

Physical and Textural Qualities of Puffed Job's Tears as Affected by Fluidized-bed Coating Conditions

Pattamaporn Ruksanook¹, Kriangsak Banlue², Sunisa Roidoung², Srinual Jantathai²,
Sudathip Inchuen² and Wasan Duangkhamchan^{2,*}

¹ Faculty of Engineering, Mahasarakham University, Kham Rieng, Kantarawichai, Maha Sarakham 44150, Thailand

² Research Unit of Process and Product Development of Functional Foods, Department of Food Technology and Nutrition, Faculty of Technology, Mahasarakham University, Kham Rieng, Kantarawichai, Maha Sarakham 44150, Thailand

pattalo@hotmail.com and wasan.d@msu.ac.th*

Abstract. *This work aims to study the effects of fluidized-bed coating parameters including spraying time (5, 10, 15 min) and inlet air temperature (50, 60, 70 °C) on physical and textural qualities of puffed Job's tears (PJT) coated with green tea solution. Response surface method associated with two independent variables (spraying time and inlet air temperature) and five responses (moisture content, water activity, chroma, hardness and crispiness) was used, and the optimal coating condition was finally determined. The results showed that both spraying time and inlet air temperature significantly affected all physical and textural qualities of coated PJT except moisture content. Based on the criteria of optimization (target values of control properties), the highest desirability was 0.81 corresponding to spraying time and inlet air temperature of 7 min and 53.4, respectively. Consequently, this fluidized-bed coating condition could be considered as suitable one for puffed Job's tears.*

Keywords:

physical and textural qualities, puffed Job's tears, fluidized-bed coating

1. Introduction

Due to change in life style and increase in health awareness among consumers, value-added cereals are receiving interest. Among various cereal grains, Job's tears has been recently chosen due to their flavor and health benefits [1].

Nowadays, green tea has become popular additive. Normally, green tea is added to Korean traditional Yukwa to improve its quality and shelf life. Park and Kim [2] demonstrate the addition of green tea extracts reduced the increases in acid value, peroxide value, P-Anisidine value and Totox value during storage at 40 °C for 12 weeks. Park et al. [3]-[4] claimed the addition with 0.1 g/100 g of non-fermented tea powder could contribute to the improvement of quality and shelf life of Yukwa during storage. Park et al. [3]-[4] also found that all sensory characteristics decreased with increasing GTP levels, but there was no significant

difference in overall acceptability between Yukwa samples without and with 1 g/100 g GTP. Park and Kim [2] found that green tea extract delayed rancidity in Yukwa, providing compelling evidence that green tea extract is an effective antioxidant for Yukwa. Furthermore, Sung et al. [5] concluded Yukwa combined with green tea reduced the effect of hypocholesterolemia.

Fluidized-bed coating is one of the effective ways to successfully add the natural extract to cereals as reported in [6]-[8]. However, in literature, any trial focusing on improving antioxidant properties of breakfast cereals by addition of natural extract has not been yet reported. Therefore, this work aimed to apply a top-spray fluidized-bed coating technique for surface-adding puffed Job's tears with green tea extract. The effects of operating parameters including feed rate of coating solution and inlet air temperature on physical and textural qualities were investigated. Finally, the optimized coating condition was determined in order to meet the consumer acceptability.

2. Materials and Methods

2.1 Puffed Job's Tears Preparation

Dried Job's tears with moisture content of 12-14% (wet basis) were purchased from the local market in Maha Sarakham province, Thailand. The cleaned Job's tears were soaked in water for 12 hr at ambient temperature. The soaked samples were then boiled at 100 °C for 20 min. Before drying they were placed on the perforated tray until reaching ambient temperature. The samples were hot-air dried under 60 °C for 24 hr and subsequently under 80°C for 2 hr, resulting in moisture content of approximately 14% (wet basis). The dried cooked Job's tears were fried in hot oil at 120°C for 10 s or until they were completely puffed. Finally, the samples were hot-air dried again under 60°C for 2 hr in order to reduce the excess oil on their surface.

2.2 Coating Solution

Green tea solution was prepared by dissolving green tea powder also purchased from the local market in distilled water with the water to the green tea powder ratio of 10:1.5. The resultant green tea solution was then added by sugar until its concentration reached 20 °Brix. The resultant mixture used as coating solution was kept under 4-5 °C until tested.

2.3 Coating Procedure

Two hundred gram of puffed Job's tears (PJT) was used in this work. Before loading the sample, the desired inlet temperature and velocity of fluidizing air were set. As soon as the desired conditions reached steady-state, the sample was loaded at the top of the reactor. The coating solution was subsequently sprayed into the fluidized bed of PJT. The experimental conditions carried out in this work included the variations of inlet air temperature (50, 60 and 70°C) and coating solution feed rate from 5 to 10 ml/min, while spraying time, fluidizing air velocity and atomization air pressure were kept constant at 10 min, 3.5 m/s and 1 bar, respectively. Due to simultaneously coating and drying in this technique, the coated PJT was not further dried. Prior to quality analyses, it was kept in an aluminium-foil bag under cold storage (4±1°C). Each condition was carried out in triplicate.

2.4 Quality Analysis

2.4.1 Moisture Content

Moisture content (MC) of all samples was determined according to the standard method of AOAC (1995). Five grams of PJT sample was dried under 103°C in a hot air oven for 72 hr. The averaged value was obtained from five replicates.

2.4.2 Water Activity

Water activity (A_w) of coated PJT was measured using a water activity meter (AquaLab model cx-2, Decagon Devices, Inc., USA). Measurement for each experiment was conducted in triplicate. The averaged value was presented.

2.4.3 Chroma

Color properties were analyzed in terms of chroma (C) value and hue angle. The chroma of coated PJT was examined by the colorimeter (ColorFlex, HunterLab Reston, VA, USA) with a D65 illuminant and observer angle of 10°. The chroma was calculated from 'Chroma = $(a^*2+b^*2)^{1/2}$ ' using the CIE $L^*a^*b^*$ color scale, a^* (redness-greenness) and b^* (yellowness-blueness). The colorimeter was first calibrated with a standard white plate

obtaining L^* of 93.19, a^* of -1.12 and b^* of 1.33. In addition, color difference (ΔE^*) was calculated from ' $\Delta E = [(L2^* - L1^*)^2 + (a2^* - a1^*)^2 + (b2^* - b1^*)^2]^{1/2}$ '. All values were measured in ten individual replicates for each experiment and the average value was presented.

2.4.4 Texture

Textural properties of PJT coated with green tea solution were measured by using a TA-XT2i texture analyzer (Stable Microsystem Ltd., UK) equipped with a 5-blade Kramer shear cell. The test was performed by compressing the samples of approximately 20 g at a testing rate of 1 mm/s until the blades completely cut through the samples. The values of peak force and a number of peaks were recorded as hardness and crispiness of samples [9]. Measurement was carried out in five replicates, and the averaged value was presented.

2.5 Optimization of Fluidized-bed Coating Condition

The commercial puffed Job's tears coated with green tea was used as a control sample. This is normally produced by two stages including immersion and drying. Its physical and textural qualities were therefore used as criteria for optimization of fluidized-bed coating condition.

Both physical and textural properties of PJT coated with green tea solution as affected by coating variables were evaluated by means of response surface method (RSM) due to its suitability for multivariate problems. In this work, a full factorial experimental design was employed with two factors including inlet air temperature and coating solution feed rate and three levels for each factor. Qualities (MC, A_w , chroma, hardness and crispiness) of the commercial coated PJT were used as responses in order to provide the consistency with the factors. A second-order polynomial equation applied to describe the effects of operating factors is expressed as follows [7]

$$Y = a_0 + \sum_{i=1}^n a_i x_i + \sum_{i=1}^n a_{ii} x_i^2 + \sum_{i=1}^n \sum_{j=i+1}^n a_{ij} x_i x_j \quad (1)$$

where a_0 is the constant; a_i and a_{ii} are the linear and quadratic effects, respectively, while the interaction effect between them is denoted by a_{ij} . x_i is the actual value of the i^{th} factor; x_1 is the inlet air temperature, and x_2 is the feed rate of coating solution.

In order to optimize the fluidized-bed coating condition, the models obtained from Eq. (1) were applied associated with the desirability criteria (target values). The suitable condition was selected based on the highest desirability value, ranging from 0 to 1.

3. Results

In order to investigate the effects of fluidized-bed coating condition on physical and textural properties of puffed Job's tears, variations of coating time and inlet air temperature were used, as seen in Table 1-3. Finally, the response surface methodology was applied to determine the optimized the coating condition.

Table 1 presents moisture content and water activity of PJT coated with green tea solution with variation of coating time and temperature. As a result that a fluidized-bed coating provides simultaneous processes including drying and coating in one equipment, associated with suitable condition, moisture contents of coated samples were not different significantly ($p < 0.05$). The moisture contents of coated sample were in a range of 4.02-4.67 which tended to be higher than that of the control.

Water activity also play important role in a term of storage ability for dried foods. From Table 1, the A_w values ranging in 0.26-0.32 which were in a safe range for dried product (< 0.6) were affected by both spraying time and inlet air temperature. At the same inlet air temperature, the A_w values tended to decrease with higher temperature. This could be due to the more coated material onto PJT surfaces when using longer spraying time. In contrast, the trend in these values was observed when considering the effect of inlet air temperature; the higher temperature, the more A_w value. The higher evaporation rate with increasing air temperature could be possible explanation.

Table 1: Moisture contents and A_w of coated PJT

Time (min)	Temperature (°C)	MC (%wb)	A_w
5	50	4.21±0.20	0.32±0.02 ^a
	60	4.14±0.37	0.32±0.03 ^{ab}
	70	4.33±0.04	0.30±0.07 ^{ab} _c
10	50	4.10±0.30	0.26±0.01 ^{cd}
	60	4.47±0.27	0.27±0.00 ^{cd}
	70	4.67±0.27	0.28±0.01 ^{ab} _c
15	50	4.14±0.31	0.26±0.01 ^{cd}
	60	4.02±0.55	0.27±0.01 ^{bc} _d
	70	4.15±0.38	0.28±0.02 ^{ab} _c
Control		4.00±0.01 ^{ns}	0.22±0.00 ^e

Table 2: Color values of coated PJT

Time (min)	Temp (°C)	L^*	a^*	b^*	Chroma
5	50	53.52±0.44 ^b	-1.85±0.28 ^f	10.28±0.10 ^d	10.35±0.16 ^f
	60	54.91±0.17 ^a	-1.57±0.22 ^e	14.75±0.84 ^a	14.34±0.33 ^a
	70	46.77±1.24 ^e	-0.92±0.05 ^c	9.69±0.49 ^d	8.47±0.76 ^e
10	50	51.70±0.02 ^c	-1.49±0.12 ^e	11.10±0.95 ^{cd}	11.75±0.06 ^d
	60	49.08±0.16 ^d	-0.13±0.01 ^a	12.31±0.04 ^{bc}	12.29±0.09 ^c
	70	46.60±0.19 ^e	-1.07±0.06 ^d	9.99±0.27 ^d	10.20±0.04 ^f
15	50	52.23±0.32 ^{bc}	-1.48±0.12 ^e	12.97±0.16 ^b	12.96±0.06 ^b
	60	49.06±0.46 ^d	-1.24±0.09 ^d	11.93±1.50 ^{bc}	11.14±0.13 ^c
	70	47.19±0.11 ^e	-0.90±0.04 ^c	12.05±1.53 ^{bc}	11.18±0.03 ^c
Control		52.34±0.11	-1.50±0.07	12.54±0.37	12.62±0.38

The effect of operating variables on the color values of PJT coated by green tea solution is presented in Table 2. This study found that both of time and temperature significantly affected the color of PJT ($p < 0.05$). The increasing temperature trended to decrease lightness, and redness, while the greenness increased with the coating temperatures. Coating times from 5 to 15 minutes showed smaller effect on the PJT color compared to the coating temperatures. From this study, coating PJT at 60°C for 5 minutes gave the best color values among all 9 treatments, according to the highest L^* and lowest b^* values (Table 2).

The bright green color would consider as a desired characteristic of the PJT coated with green tea. In addition, the Chroma value from this treatment was 14.34, which represented the highest color intensity among all 9 treatments. Moreover, comparing to control, the coating at 60°C for 5 minutes presented the higher L^* , Chroma and lower b^* values, which could interpret that the selected coating condition in this study could produce green tea coated PJT with brighter with more intense of greenness than the control.

Table 3: Hardness and crispiness of coated PJT

Time (min)	Temperature (°C)	Hardness (N)	Crispiness (no. of peak)
5	50	62.62±0.02 ^c	282.80±9.99 ^b
	60	62.84±0.06 ^b	254.99±3.28 ^{cd}
	70	63.16±0.07 ^a	233.60±12.34 ^{de}
10	50	62.89±0.03 ^b	210.55±8.17 ^f
	60	62.87±0.07 ^b	232.79±11.29 ^{de}
	70	62.66±0.06 ^d	223.46±9.82 ^{ef}
15	50	62.88±0.02 ^b	238.92±12.91 ^{de}
	60	63.09±0.03 ^a	249.32±26.51 ^d
	70	62.79±0.05 ^b	274.11±3.52 ^c
Control		62.75±0.17 ^b	237.87±7.36

Spraying time and inlet air temperature were varied in order to investigate the effect of these operating variables on textural properties including hardness and crispiness of PJT coated by green tea solution, as demonstrated in Table 3. From this table, it can be seen that the textural properties were affected significantly by coating parameters tested. Taking spraying time into consideration, hardness of coated samples tended to increase with higher inlet air temperature at low spraying time, while this trend could not be observed obviously at longer ones. Regarding the influence of inlet air temperature, at the same level of spraying time, the hardness of coated PJT increased with higher temperature.

In order to evaluate the texture of puffed products, crispiness also plays important role as an indicator for consumer acceptability. It was, therefore, measured in this work. Table 3 also presents crispiness of coated PJT. This value ranged in 210 – 282. This highest one was found at spraying time of 5 min and inlet temperature of 50°C, while the lowest one was obtained when using spraying time and temperature of 10 min and 50°C, respectively. The trend of crispiness was not observed obviously. It could be explained by complex flow pattern of irregular shape of the samples and wall and inter-collisions. However, when compared with that of the control, crispiness of PJT coated under spraying of 15 min and temperature of 50°C seemed to be the best one. Therefore, this coating condition could be considered as the suitable one when regarding crispiness of the products.

As mentioned above, it could be observed that both spraying time and inlet air temperature affected significantly the physical and textural properties in different manners. The suitable coating conditions could be select for

each operating variables. However, the appropriate fluidized-bed coating condition could not only be determined by using one of them, but it was also selected by combining both parameters. As a result, the optimal coating condition was investigated by defining a 2-dimension global desirability plot, as shown in Fig.1. Based on the target properties of the control including MC, A_w, Chroma, hardness and crispiness, the highest desirability was 0.811 corresponding to spraying time and inlet air temperature of 7 min and 53.4°C, respectively, meaning that the combination of the different independent operating parameters was globally optimal.

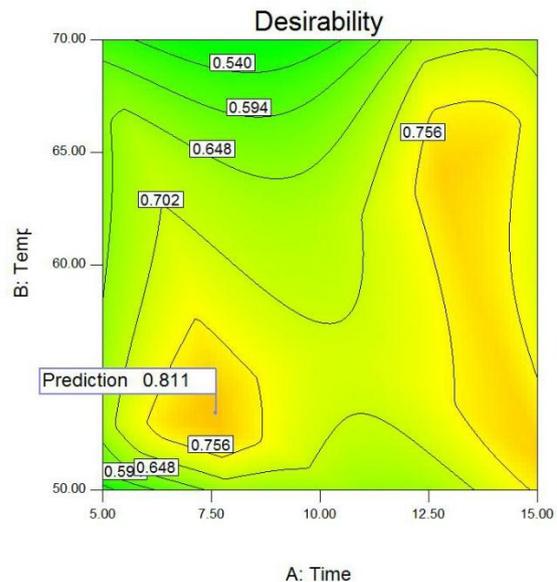


Fig. 1: Contour plot of desirability of fluidized-bed coating conditions for PJT (Temp: °C and Time:min)

4. Conclusion

This work aims to study the effects of fluidized-bed coating parameters including spraying time (5, 10, 15 min) and inlet air temperature (50, 60, 70°C) on physical and textural qualities of puffed Job’s tears (PJT) coated with green tea solution. Response surface method associated with two independent variables (spraying time and inlet air temperature) and five responses (moisture content, water activity, chroma, hardness and crispiness) was used, and the optimal coating condition was finally determined. The results showed that both spraying time and inlet air temperature significantly affected all physical and textural qualities of coated PJT except moisture content. Based on the criteria of optimization (target values of control properties), the highest desirability was 0.81 corresponding to spraying time and inlet air temperature of 7 min and 53.4°C, respectively. Consequently, this fluidized-bed coating condition could be considered as suitable one for puffed Job’s tears.

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Biography



Sudathip Inchuen received her doctoral degree in Food Science from King Mongkut's Institute of Technology Ladkrabang, Thailand, in 2009. She is currently a lecturer at the Faculty of Food technology and Nutrition, Mahasarakham University, Thailand.

Her research interests include influence of heat treatment on antioxidant capacity and color of Thai red curry paste.



Wasan Duangkhamchan received his doctoral degree in Applied Biological Science, Food Engineering, Ghent University, in 2013, Belgium. He is currently a lecturer at the Faculty of Food Technology and Nutrition, Mahasarakham University, Thailand. His research interests include CFD modelling of the fluidised bed coating process.



Pattamaporn Ruksanook received her Master degree of Science Food Technology, Mahasarakham University, Thailand. She is currently a lecturer at the Faculty of Engineering, Mahasarakham University, Thailand. Her research interests Optimized infrared drying process of paddy: Factors of infrared temperature and heating time.



Kriangsak Banlue received his doctoral degree in Food Science United Graduate School of Agricultural Sciences, Ehime University, Japan. He is currently a lecturer at the Faculty of Food technology and Nutrition, Mahasarakham University, Thailand. His research interests Quality of Fish Ball from Surimi as Affected by Starch and Sterilizing Conditions.



Sunisa Roidoung received her doctoral degree in Food Science, Michigan State University, USA. She is currently a lecturer at the Faculty of Food Technology and Nutrition, Mahasarakham University, Thailand. Her research interests are estimation of kinetic parameters of anthocyanins and color degradation in vitamin C fortified cranberry juice during storage.



Srinual Jantathai received her doctoral Science degree (Food Science) University of Natural Resources and Life Sciences (BOKU), Austria in 2015. She is currently a lecturer at the Faculty of Food Technology and Nutrition, Mahasarakham University, Thailand. Her research interests sensory expectations and perceptions of Austrian and Thai consumers: A case study with six colored Thai desserts.