Journal of Chemical Health Risks

www.jchr.org

ORIGINAL ARTICLE

Biodegradable Films Based on Cassava Starch/*Mentha piperita* Essence: Fabrication, Characterization and Properties

Vajihesadat Moosavian[1], Mohammad Mehdi Marvizadeh[*2], Abdorreza Mohammadi Nafchi[2]

[1]Department of Food Science and Technology, Damghan Branch, Islamic Azad University, Damghan, Iran

[2] Young Researchers and Elite Club, Damghan Branch, Islamic Azad University, Damghan, Iran

(Received: 18 September 2016 Accepted: 21 November 2016)

KEYWORDS

Cassava starch;
Edible film;
Physicochemical properties;
Mentha piperita essence

ABSTRACT: In this study, the effect of *Mentha piperita* essence (MPE) incorporation into cassava films on the hydrophilic and physicochemical properties of the resulting biodegradable films was investigated. The properties included solubility, moisture uptake and contact angle. MPE was added into biodegradable films at different amounts (1, 2 and 3%, w/w total solid). All biofilms were plasticized with 40 % (w/w total solid) combination of glycerol / sorbitol at 1:3 ratio. The incorporation of MPE into cassava films decreased solubility. The moisture uptake of the edible films was found to decrease by MPE reinforcement, and hydrophilic property of biofilms was decreed by increasing MPE.

INTRODUCTION

Food packaging can increase shelf life by avoiding bacteria, spoilage or protection food nutrients [1, 2]. For the past decade, synthetic plastic were used for food packaging to protective food products. Synthetic plastics used in different applications are derived from non-renewable plastic resources [3]. Food packaging based on nonbiodegradeable plastic is the main type contributors to waste and some compound can be recycled and recovered. Many non-renewable polymers based on petroleum materials are in the environment or landfill [4]. Damages related to packaging based on synthetic polymers used have driven numerous researchers to discover and fabricate biopackaging used in industrial packaging [5, 6]. Therefore increasing concerns of non-renewable plastic lead to the development of biodegradable packaging, which is a novel packaging [3].The use of a natural polymer can be a fine solution because biopolymers are edible and biodegradable [7]. Beside, biodegradable films based on natural polymer can prevent food products against microbial contamination [8].

Improving nutritional value, food quality and biodegradable are the reasons of developing packaging and edible coating. Biofilms can be

* Corresponding author: engmmarvi@gmail.com (M.M. Marvizadeh).

manufactured from proteins, lipids, polysaccharides or their combination [9]. On the other hand, high water vapor transfers in foods stuff, affected on quality, safety and stability. Rapid water vapor between the food products and the atmosphere completely cover the food product with coating or edible film is reduced [10]. The end of biofilm is not only to produce safety food but also to enhance food quality and improve food properties [7].

Among natural polymers, starches have received so much interest for its potential use as edible and biodegradable film, because starches have shown mechanical properties better than polysaccharides that can act as gases barriers [11]. Mechanical parameters of edible films based on starch are influenced by special factors for example amylopectin to amylose ratio in starch macromolecule that plays a main role in the mechanical strength properties of the edible films. Starches biofilms are renewable products that are cost, transparent, semi-transparent, readily available and highly safe. Due to biodegradability, taste-less, flavorless and colorless, starch is of the base materials used for edible coating. However, starch biofilms alone have some defects such as brittleness and poor mechanical properties [12].

Although most natural polymers possess fine properties that are comparable with those of nonrecycled plastics, certain properties such as high permeability and hydrophilic property, limit their applications. Therefore, studies works on biodegradable macromolecule have recently focused on improving their vapor barrier and water resistance [13].

A kind of starch, cassava, was extracted from root of cassava herb. Due to high molecular weights of amylopectin and amylose, low level of residual compounds (fat, ash and protein) amylose, starch obtained from cassava is differentiated from other native starches [14].

Due to increasing public concerns regarding the food healthy and safety incorporation of active compounds into packaging materials has attracted so much attention. Active packaging is ‘a type of packaging that changes the condition of the packaging to extend shelf life or improve safety or sensory properties while maintaining the quality of the food’ (European FAIR project CT 98-4170). The end of active packaging is to increase shelf life, protect food quality and improve food properties [15]. Active packaging, one of the novel packaging concepts, has attracted many studies in food preservation [16]. “Active ingredients can be added into biofilms and edible coatings to provide new functions that do not exist in neat coatings” [17]. Biopackaging may carry essence, antioxidants, colors, oxygen scavenger, antimicrobial, herb exctraction and fortified nutrients [18, 19].

Despite new findings in epidemiological searches and food safety, have illustrated that the number of infections caused by pathogenic microorganisms of food [20]. Therefore, one of the main challenges for food industries is the design and produce of active packaging. Essential oils from spices or plants are fine sources of natural active compounds such as phenolic acids and terpenoids. The ability of herbal essential oils to protect foods stuff against pathogenic and infection microorganisms has been explained by several studies [21].

Therefore, the goal of this paper was to develop an essence film based on cassava starch and *Mentha piperita* essence; and the effect of the addition of *M. piperita* essence on the hydrophilic as well as physicochemical properties of biofilms to test their potential applications as novel essence packaging.

MATERIALS AND METHODS

Cassava starch was purchased from SIM Company

(Malaysia). Food-grade sorbitol and Food-grade glycerol were obtained from Sigma–Aldrich (USA).

Edible Film preparation

Aqueous suspension of cassava starch was prepared by dispersing 4 g of cassava powder in 100 mL of distilled water to obtain a 4% w/w native starch solution, using a magnetic stirring plate at 87 °C and 750 rpm for 45 min and then cooled to 37 °C. As the cassava biofilm was brittle, 1.6 g of glycerol and sorbitol (1:3) [22] was added into the biofilm suspension. Appropriate levels of *M. piperita* essence were added into the suspension, to reach an end level of 1%, 2%, 3% w/w, on the basis of pure cassava starch solution, and added to starch dispesion. The cassava starch/MPS solutions (92 cc) were cast in casting plate with dimension of 16 × 16 cm, then dried at control conditions (RH = 50% and T = 35 C) to prepare essence films. Dried biofilms containing MPS were then peeled and placed in a humidity champer at 23 C and 50% relative humidity until determination. The neat film of cassava starch was fabricated similarly but without incorporation of MPS.

Contact angle measurements of cassava starch films

Contact angel of the biofilms was determined using static contact-angle meter (CAM-PLUS, Tantec, Germany). Results presented are the means of four independent measurements at different film samples. The hydrophobicity of cassava starch film was determined from contact angle measurement, based on sessile drop Half-AngleTM Tangent line method [23].

Moisture uptake of cassava starch films

Moisture uptake of films (110ºC for 3s) was determined [24] with slight modifications for biodegradable films. The edible films were cut to 25 mm × 25 mm and conditioned by $CaCl_2$ in an oven at 40 °C for 24 h. Film samples were weighed (w_i) and placed into desiccators containing deionized water for 24 h. At last, edible films were weighed (w_f). Moisture uptake of biofilms was calculated as follows:

$$\text{Moisture uptake} = \frac{W_f - W_i}{W_i}$$

Water solubility of cassava starch films

Water solubility of the films was determined [25]. For water solubility measurement, each biofilm sample was cut into 20 × 30 mm pieces and dried by $cacl_2$ salt in an oven at 40 °C for 1 d. Then film samples immersed in 80cc-deionized water and stirred via agitator at 25°C for 1 h. The remaining Film pieces were filtered using a Whatman No. 1 tissue, at last oven at 60°C to be dried. Data of water solubility of cassava starch were computed using the following equation:

$$\text{Solubility (\%)} = \frac{\text{Initial film (w)} - \text{Final film}}{\text{Initial film (w)}}$$

STATISTICAL ANALYSIS

The one way ANOVA and Tukey's post hoc tests were conducted to compare the means of physicochemical and hydrophilic properties of cassava starch/*M. piperita* essence films at 5% significance level. Data analysis was conducted using GraphPad Prism version 6.

RESULTS AND DISCUSSION

Hydrophobic effects of Mentha piperita essence

Most of the natural polymers are sensitive to water. Generally, the effects of fillers on the contact angel of biofilms depend on the type of additive and its concentration and hydrophobicity indices [26].

Contact angel of cassava starch films incorporated with *M. piperita* essence at different amounts is shown in Figure 1. Contact angel increased when MPE levels increased. Contact angel increased from 59.83 degree for control film to 71.57 for cassava film containing 3% MPE. Biofilms containing 3% MPE exhibited higher hydrophobicity in comparison with those without MPE. Therefore, incorporation of MPE to cassava starch decreased absorbs water and films became less hydrophilic. This result is likely due to hydrophobic effects of MPE, which reduced the hydrophilic property of biodegradable film, consequently resulting to a more contact angel [25]. These findings are in agreement with another study on biodegradable film [27].

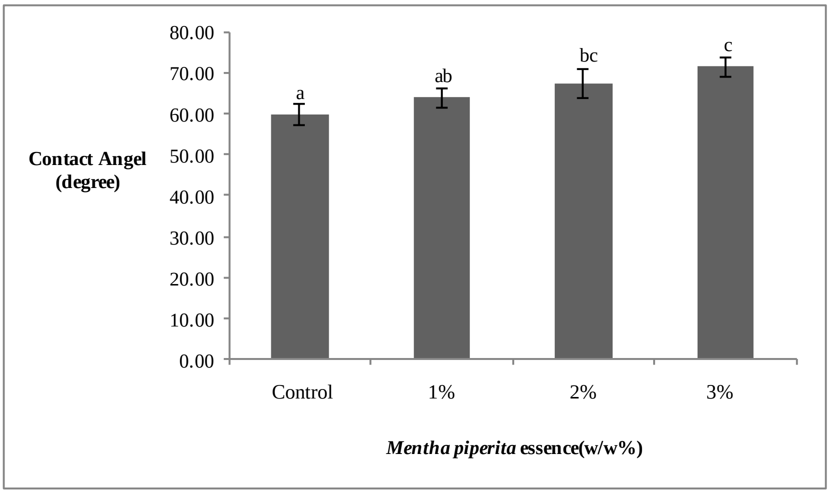

Figure 1. Effects of MPE content on contact angel of cassava starch films. Bars show the mean ± Standard Deviation. Different small letters on concetration shows significant difference at 95% level of confidence among cassava films

Moisture uptake

The moisture uptake value varied from 0.99 to 0.46 g water/g dried film as presented in Figure 2. Incorporation of MPE affected the moisture uptake of the starch edible films. The moisture uptake value tended to decrease as low amount of MPE was incorporated. Incorporation of low concentration essence to starch films significantly decreased the moisture uptake of edible film (P<0.05). However, no significant difference was observed between 2% and 3% essence level (P>0.05). This result is likely due to the addition hydrophobic essence, which reduced H-bonding among biopolymer matrix and water, consequently resulting to a less water absorption biopolymer [25]. The moisture uptake of the starch film containing different level of eucalyptus extract was lower than that of neat film [28].

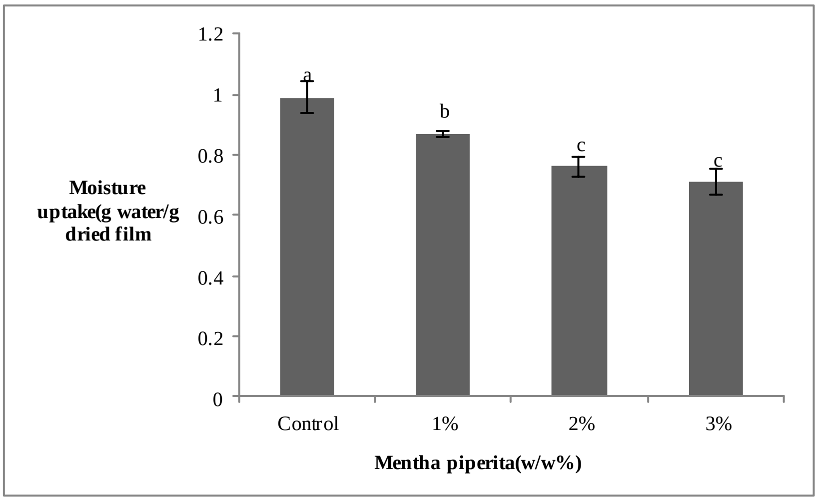

Figure 2. Effects of MPE content on moisture uptake of cassava starch films. Bars show the mean ± Standard Deviation. Different small letters on concetration shows significant difference at 95% level of confidence among cassava films

Solubility in water

Solubility in water of the biofilm is important factors in packaging industry. Solubility may be an important parameter in defining applications for biopolymer films. By addition nanoparticles, extraction or lipids, absorb water could be decreased [26, 29, 30]. The solubility in water of the cassava starch/ MPE films is presented in Figure 3. Results indicated that MPE affected on solubility in water of cassava starch films significantly. Addition 3% of essence to cassava films decreased the solubility by 22%. On the other hand, there was no significant difference between solubility of essence films containing 2, and 3% MPE (*P*>0.05). The water solubility of the biofilms was also consistent with the moisture uptake and contact angel results. Decreasing water solubility of the edible films is related to the reduction the availability of the hydroxyl group (OH) to interact with water. These findings are consistent with previous studies on biodegradable film [25, 28].

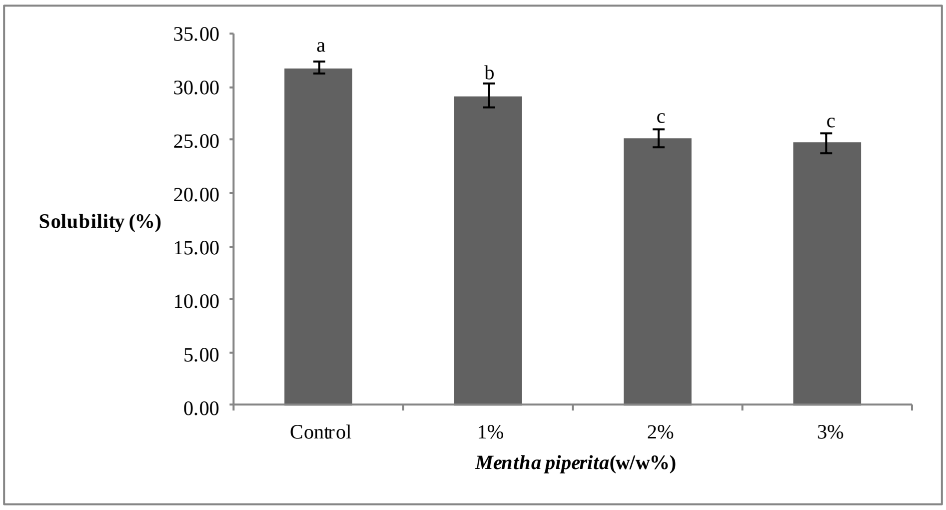

Figure 3. Effects of MPE content on solubility of cassava starch films. Bars show the mean ± Standard Deviation. Different small letters on concetration shows significant difference at 95% level of confidence among cassava films.

CONCLUSIONS

In this paper, we added *M. piperita* essence to the cassava starch film to fabricate essence film. All essence films indicated significant improvement in moisture uptake when compared with control film. Cassava starch/MPE film improved the water sensitive of biodegradable film in comparison with neat sample.

The addition of essences decreased the hydrophilic property of biofilms made from cassava starch. *M. piperita* essence incorporated to cassava biofilms have potential applications in agriculture and food packaging.

ACKNOWLEDGMENTS

The authors declare that there is no conflict of interest.

REFERENCES

1. Brody A.L., 2003. Nano food packaging technology. Food Technol. 57(12), 52–54.
2. Chaudhry Q., Scotter M., Blackburn J., Ross B., Boxall A, Castle L, et al., 2008. Applications and implications of nanotechnologies for the food sector. Food Addit Contam. 25(3), 241–258.
3. Zhao R., Torley P., Halley P.J., 2008. Emerging biodegradable materials: starch-and protein-based bio-nanocomposites. Jf Mater Sci. 43(9), 3058-3071.

4. Pelissari F.M., Grossmann M.V.E., Yamashita F., Pineda E.A., 2009. Antimicrobial, mechanical, and barrier properties of cassava starch–chitosan films incorporated with oregano essential oil. J Agricult Food Chem. 57, 7499–7504.

5. Ghanbarzadeh B., Almasi H., 2011. Physical properties of edible emulsified films based on carboxymethyl cellulose and oleic acid. Int J Biol Macromol. 48, 44–49.

6. Sorrentino A., Gorrasi G., Vittoria V., 2007. Potential perspectives of bionanocomposites for food packaging applications. Trends Food Sci Technol. 18, 84–95.

7. García M.A., Martino M.N., Zaritzky N.E., 2001. Composite starch-Based coatings applied to strawberries (Fragaria ananassa). Food/Nahrung. 45(4), 267–272.

8. Tavassoli-Kafrani E., Shekarchizadeh H., Masoudpour-Behabadi M., 2016. Development of edible films and coatings from alginates and carrageenans. Carbohydr Polymers. 137, 360-374.

9. Cagri A., Ustunol Z., Ryser E.T., 2004. Antimicrobial edible films and coatings. J Food Prot. 67, 833–848.

10. Brandenburg A.H., Weller C. L., Testin R.F., 1993. Edible Films and Coatings from Soy Protein. J Food Sci. 58, 1086-9.

11. Lourdin D., Della Valle G., Colonna P., 1995. Influence of amylose content on starch films and foams. Carbohydr Polymers. 27(4), 261–270.

12. Li J.H., Hong R.Y., Li M.Y., Li H.Z., Zheng Y., Ding J., 2009. Effects of ZnO nanoparticles on the mechanical and antibacterial properties of polyurethane coatings. Prog Org Coat. 64, 504–509.

13. Dean K., Yu L., 2005. Biodegradable protein-nanocomposites. In: Smith R (ed) Biodegradable polymers for industrial application. CRC Press, Boca Raton. pp. 289–309

14. Burt S., 2004. Essential oils: Their antibacterial properties and potential applications in foods: A review. Int J Food Microbiol. 94, 223–253.

15. Vermeiren L., Devlieghere F., Beest M.V., Kruijf N.D., Debever J., 1999. Developments in the active packaging of foods. Trends in Food Sci Technol. 10, 77-86.

16. Siripatrawan U., Harte B.R., 2010. Physical properties and antioxidant activity of an active film from chitosan incorporated with green tea extract. Food Hydrocolloids. 24(8), 770-775.

17. Quintavalla S., Vicini L., 2002. Antimicrobial food packaging in meat industry. Meat Sci. 62, 73-380.

18. Han J.H., 2001. Edible and biodegradable films/coatings carrying bioactive agents. Available from: www.den.davis. ca.us / ~ han / CyberFoodsci / volume 2001. htm. Downloaded in May 2001.

19. Pena D.C.R., Torres J.A., 1991. Sorbic acid and potassium sorbate permeability of an edible methylcellulose-palmitic acid films: water activity and pH effects. J Food Sci. 56(2), 497–499.

20. Rojas-Graü M.A., Avena-Bustillos R.J., Friedman M., Henika P.R., Martin-Belloso O., McHugh T.H., 2006. Mechanical, barrier, and antimicrobial properties of apple puree edible films containing plant essential oils. J Agricult Food Chem. 54, 9262–9267.

21. Souza A.C., Goto G.E.O., Mainardi J.A., Coelho A.C.V., Tadini C.C., 2013. Cassava starch composite films incorporated with cinnamon essential oil: Antimicrobial activity, microstructure, mechanical and barrier properties. LWT-Food Sci Technol. 54(2), 346-352.

22. Mohammadi Nafchi A., Cheng L.H., Karim A.A., 2011. Effects of plasticizers on thermal properties and heat sealability of sago starch films. Food Hydrocolloids. 25, 56-60.

23. Mohammadi Nafchi A., Alias A.K., Mahmud S., Robal M. 2012. Antimicrobial, rheological, and physicochemical properties of sago starch films filled with nanorod-rich zinc oxide. J Food Eng. 113(4), 511-519.

24. Tajik S., Maghsoudlou Y., Khodaiyan F., Jafari S.M., Ghasemlou M., Aalami M., 2013.

Soluble soybean polysaccharide: A new carbohydrate to make a biodegradable film for sustainable green packaging. Carbohydr Polymers. 97(2), 817–824.

25. Maizura M., Fazilah A., Norziah M.H., Karim A.A., 2007. Antibacterial Activity and Mechanical Properties of Partially Hydrolyzed Sago Starch–Alginate Edible Film Containing Lemongrass Oil. J Food Sci. 72, C324-C330.

26. Pavlath A., Orts W., 2009. Edible Films and Coatings: Why, What, and How? In: Huber KC, Embuscado ME, eds. Edible Films and Coatings for Food Applications: Springer New York; 2009:1.

27. Ramírez C., Gallegos I., Ihl M., Bifani V., 2012. Study of contact angle, wettability and water vapor permeability in carboxymethylcellulose (CMC) based film with murta leaves (Ugni molinae Turcz) extract. J Food Eng. 109(3), 424-429.

28. Rojhan M., Nouri L., 2013. Antimicrobial, Physicochemical, Mechanical, and Barrier Properties of Tapioca Starch Films Incorporated with Eucalyptus Extract. J Chem Health Risks. 3(3), 43-52.

29. Marvizadeh M.M., Mohammadi Nafchi A.R., Jokar M., 2014. Preparation and Characterization of Novel Bionanocomposite Based on Tapioca Starch/Gelatin/Nanorod-rich ZnO: Towards Finding Antimicrobial Coating for Nuts. Journal of Nuts. 5(2), 39-47.

30. Marvizadeh M.M., Mohammadi Nafchi A., Jokar M., 2014. Improved physicochemical properties of tapioca starch/bovine gelatin biodegradable films with zinc oxide nanorod. J Chem Health Risks. 4(4), 25-31.