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Original Research Article

Effect of spray-dried rice bran extract on inhibition of enzymatic browning in potato puree

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ABSTRACT

Enzymatic browning is a major problem in the quality loss of fruits and vegetables. It is also deleterious flavor, nutritional values and consumer's acceptance. Sulfites are widespread agents used to control browning reaction. Due to adverse health effects, they could be a problem for human health. Thus, non-sulfite antibrowning agents are searched for food industry. Rice bran is a by-product from rice milling industry. It is a good source of natural antioxidants and phenolic acids. Therefore, the objective of this research was to investigate the effect of rice bran extract prepared by spray-drying on enzymatic browning inhibition in potato puree. Rice bran extract (RBE) was prepared by distilled water (DW) extraction. It was spray-dried to obtain spray-dried RBE powder (SD-RBE). The solution of SD-RBE powder was investigated for its enzymatic browning inhibition in potato puree by color measurement at room temperature for 6 hr. The browning values were calculated. Potato PPO inhibition was studied by measuring absorbance at 420 nm with catechol as substrate. SD-RBE solution showed greater enzymatic browning inhibitory efficiency than DW. Browning values and a* values of potato puree treated with SD-RBE solution were lower; whereas, L* and b* values were higher than those treated with DW during storage for 6 hr ($p \leq 0.05$). Its browning, a*, L* and b* values at 6 hr storage were 25.35, 4.05, 54.12 and 18.93, respectively; while those of DW treatment were 38.12, 5.47, 45.55 and 12.41, respectively. SD-RBE showed high potato PPO activity inhibition with the value of 66.12%. The results revealed that SD-RBE exhibited enzymatic browning inhibition in potato puree. Thus, SD-RBE has a potential to be used as a natural antibrowning agent for potato puree.

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INTRODUCTION

Potato (*Solanum tuberosum* L.) is the world's fifth largest food crop after sugar cane, corn, rice and wheat. In 2016, global potato production was about 380 million tonnes (FAO, 2018). It is rich in vitamins, minerals, high quality starch and protein (Li et al., 2017). However, potato turns brown after mechanical injury during processing, resulted in deleterious flavor, nutritional values and consumer's acceptance (Severini et al., 2003).

Enzymatic browning reactions are primarily catalyzed by polyphenol oxidase (PPO) in the presence of oxygen (Martinez and Whitaker, 1995). The most widespread agent used to control browning is sulfiting agents. Due to the adverse health effects, they could cause the problems for human health (Sapers, 1993). Thus, the researches of finding non-sulfite anti-browning agents for food industry have been interested. Rice bran is a by-product from rice milling industry. It is a good source of natural phytochemicals. Rice bran contained phenolic compounds such as ferulic acid, *p*-coumaric acid, vanillic acid and sinapic acid that might be responsible for the enzymatic browning (Sukhonthara et al., 2016). Rice bran extract (Theerakulkait and Boonsiripiphat, 2007; Sukhonthara et al., 2016) could reduce the enzymatic browning in potato. In addition, Kubglomsong and Theerakulkait (2014a, b); Kubglomsong et al. (2018) also found that rice bran protein and rice bran protein fraction could inhibit enzymatic browning. However, there is limited information about the enzymatic browning inhibition in vegetables and fruits by spray- dried rice bran extract.

Spray drying is widely applied to preserve the natural extracts. This technique has been used for drying aqueous or organic solutions, emulsions etc., in chemical and food industry. It has been successfully employed with many food products such as coffee, milk and egg (Bhandari et al., 1993). In addition, there have been several studies investigated for applying spray drying technique to produce powder from natural extracts such as grape seed extract, apple polyphenol extract and olive leaf extract (Kosaraju et al., 2008), green tea extract (Tang et al., 2011; Susantikarn and Donlao, 2016) and black mulberry juice (Fazaeli et al., 2012). Spray drying is an economical, flexible, continuous operation (Susantikarn and Donlao, 2016). Therefore, the main purpose of this research was to investigate the effect of rice bran extract prepared by spray-drying on the inhibitory effectiveness of enzymatic browning in potato puree.

MATERIALS AND METHODS

Materials and chemicals

Potato (*Solanum tuberosum* L.) was purchased from local market in Bangkok, Thailand. Full-fatted rice bran from the aromatic rice (*Oryza sativa* L. cv. Khao Dawk Mali 105) was obtained from Patum Rice Mill and Granary Public Co. Ltd., Thailand. Catechol, Triton X-100 and Folin-Ciocalteu reagent were purchased from Fluka Chemika (Buchs, Switzerland). Sodium carbonate was purchased from Merck Laboratories (Darmstadt, Germany). Polyvinylpyrrolidone was purchased from Sigma Chemical (St Louis, MO, USA). The other chemicals and solvents in this study were analytical grade.

Preparation of spray-dried RBE powder (SD-RBE)

Full-fatted rice bran was ground and sieved through a 50-mesh screen, and then extracted with distilled water (DW) at a ratio of rice bran to DW of 1:3 (w/w) using overhead stirrer at 700 rpm for 30 min. The supernatant was separated by centrifugation at 8,000×g at 25°C for 20 min, and then consequently spray-dried. The obtained powder was spray-dried rice bran extract powder (SD-RBE). SD-RBE was determined for moisture content according to the method of AOAC (934.06) (AOAC, 1990). The color values (L*, a* and b*) of SD-RBE was measured by colorimeter (CM-3500D, Minolta, Japan). Total soluble solid (TSS) was measured by refractometer. SD-RBE was dissolved with water, and then total phenolic content was measured. Total phenolic content of SD-RBE solution was adjusted to be equal to that of sample before spray-drying.

Determination of total phenolic content

Total phenolic content was determined according to the modified method of Zhou and Yu (2004) with catechol as a standard phenolic compound. Fifty µL of SD-RBE solution was mixed with 3 mL of DW and 0.25 mL of Folin-Ciocalteu reagent. The reaction mixture was let to stand at room temperature for 10 min. Then, 0.75 mL of 20% (w/v) of sodium carbonate was added and mixed. The reaction mixture was then left to stand at 40°C in water bath for 20 min, then stopped the reaction by immerging in ice bath. The absorbance at 765 nm was measured against blank (DW).

Determination of browning inhibition

Potato puree was prepared by peeling potato and blending pulp for 30 s with DW or SD-RBE at ratio of 2:1 (w/w). The color values (L*, a* and b*) of the samples were measured with colorimeter (CM-3500D, Minolta, Japan) at 0, 0.5, 1, 2, 4 and 6 hr (s) that were sufficient storage times to distinguish between treatments. Browning values (($\Delta L^*/L_0^*$) x 100) were calculated; when ΔL^* was L_0^*-L*; L* was the L* value at any storage time, and L_0^* was the initial L* measurement (Labuza et al., 1990).

Potato PPO preparation

Potato PPO was prepared following the modified method of Galeazzi et al. (1981). Twenty five grams of potato was homogenized in blender for 20 s with 50 mL of 0.2 M phosphate buffer pH 6.5 containing with 1% polyvinylpyrrolidone and 0.5% Triton X-100, and then centrifuged at 25,560xg at 4°C for 20 min. The supernatant was collected and used as crude enzyme.

Determination of PPO inhibition

The reaction mixture containing 3.0 mL of 0.2 M catechol in phosphate buffer pH 6.5, and 0.2 mL of SD-RBE solution or control (DW) were mixed and incubated for 30 s, then 0.02 mL of crude potato PPO was added and mixed. The increasing in absorbance at 420 nm was immediately recorded (Duangmal and Apenten, 1999). One unit of PPO activity was defined as the changed in absorbance of 0.001 at pH 6.5, 25°C. Percent PPO inhibition was calculated as follows:

% PPO inhibition = [(activity of control - activity of treatment) / activity of control] x 100

Statistical analysis

Three replicates of all experiments were performed. Statistical significance was assessed by one-way analysis of variance. Significant difference (P≤0.05) among treatments was detected using Least Significant Difference (LSD) tests.

RESULTS AND DISCUSSION

Some characteristics of SD-RBE

Rice bran extract (RBE) was prepared by distilled water (DW) extraction, then spray-dried RBE powder (SD-RBE) was obtained. Its color values and moisture content were measured. It was found that L*, a* and b* value of SD-RBE were 88.93, 0.06 and 11.27, respectively. Moisture of SD-RBE was 15.29%. Total phenolic content of SD-RBE was 997 mg/L. To investigate the enzymatic browning inhibition efficiency of SD-RBE, it was prepared as solution with equal in concentration of phenolic compounds that exist in RBE before spray-drying (1,517 mg/L). Total soluble solid (TSS) of SD-RBE solution was 14.9°Brix.

Effect of SD-RBE on enzymatic browning inhibition of potato puree

Effect of SD-RBE on the inhibition of enzymatic browning in potato puree was determined by color measurement. Browning values of potato puree that treated with SD-RBE solution and DW and stored at 25°C for 6 hr are shown in Figure 1. It was found that browning values of potato puree treated with SD-RBE solution were lower than those treated with DW during the storage time of 4 to 6 hr (P≤0.05). Browning value of potato puree treated with SD-RBE solution and DW at 6 hr storage was 25.35 and 38.12, respectively.

L* values of potato puree that treated with SD-RBE solution and DW and stored at 25°C for 6 hr are shown in Figure 2. L* values of potato puree treated with SD-RBE solution were higher than those treated with DW during the storage time of 4 to 6 hr (P≤0.05). L* value of potato puree treated with SD-RBE solution and DW at 6 hr storage was 54.12 and 45.55, respectively.

In addition, a* values of potato puree that treated with SD-RBE solution and DW and stored at 25°C for 6 hr are shown in Figure 3. It was found that a* values of potato puree treated with SD-RBE solution were lower than those treated with DW during the storage time of 0.5 to 6 hr (P≤0.05). The a* value of potato puree treated with SD-RBE solution and DW at 6 hr storage was 4.05 and 5.47, respectively.

Moreover, b* values of potato puree that treated with SD-RBE solution and DW and stored at 25°C for 6 hr are shown in Figure 4. It was found that b* values of potato puree treated with SD-RBE solution were higher than those treated with DW during the storage time of 0 to 1 hr and 4 to 6 hr (P≤0.05). The b* value of potato puree treated with SD-RBE solution and DW at 6 hr storage was 18.93 and 12.41, respectively.

The higher L* and b* values mean lighter color; and the lower a* value means decreased the development of browning occurring during storage. Regarding to browning, L*, a* and b* values, it revealed that SD-RBE solution exhibited enzymatic browning inhibition greater than DW.

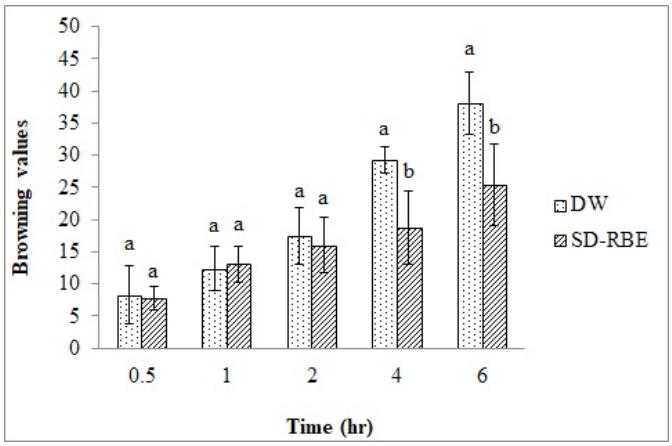

Figure 1. Browning values of potato puree treated with distilled water (DW) and spray-dried RBE powder (SD-RBE) solution
[a, b] Means ± SD with different letters at each storage time are significantly different (P≤0.05).

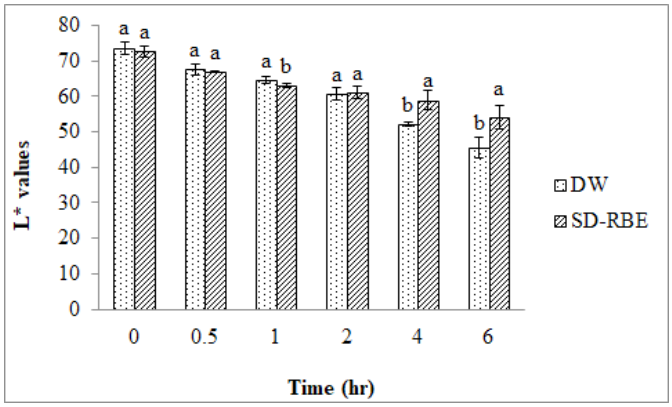

Figure 2. L* values of potato puree treated with distilled water (DW) and spray-dried RBE powder (SD-RBE) solution
[a, b] Means ± SD with different letters at each storage time are significantly different (P≤0.05).

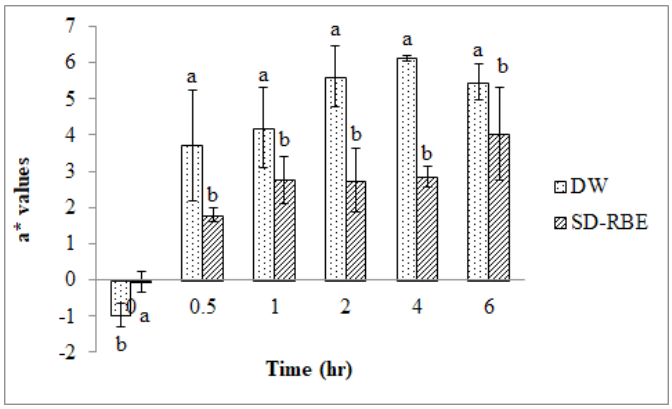

Figure 3. a* values of potato puree treated with distilled water (DW) and spray-dried RBE powder (SD-RBE) solution
[a, b] Means ± SD with different letters at each storage time are significantly different (P≤0.05).

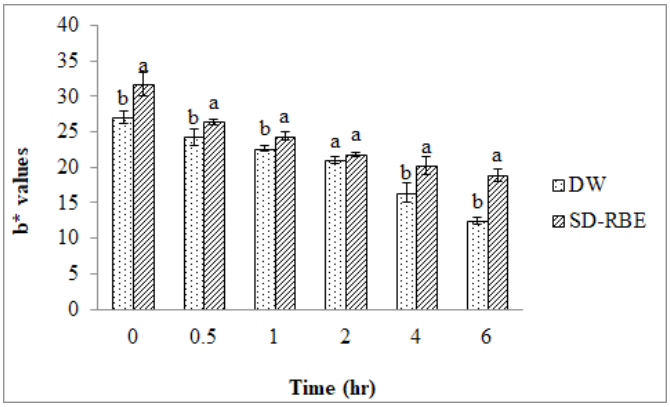

Figure 4. b* values of potato puree treated with distilled water (DW) and spray-dried RBE powder (SD-RBE) solution
[a, b] Means ± SD with different letters at each storage time are significantly different (P≤0.05).

Effect of SD-RBE on potato PPO activity inhibition

Enzymatic browning in potato is mainly cause by the activity of PPO. Thus, inhibition of PPO activity could retard browning formation. Therefore, we investigated the inhibitory effect of SD-RBE on potato PPO activity. The result is shown in Table 1. SD-RBE solution showed % potato PPO activity inhibition of 66.12. This indicated that SD-RBE solution effectively inhibited potato PPO activity. This result agreed with the color measurement. From the results of color measurement and potato PPO activity inhibition, it revealed that SD-RBE solution effectively inhibited enzymatic browning in potato puree. Rice bran contained phenolic compounds such as ferulic acid, *p*-coumaric acid, vanillic acid, syringic acid and sinapic acid (Kim and Chun, 1996; Kern et al., 2003; Sukhonthara et al., 2016; Pang et al., 2018). These phenolic compounds in rice bran might be the compounds that responsible for the enzymatic browning in potato. Sukhonthara et al. (2016) reported that rice bran extract could inhibit enzymatic browning in potato and apple. In addition, Theerakulkait and Boonsiripiphat (2007) found that rice bran extract exhibited an enzymatic browning inhibitory effect in potato, banana and apple.

Table 1. Percent inhibition of potato PPO activity by distilled water (DW) and spray-dried rice bran extract (SD-RBE) solution

Substance	% Potato PPO inhibition
DW	0.00 ± 0.00 [b]
SD-RBE solution	66.12 ± 6.50 [a]

[a, b] Means ± SD with different letters are significantly different (P≤0.05).

CONCLUSIONS

Spray-dried rice bran extract powder (SD-RBE) showed the ability to reduce browning in potato puree and potato PPO activity inhibition. It suggested that SD-RBE could be a potentially natural antibrowning agent for potato puree.

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REFERENCES

AOAC. 1990. Official Method of Analysis of the Association of Official Analytical Chemists. No. 934.06, Arlington, VA.

Bhandari, B.R., Senoussi, A., Dumoulin, E.D. and Lebert, A. 1993. Spray drying of concentrated fruit juices. Drying Technology 11: 1081-1092.

Duangmal, K. and Apenten, R.K.O. 1999. A comparative study of polyphenoloxidases from taro (*Colocasia esculenta*) and potato (*Solanum tuberosum* var. Romano). Food Chemistry 64: 351-359.

FAO. 2018. FAOSTAT, crops production. Retrieved October 5, 2018 from: http://www.fao.org/faostat/en/#data/QC.

Fazaeli, M., Emam-Djomeh, Z., Ashtari, A.K. and Omid, M. 2012. Effect of spray drying conditions and feed composition on the physical properties of black mulberry juice powder. Food and Bioproducts Processing 90: 667-675.

Galeazzi, M.A.M., Sgarbieri, V.C. and Constantinides, S.M. 1981. Isolation, purification and physicochemical characterization of polyphenoloxidases (PPO) from a dwarf variety of banana (*Musa cavendishii*, L). Journal of Food Science 46: 150-155.

Kern, S.M., Bennett, R.N., Mellon, F.A., Kroon, P.A. and Garcia-Conesa, M.T. 2003. Absorption of hydroxycinnamates in humans after high-bran cereal consumption. Journal of Agricultural and Food Chemistry 51: 6050-6055.

Kim, I.H. and Chun, H.S. 1996. Composition of fatty acid and phenolic acid in rice with different milling fractions. Journal of the Korean Society of Food Science and Nutrition 25: 721-726.

Kosaraju, S.L., Labbett, D., Emin, M., Konczak, I. and Lundin, L. 2008. Delivering polyphenols for healthy ageing. Nutrition & Dietetics 65: S48-S52.

Kubglomsong, S. and Theerakulkait, C. 2014a. Effect of rice bran protein extract on enzymatic browning inhibition in potato puree. International Journal of Food Science and Technology 49:551-557.

Kubglomsong, S. and Theerakulkait, C. 2014b. Effect of rice bran protein extract on enzymatic browning inhibition in vegetable and fruit puree. Kasetsart Journal (Natural Sciences) 48:205-213.

Kubglomsong, S., Theerakulkait, C., Reed, R.L., Yang, L., Maier, C.S. and Stevens, J.F. 2018. Isolation and identification of tyrosinase-inhibitory and copper-chelating peptides from hydrolyzed rice-bran-derived albumin. Journal of Agricultural and Food Chemistry (in press).

Labuza, T.P., Lillemo, J.H. and Taoukis, P.S. 1990. Inhibition of polyphenol oxidase by proteolytic enzymes "killer enzymes". In Proceedings of the symposium on the 20th International Symposium International Federation of Fruit Juice Producers (pp. 1-15). Paris, France.

Li, L., Bai, J., Wu, M., Zhao, M., Wang, R., Guo, M., Liu, H. and Liu, T. 2017. Studies on browning inhibition technology and mechanisms of fresh-cut potato. Journal of Food Processing and Preservation 41: e13263.

Martinez, M.V. and Whitaker, J.R. 1995. The biochemistry and control of enzymatic browning. Trends in Food Science & Technology 6: 195-200.

Pang, Y., Ahmed, S., Xu, Y., Beta, T., Zhu, Z., Shao, Y. and Bao, J. 2018. Bound phenolic compounds and antioxidant properties of whole grain and bran of white, red and black rice. Food Chemistry 240: 212-221.

Sapers, G.M. 1993. Browning of foods: control by sulfites, antioxidants, and other means. Food Technology 47: 75-84.

Severini, C., Baiano, A., De Pilli, T., Romaniello, R. and Derossi, A. 2003. Prevention of enzymatic browning in sliced potatoes by blanching in boiling saline solutions. LWT-Food Science and Technology 36: 657-665.

Sukhonthara, S., Kaewka, K. and Theerakulkait, C. 2016. Inhibitory effect of rice bran extracts and its phenolic compounds on polyphenol oxidase activity and browning in potato and apple puree. Food Chemistry 190: 922-927.

Susantikarn, P. and Donlao, N. 2016. Optimization of green tea extracts spray drying as affected by temperature and maltodextrin content. International Food Research Journal 23: 1327-1331.

Tang, W.-Q., Li, D.-C., Lv, Y.-X. and Jiang, J.-G. 2011. Concentration and drying of tea polyphenols extracted from green tea using molecular distillation and spray drying. Drying Technology 29: 584-590.

Theerakulkait, C. and Boonsiripiphat, K. 2007. Effects of rice bran extract on browning and polyphenol oxidase activity in vegetable and fruit. Kasetsart Journal (Natural Sciences) 41: 272-278.

Zhou, K. and Yu, L. 2004. Effects of extraction solvent on wheat bran antioxidant activity estimation. LWT-Food Science and Technology 37: 717-721.