STUDY ON EFFICACY OF EDIBLE PROTEIN-BASED FRUIT COATING TO DELAY THE RIPENING OF BANANA (MUSA SPP)

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ABSTRACT

The main goal of postharvest handling is to extend the shelf life and maintaining the quality of produce. One of the methods is by introducing coating in postharvest handling activities. Coating can create artificial layer that will reduce water loss and maintaining the strength of peel tissue and retain fruits volatile compound. Softening of banana is a major postharvest problem in banana. The softening is more severe during later stage of maturity hence delaying the ripening can prolong shelf life of bananas. Two source of readily available protein isolate from soy (SPI) and whey (WPI) protein isolate at different concentration (5% and 10%) were use as base of coating and formulated according to previous study. Berangan Bananas hand were coated and air dried before packed in CFB box and stored at ambience. SPI 5% shows the best result in term of percent of weight loss. WPI formulation are not suitable as it is too sticky and took long time to dry on fruit surface. An in vitro study was conducted to evaluate potential essential oil which is betel leaf, cinnamon, clove, eucalyptus, thyme and garlic to incorporate into the formulation. Results shows that clove's EO can significantly control the growth of Colletotrichum sp. The essential oils were then incorporate into 5% SPI formulations at 1% to observe effects on banana. All coated fruits show positive response in delaying ripening with clove and garlic formula sample shows best result. However, further studies need to be conducted to stabilize the formulation to ensure essential oils can mixed evenly with the protein base.

Key words: edible film, essential oil, shelf life, soy protein isolate

INTRODUCTION

Edible coating (EC) has garnered consumer attention as an alternative to the synthetic coating that derived from petroleum-based or plastics materials. EC will build thin layers of film when applied directly to the food or fruits surface that will act as barrier to protect and improve product quality. The most important properties of coatings are edibility and biodegradability, migration, permeation, and barrier functions, physical and mechanical protection, allowing the quality preservation and shelf-life extension (Palou *et al.*, 2015). Coatings can be prepared from various sources such as polysaccharides, proteins, lipids and composites that can be eaten directly without removing the layer. Protein based is one of important source of EC since it can give impressive gas barrier and provide better mechanical properties compared to lipids and polysaccharides. Protein used in EC is usually in forms of isolate protein powder that can come from plant source (Soy protein isolate) or dairy/poultry industry (Whey protein isolate, Albumin). Although protein-based EC can provide good oxygen barrier, it has been reported to be inefficient against moisture loss. Thus, cross linking agents are added to improve the protein structure by imposing the use of physical, chemical or enzymatic means. Although currently this type of coating is mostly applied on fresh cut fruits or seafoods products, this study was conducted to assess its effectiveness on skin of whole fruit such as bananas.

MATERIALS AND METHODS

Soy and Whey protein isolate coating preparation
Soy and whey protein isolate with more than 90% protein content in a powder form were obtained from supplier. Both coatings were prepared according to the method described by Ghavidel *et al* (2013) where 5% of SPI, 2.5% glycerol mixed evenly with distilled water. pH meter was used to measure pH value of solution before adjusting using 1 M sodium hydroxide until reached 10 ± 1 pH. Solutions were then heated for 20 minutes at 70C in water bath. For WPI coating, 5% WPI were dissolved in distilled water before placing the solution in the water bath at 90C for 30 minutes to ensure protein denaturation. Glycerol (50%, w/w) as plasticizer were added to the solution after its cooled to room temperature and stirred until completely dissolved.

Sample preparation and coating
Banana var. Berangan in a bunch were obtain from local farmer in Kedah, Malaysia at mature green stage. By using clean and sharp knife, hands of banana were removed from main stem. Fruits were dipped into 1% aluminium sulfate water to stop the latexes and removing any remaining debris or dirt before dipped into the coating solution until the fruits were evenly coated and air dried before put into corrugated fiberboard (CFB) box. Samples were stored at ambience temperature for observation and analysis. Fruits were weighed every week to monitor weigh loss

Fruit quality assessment
Quality assessments were done to evaluate soluble solid contents (SSC), pH, titratable acidity (TA), ascorbic acid and sugar acid ratio. Soluble solid contents were measured by using digital handheld refractometer, ATAGO CO. LTD PAL-α while pH was taken by using pH meter model HANNA Instrument HI2211. Titratable acidity content was measured by titrating 20 mL extract from sample with 0.1 M 1-1NaOH until reach 8.2 pH while for ascorbic acid, 10 mL extract from 10g and 100ml 3% metaphosporic acid were titrated with standard dye until extract turn into faint pink colour

In Vitro and in vivo evaluation of essential oil effectiveness against Colletotrichum sp
Six type of essential oil of betel leaf, cinnamon, clove, eucalyptus, thyme and garlic were obtained from local suppliers. This EO were choose based on previous studies on its effectiveness against causal agent of postharvest diseases on banana. Autoclaved potato dextrose agar (PDA) (>125 plates) were prepared. PDA petri dishes were then marked with two perpendicular lines at the bottom to indicate the center of the plate. Treatment is applied by spreading 50 µl of EO on agar with hockey stick and after 1 day, the pathogen was aseptically transferred to the center of the plate. One line will be marked 'x' for easy data collection. Radial growth of the pathogen is measured daily at line 'x'. The percentage growth inhibition (PGI) was calculated. For the in vivo study, EO at 1% were added into 5% SPI formulation before the coating process of bananas hands.

Statistical analysis
Experiment was designed using Completely Randomized Design (CRD) with four replications. Statistical analysis was performed by using ANOVA and difference of means was determined by using Duncan Multiple Range Test at 5% level.

RESULT AND DISCUSSION

From the table, result from first study shows that there was no significant difference for the total titratable acidity and sugar acid ratio in bananas treated by different formulations. However, in term of weight loss, 5% SPI exude the best result to control the weight loss of the fruits (Figure 1). 10% SPI shows the lowest L reading which indicate the fruits color are greener than other treatments but, 10% SPI samples had experience much higher losses especially on day 6 (Figure 1). For the evaluations of effectiveness of adding essential oil into the formulation, an in vitro study was conducted using six difference sources of essential oil against *Colletotrichum sp*. Results shows that essential oil from clove can significantly reduce the growth of fungal (Table 2) while eucalyptus oil that had been autoclaved scored almost similar to the control plate which means the substance does not helping at all to control the fungal growth after been exposed to high temperature during autoclave process. Addition of essential oil into the formulation can upsurge the potential of formulation but it is noticeable during the study that some oils are not binding well into the formulation and causing dark spot lesion on bananas skin. Although soy protein has good ability to stabilize oil and water in emulsification process due to their amphipathic nature (Chuan-He T. 2015), fews modification needs to be done to ensure the essential oils can properly dissolve in the formulation to allow even dispersion to the skin of fruits.

Previous studies of edible coating are mostly focusing on fresh cut produce or frozen seafoods. In 2013, Ghavidel *et al* (2013) had evaluate the effects of edible coatings on fresh cut apples and the results shows that use of coatings can helps to extend the shelf lifes while maintaining the quality of produce. A study on fresh cut of apples, potatoes and carrots also shows similar results where edible coating can decrease weight loss of samples (Rossi Marquez *et al*.,2016). Coatings in whole fruits with the skin part still intact are more versatile and may come from various sources such as lipids, carbohydrates, wax and other. For example, treating pineapple with wax solution at 65 g L^{-1} for 1 minute demonstrate that it can effectively control the ripening by delaying color changes, lower the respiration rate and ethylene production (Li *et al*., 2018). Protein based coating used in this study also shows the ability to delay the ripening of bananas hence slowing the senescense process of fruits and at the same time can control tissue softening.

Table 1: Changes in soluble solids content (SSC), pH, total titratable acidity (TTA), ratio TSS/TTA, vitamin C content, and colour of fruit of Banana (Berangan) coated with different protein-based coatings at different storage day stored at ambience (24°C)

	SSC (°BRIX)	pH	TTA (% citric acid)	Ratio TSS/TTA	Vit C (mg/100g)	Fruit Colour		
						L	C	h°
Treatments (T)								
Control	8.14^{d}	5.998^{b}	0.675^{a}	0.380^{a}	21.396^{c}	29.376^{d}	27.647^{d}	103.876^{c}
SPI 5%	13.18^{c}	5.768^{c}	0.624^{a}	0.428^{a}	29.060^{b}	30.958^{c}	28.861^{c}	134.054^{bc}
SPI 10%	7.41^{e}	6.222^{a}	0.493^{a}	0.426^{a}	17.987^{d}	29.806^{cd}	27.131^{d}	104.837^{c}
WPI 5%	14.86^{a}	5.548^{d}	0.674^{a}	0.401^{a}	35.772^{a}	32.288^{b}	31.014^{b}	162.361^{b}
WPI 10%	13.85^{b}	5.381^{e}	0.556^{a}	0.367^{a}	36.679^{a}	35.044^{a}	32.431^{a}	211.717^{a}
F-Test Significant	**	**	NS	NS	**	**	**	**
Storage (D)								
0 Days	4.10^{d}	6.240^{a}	0.814^{a}	0.322^{c}	12.870^{c}	32.375^{a}	30.993^{a}	109.853^{c}
17 Days	16.32^{a}	5.345^{c}	0.332^{c}	0.473^{a}	35.762^{a}	32.755^{a}	29.499^{b}	165.946^{a}
23 Days	12.19^{c}	5.825^{b}	0.618^{b}	0.405^{b}	30.493^{b}	30.148^{b}	27.791^{d}	150.457^{ab}
28 Days	13.21^{b}	5.809^{b}	0.678^{b}	0.410^{b}	32.816^{b}	29.612^{b}	28.623^{c}	131.097^{bc}
F-Test Significant	**	**	**	**	**	**	**	**
Interaction T*D	**	**	**	**	**	**	**	**

Means separation within columns and main effect by Duncan's Multiple Range test at P≤0.05.
L*= lightness, C*= chroma and h° = hue angle
NS, *, ** Non significant or significant or highly significant at P≤0.05, respectively.

Figure 1: % Weight loss for banana coated with different treatments and stored at ambient temperature

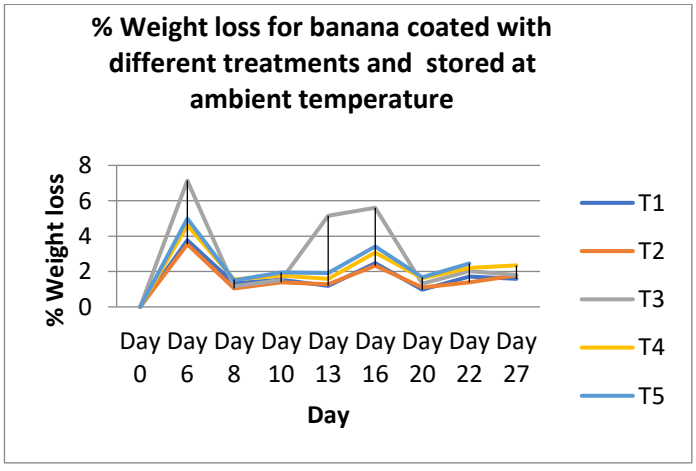

Table 2: Growth of fungal in *in vitro* study of different essential oil efficacy against Colletotrichum sp. Means with the same letter are not significantly different according to Duncan's Multiple Range test at P≤0.05.

Treatment		Growth
Control	-	7.6000[a]
Betel leaf	Non- Autoclaved	1.4600[bc]
Betel leaf	Autoclaved	1.9000[bc]
Cinnamon	Non- Autoclaved	1.6400[bc]
Cinnamon	Autoclaved	3.0400[bc]
Clove	Non- Autoclaved	1.0200[c]
Clove	Autoclaved	1.1800[bc]
Eucalyptus	Non- Autoclaved	2.4000[bc]
Eucalyptus	Autoclaved	7.7800[a]
Garlic	Non- Autoclaved	1.1000[bc]
Garlic	Autoclaved	3.9000[b]
Thyme	Non- Autoclaved	2.1000[bc]
Thyme	Autoclaved	3.7600[bc]

CONCLUSION

Although previous study mostly focusing on using or testing edible films on fresh cut of fruits, this study had proved its potential to be used on whole bananas too. Further study in development suitable and stable formulation can helps to give another alternative in bananas industry to prolong shelf life of fruits.

REFERENCES

Chuan-He Tang (2015): Emulsifying Properties of Soy Proteins: A Critical Review with Emphasis on the Role of Conformational Flexibility, Critical Reviews in Food Science and Nutrition

Ghavidel R.A., Davoodi M.G., Asl A.F.A., Tanoori T., and Sheykholeslam Z. (2003) Effect of selected edible coatings to extend shelf-life of fresh cut apples. International Journal of Agriculture and Crop Sciences Vol.6, 1171-1178

Li X., Zhu X., Wang H., Lin X., Lin H., and Chen W. (2018) Postharvest application of wax controls pineapple fruit ripening and improves fruit quality. Postharvest Biology and Technology 136,99-110

Ozdemir M., and Floros J.D. (2008) Optimization of efible whey protein films containing preservatives for water vapor permeability, water solubility and sensory characteristics. Journal of Food Engineering 86, 215-224

Palou L., Valencia-Chamorro S.A., Pérez-Gago M.A. (2015) Antifungal Edible Coatings for Fresh Citrus Fruit: A Review. Coatings, 5, 962-986

Rossi Marquez G., Di Pierro P., Mariniello L., Esposito M., Giosafatto C.V.L., and Porta R. (2017) Fresh-cut fruit and vegetable coatings by transglutamninase crosslinked whey protein/pecton edible films. LWT-Food Science and Technology 75, 124-130

Shafiur Rahman M. (2007) Handbook of Food Preservation, Second Edition, CRC Press