Effect of drying methods on properties of green curry powder

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Abstract. In this study, the effects of two drying methods: hot-air and freeze drying for Thai green curry paste in a terms of drying time and qualities have been investigated. The hot-air drying was carried out in tray dryer at temperature of 50, 60 and 70 °C. The freeze drying was carried out in freeze dryer at freezing temperature of -20°C, primary drying temperature of -10°C and secondary drying temperature of 50°C. Moisture content, water activity, colour, bulk density, and total phenolic content (TPC) were determined in samples. Freeze dried sample had significantly ($p<0.05$) lower moisture content, water activity, bulk density, total colour difference and browning index than hot air dried samples. For antioxidant activity, the results showed hot-air drying at 70°C effected highest TPC similar to freeze drying.

1. Introduction

Nowadays, most of people is paying an attention to healthy food. Especially, the food which have vegetables and herbs as main ingredient. Vegetables and herbs contain with many benefits such as antioxidant and phenolic compounds [1]. One of dishes used many herbs to be the main ingredient is Thai food named Thai green curry. Besides containing many benefits, Thai green curry paste is famous curry and accepted by people from the other country.

Thai green curry paste is kind of spicy paste included green chili, garlic, shallot, galangal, lemongrass and kaffir lime zest. These paste ingredients are the main power for antioxidant, anti-inflammatory and antimutation [2-3]. Short shelf-life of green curry paste is caused containing high moisture content over 70 percentage. There are several products was created for extending the paste shelf-life such as green curry paste in retort pouch or saterilized canned. However, the quality of ingredients is reduced by these process and cost of transportation is been higher from the higher weight [4]. With all of these reasons, drying a green curry paste was created for reducing the transportation cost and extended shelf-life of the paste.

To antimicrobial by reducing moisture content and water activity from a green curry paste is the process most selected by entrepreneurs. In present, there are many ways to drying a product but the easy and low-cost way, which is selected by entrepreneurs, is hot air drying; nevertheless, nutrition, flavor and colour of food were reduced by hot air-drying process [5-6]. The research of Huttakovit *et al.* in 2007 [7] found that high temperature was caused curry paste turns more browning as same as

the research of Inchuen *et al.* [8] and Kausilya *et al.* [9] said the high temperature was caused the lower quality product, especially, total phenolic content and antioxidant activity were been lower by increasing temperature. In some case, it was found that total phenolic content of some herbs increased when it passed high temperature [11]. Meanwhile, total phenolic content and antioxidant activity were reduced by drying at the lower temperature but taking longer time because some type of foods are composed with sensitive substances. Then, drying at low temperature like freeze drying was selected to be the best process to maintain the quality of food and also maintain food property as a fresh food. [10-11].

In addition, drying process and condition which effect with product qualities, physical and chemical properties were studied by many researchers. For instance, Chee fah chili [12], oregano [13], rosemary, basil, thyme, marjoram and sage [5], olive [14], aerial and leaf of coriander [15], kimchi [16], onion [18], and Thai red curry paste [8]. Following the study of An *et al.* [17] has been reported that antioxidant activity total phenolic content and other important substances were obtained by freeze drying which is higher than hot air drying. On the other hand, time and energy were more spent with freeze drying process and it also caused higher cost than hot air drying. Moreover, it was found that high rehydration is affected by low moisture content of freeze drying process which is not proper with some products [19-20].

In conclusion, drying method and drying temperature are directly affected with food quality. However, the comparison between hot air and freeze drying have not been performed to dried Thai green curry paste. The aim of this study was to investigate drying which affects with

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the qualities of green curry powder. Moisture content, water activity, colour, bulk density and total phenolic content were investigated in the study.

2. Materials and Methods

2.1 Materials and chemicals

Fresh herbs i.e. green chilli, garlic, shallot, lemon grass, galanga, kaffir lime zest and some spices (coriander seed, cumin and pepper) were purchased from local market in Khlong Luang district, Pathum Thani Province, Thailand. Folin Ciocalteu's reagent and gallic acid were sourced from Sigma-Aldrich (USA). All other chemicals and reagents were of analytical grade.

2.2 Sample preparation

Fresh green curry paste was prepared by blending sliced herbs, spices and seasoning together in milling machine (Ngowhuatyo, Thailand). The 500 g of paste sample was packed in polyethylene bag, then frozen at -35°C for 90 min and stored at -18°C until used. The initial moisture content of the green curry paste was determined as 75.9% wet basis (w.b.).

2.3 Drying experiment

Frozen green curry paste samples were thawed at 4°C in refrigerator and spread on trays of each dryer, with 5 mm thickness. All samples were dried until final moisture content was below 10% w.b. [9]. Dried samples were ground into powder by using electric blender (HR2118, Philips, Nederland). The powdered was keep in aluminum foil bag for further studies.

2.3.1 Hot-air drying (AD)

Fresh green curry paste samples were dried using tray dryer (Convection Dryer, KluayNamThai - KarnChang, Thailand) at constant air velocity of 1 m/s and three different temperatures: 50, 60 and 70°C.

2.3.2 Freeze drying (FD)

Green curry paste samples were dehydrated in freeze dryer (Kryo 'D' Freezer, ITC, Thailand). The samples were frozen at -50°C until the core temperature of samples were -20°C and then were dried in primary drying at -20°C and 40 Pa vacuum pressure. After that, samples were dried in secondary drying at 50°C until core temperature of samples were 50°C, the process was completed.

2.4 Moisture content

Moisture content was determined using hot air oven method [21]. Powder sample was dried in the oven at 100°C until a constant weight was achieved. Then, the following relation was used:

$$\text{Moisture content} = \frac{(W_1 - W_2)}{W_1} \times 100 \quad (1)$$

Where W_1 is weight of powder before drying (g) and W_2 is weight of powder after drying (g). Moisture content was expressed as percentage (wet basis). The analysis was triplicated.

2.5 Water activity

Air dried and freeze dried paste samples were taken around 1-2 g to determine water activity using electronic water activity meter (Decagon Model, AquaLab, USA). Three replications of water activity were performed for each sample.

2.6 Bulk Density

Bulk density of samples were determined according to Seerangurayar *et al.* [20] with some modifications. Sample receiving cup was set up distance between bottom of loading funnel and top of sample receiving cup as 15 cm, using 60 cm³ cylindrical cup. The powder was loaded to flow through the funnel into the cup until it overflows and carefully scraped excess powder from the top of the cup by smoothly moving spatula. The cup occupied by powder was then weighed. Bulk density was expressed using the equation:

$$\rho = \frac{m}{V} \quad (2)$$

Where ρ (g/ cm³) is bulk density, m (g) is the mass of powder samples and V (cm³) is the volume of receiving cup. The bulk density measurements were performed in triplicate.

2.7 Colour and browning index

The fresh and dry-rehydrated green curry paste samples were measured using spectrophotometer (ColorFlex, Hunter Lab, UK) in terms of CIE L^* , a^* and b^* values. L^* represents the range from lightness to darkness (0 - 100) of the object. a^* indicates redness (+) or greenness (-). b^* represents yellowness (+) or blueness (-). For each sample, three replications of the colour test were performed. total colour difference (ΔE) was also determined using the equation:

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2} \quad (3)$$

where $\Delta L^* = L^* - L_f^*$, $\Delta a^* = a^* - a_f^*$, $\Delta b^* = b^* - b_f^*$, and L^* , a^* and b^* are the colour values of sample and L_f^* , a_f^* and b_f^* are the colour values of fresh sample [22]

Browning index (BI) was determined using method of Park *et al.* [16] with slight modification. Fresh and powder samples about 1 g were extract with 50 mL of distilled water for 24 hours. The extract was filtered through Whatman No.1 filter paper (UK). The filtrate was diluted with an equal volume of 95% ethanol and then centrifuged at 4,000 rpm, 4°C for 15 min by centrifuge (MIKRO 220R, Hettich, Germany). The supernatant was measured based on its absorbance at 420 nm using spectrophotometer (GENESYS 10S, Thermo Scientific, UK). Measurements were performed in triplicate. The BI values were expressed as absorbance per g dry matter.

2.8 Total phenolic content

The sample extract was obtained from determination of Incheun *et al.* [8] with some modification. Powder (1 g) was extracted with 25 mL of 90% ethanol and incubated at 150 rpm, 30°C for 24 h. The extract was centrifuged at 6,000 rpm, 4°C for 20 min.

Total phenolic content (TPC) in the green red curry product extracts was determined using the Folin-Ciocalteu method described by Chan *et al.* [23] with some modifications. The diluted extract (2.25 mL) was mixed with 0.25 mL of Folin–Ciocalteu's reagent by vortex. After 5 min, 1.00 mL of 10% w/v Na₂CO₃ was added to the mixture. The absorbance was measured at 730 nm using a spectrophotometer after 10 min reaction. Distilled water was added instead of sample taken as blank. The amount of TPC was expressed as gallic acid equivalent per g dry matter.

3. Results and Discussion

3.1 Effect of drying methods on drying time and properties of Thai green curry paste powder.

Fresh Thai green curry paste with 5 mm thickness samples were dried with four drying methods: hot-air drying at 50, 60, and 70°C and freeze drying. The drying time are presented in Table 1. Freeze dry had the longest drying time with drying time of 36 hours and 40 min. Hot-air dried at 50°C samples went through the second longer drying time of 480 min, while dried at 70°C had shortest drying time.

The drying temperature had significant difference in water activity ($p < 0.05$) as shown in Table 1. Freeze dried sample had lowest water activity of 0.129, like the freeze drying can extremely reduce moisture content and water activity. For hot-air dried powder at 70°C resulted in lower water activity than dried at 50°C and 60°C due to increasing of temperature.

Bulk density is important in packaging, storage and transportation for powdered food [20]. Table 1 show the increasing of temperature caused reduction in bulk density of hot-air dried powder. The highest bulk density (0.57 g/cm³) was at 50°C air drying and it was reduced by 8% at 70°C. Whereas, freeze dried sample had lowest bulk density as 0.30 g/cm³ because lyophilization during freeze drying affected high porosity in sample [24].

3.2 Effect of drying methods on colour properties of Thai green curry paste.

From consumer acceptance viewpoint, colour properties are very important of dried product. A main colour of Thai green curry paste is green attribute to chlorophyll from the fresh green chilli [25].

The colour values in a term of CIE L^* , a^* and b^* system of products and total colour difference (ΔE) are presented in Table 2. There were significant differences of ΔE at the 95% confidence level between 4 products. Freeze dried sample had the lowest ΔE (4.13) and ΔE of 50, 60 and 70°C hot-air dried samples were increased with temperature increasing. Due to a^* values of dry-rehydrated green curry paste from hot-air drying increased when compared with fresh sample, whereas the value of freeze dried sample was more similar than them. That can indicate products from hot-air drying were less green. The discoloration of samples during drying was related to pigment destruction, enzymatic browning and non-enzymatic browning. Hence, results showed hot-air dried samples were more influenced by browning reaction than freeze dried sample, like BI value as shown in Table 2. There was no significant difference between BI value of fresh and freeze dried sample. But BI value of fresh product was significantly less than the 50, 60 and 70°C hot-air dried samples, which indicated that brown pigments formation occurred during processes. Similar to results were obtained from Park *et al.* [16] which drying of kimchi.

Table 1 Drying time, moisture content and water activity of Thai green curry paste at different drying methods.

Drying method	Drying time (min)	MC (%w.b.)	Water activity	Bulk density (g/cm ³)
AD50	480	8.71 ± 0.15	0.311 ± 0.004 ^d	0.5701 ± 0.0052 ^d
AD60	340	8.54 ± 0.20	0.247 ± 0.003 ^c	0.5476 ± 0.0022 ^c
AD70	250	8.48 ± 0.15	0.226 ± 0.005 ^b	0.5262 ± 0.0052 ^b
FD	2,200	3.84 ± 0.05	0.129 ± 0.008 ^a	0.3047 ± 0.0010 ^a

Means (± standard deviation) with different superscripts in each column significantly different ($p < 0.05$)

Table 2 Colour values, total colour difference and browning index of green curry powder at different drying methods.

Sample	L^*	a^*	b^*	ΔE	BI (abs/g dry matter)
Fresh	37.96 ± 0.43 ^a	-2.89 ± 0.27 ^a	30.14 ± 0.56 ^a	-	1.224 ± 0.021 ^a
AD50	38.73 ± 0.04 ^b	3.13 ± 0.16 ^c	31.11 ± 0.53 ^{ab}	6.16 ± 0.10 ^b	1.368 ± 0.007 ^b
AD60	38.28 ± 0.33 ^{ab}	3.99 ± 0.03 ^d	30.57 ± 0.54 ^a	6.92 ± 0.08 ^c	1.346 ± 0.003 ^b
AD70	38.04 ± 0.10 ^a	3.92 ± 0.30 ^d	32.09 ± 1.38 ^b	7.17 ± 0.18 ^d	1.409 ± 0.010 ^c
FD	41.34 ± 0.13 ^d	-1.04 ± 0.11 ^b	31.57 ± 0.35 ^{ab}	4.13 ± 0.05 ^a	1.226 ± 0.018 ^a

Means (± standard deviation) with different superscripts in each column significantly different ($p < 0.05$)

Fig. 1. Total phenolic content of fresh and dried green curry paste products.

3.3 Effect of drying methods on total phenolic content of Thai green curry paste powder.

In addition, TPC is one of the most important properties that indicates health benefit of the paste. Fig. 1 show TPC of four dried samples. It has been found that there was a significant difference at the 95% confidence level between hot-air and freeze dried sample at 50°C. Freeze dried powder was much higher than hot-air dried powder. Similar to results were obtained from Asami *et al.* [26] which reported that freeze dried marionberry, strawberry and corn had higher TPC hot-air dried samples. During hot-air dry process, the product is dried at atmospheric pressure whereas there is very little oxygen in the freeze drying chamber, which is the cause of oxidation reaction [27]. For effect of temperature of hot-air drying, it was found that TPC was increased when temperature was increased. Due to the higher temperature would promote decomposition of complex phenolic compounds affected higher TPC [17].

4. Conclusion

Based on the results of present investigation, properties of dried Thai green curry paste products were significantly affected by drying techniques. Freeze drying took longest drying time. However, physical properties of Thai green curry paste powder from freeze drying were lower than hot-air dried products. The lowest percentage of moisture content was freeze dried powder, whereas it had no significant difference among hot-air dried powder. Similar to water activity, freeze dried powder had lowest water activity. But water activity of hot-air dried samples were decreased when temperature was increased. And bulk density of freeze dried sample was lowest. For colour properties, it was found that freeze drying gave lowest ΔE and BI value. The results of TPC showed that hot-air drying at 70°C effected highest TPC similar to freeze drying.

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