review. *Critical Review In Food Science and Nutritions,* 42 (2002) 67-89.

[9] J.W. Rhim. Physical and mechanical properties of water resistant sodium alginate films. LWT - *Food Science and Technology,* 37(3) (2004) 323-330.

[10] Y. Xu, X. Ren, M.A. Hanna. Chitosan clay nano composites films preparation and characterization. *Journal of Applied Polymer Science,* 99(4) (2006) 1684-1691.

[11] B. Arifin, P. Sugita, D.E. Masyudi. Chitosan and lauric acid addition to corn starch-film based effect: physical properties and antimicrobial activity study. *International Journal of Chemical Science,* 14(2) (2006) 529-544.

[12] F.M. Fakhouri, S.M. Martelli, T. Caon, J.I. Velasco, R.C. Buontempo, A.P. Bilck, L.H.I. Mei. The effect of fatty acids on the physicochemical properties of edible films composed of gelatin and gluten proteins. *LWT- Food Science and Technology,* 87 (2018) 293-300.

[13] E. Ayranchi, S. Tunc. The effect of fatty acid content on water vapour and carbon dioxide transmissions of cellulose-based edible films. *Food Chemistry,* 72 (2001) 231-236.

[14] L.C. Bertan, P.S. Tanada-Palmu, A.C. Siani, C.R.F. Grosso. Effect of fatty acids and Brazilian elemi on composite films based on gelatin. *Food Hydrocolloids,* 19 (2005) 73-82.

[15] R. Thakur, P. Pristijono, J.B. Golding, C.E. Stathopoulos, C.J. Scarlett, M. Bowyer, S.P. Singh, Q.V. Vuong. Amylose-lipid complex as a measure of variations in physical, mechanical and barrier attributes of rice starch-ι-carrageenan biodegradable edible film. *Food Packaging and Shelf Life,* 14 (2017) 108-115.

[16] L.R. Beuchat, D.D. Golden. Antimicrobial occurring naturally in foods. *Food Technology,* 43 (1989) 134-142.

[17] J.J. Kabara. Medium-chain fatty acids and esters. In P.M. Davidson and A.L. Branen. Antimicrobials in foods. New York: Marcel Dekker (1993) p. 307-342.

[18] J.K. Fauser, G.M. Matthews, A.G. Cummins, G.S. Howarth. Induction of apoptosis by the medium-chain length fatty acid lauric acid in colon cancer cells due to induction of oxidative stress. *Chemotheraphy,* 59 (2013) 214-224.

[19] A. Cagri, Z. Ustunol, E.T. Ryser. Inhibition of three pathogens on bologna and summer sausage using antimicrobial edible films. *Journal of Food Science,* 67 (2002) 2317-2324.

[20] O. Erkmen, A.O. Barazi. General characteristics of edible films. *Journal of Food Biotechnology Research,* 2 (2018) 1-4.

[21] K. Limpisophon, M. Tanaka, K. Osako. Characterisation of gelatin-fatty acid emulsion films based on blue shark (Prionaceglauca) skin gelatin. *Food Chemistry,* 122(4) (2010) 1095-1101.

[22] M. Soazo, A. Rubiolo, R. Verdini. Effect of drying temperature and beeswax content on physical properties of whey protein emulsions films. *Food Hydrocolloids,* 25 (2011) 1251-1255.

[23] A. Nor Amalini, M.H. Norziah, I. Khan, M.K.M. Haafiz. Exploring the properties of modified fish gelatin films incorporated with different fatty acid sucrose esters. *Food Packaging and Shelf Life,* 15 (2018) 105-112.

[24] H. Pan, B. Jiang, J. Chen, Z. Lin. Blend-modification od soy protein/lauric acid edible films using polysaccharides. *Food Chemistry,* 151 (2014) 1-6.

[25] F. Chang, X. He, Q. Huang. Effect of lauric acid on the v-amylose complex distribution and properties of swelled normal corn starch granules. *Journal Cereal Science*, 58 (2013) 89-95.

[26] B. Zhang, Q. Huang, F.X. Luo, X. Fu. Structural characterizations and digestibility of debranched high-amylose maize starch complexed with lauric acid. *Food Hydrocolloids,* 28 (2012) 174-181.

[27] M.C. Tang, L. Copeland. Analysis of complexes between lipids and wheat starch. *Carbohydr Polymer,* 67 (2007) 80-85.

[28] R. Wang, P. Liu, B. Cui, X. Kang, B. Yu. Effects of different treatment methods on properties of potato starch-lauric acid complex and potato starch-based films. *International Journal of Biological Macromolecules,* 124 (2019) 34-40.

[29] L.C. Bertan, F.M. Fakhouri, A.C. Siani, C.R.F. Grosso. Influence of the addition of lauricc acid to films made from gelatin, triacetin and blend of stearic and palmitic acids. *Macromolecular Symposia,* 229 (2005) 143-149.

[30] T. Sartori, F. Menegalli. Development and characterization of unripe banan starch films incorporated with solid lipid microparticles containing ascorbic acid. *Food Hydrocolloids,* 55 (2016) 210-219.

[31] E. Salleh, I. Muhamad, N. Khairuddin. Preparation, characterization and antimicrobial analysis of antimicrobial starch-based film incorporated with chitosan and lauric acid. *Asian Chitin Journal,* 3 (2007) 55-68.

[32] M.M. Nobrega, J.B. Olivato, M.V.E Grossmann, E. Bona, F. Yamashita. Effects of the incorporation of saturated fatty acids on the mechanical and barrier properties of bidegradable films. *Journal of Applied Polymer Science,* 124(5) (2012) 3695-3703.

[33] S. Immel, F.W. Lichtenthaler. The hydrophobic topographies of amylose and its blue iodine complex. *Starch-Starke,* 52 (2000) 1-8.

[34] W.T. Winter, A. Sarko. Crystal and molecular structure of v-anhydrous amylose. *Biopolymers,* 13 (1974) 1447-1460.

[35] S. Meng, Y. Ma, J. Cui, D.W. Sun. preparation of corn starch-fatty acid complexes by high-pressure homogenization. *Starch-Starke,* 66 (2014) 809-817.

[36] L. Yang, A.T. Paulson. Mechanical and water vapor barrier properties of edible gellan films. *Food Research International*, 33(7) (2000) 563–570.