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Short Communication

Optimization of green tea extracts spray drying as affected by temperature and maltodextrin content

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Abstract

The optimum spray drying condition of green tea extract was investigated in this study. Dried green tea leaves samples were ground using a hammer mill and passed through a 5 mm mesh. One kilogram of product was extracted with 20 L of 90°C water for 60 minutes. Solids were filtered off, extract was concentrated to obtain solution containing 10% total solid using a vacuum evaporator. The concentrated extract was then mixed with maltodextrin at a ratio of 3, 5 and 7% (w/v), respectively. The solutions were subjected to spray drying at 170, 190 and 210°C, with 80°C outlet temperature. The tea powder were collected and kept in aluminum foil bags for analysis. The results revealed that moisture content and total phenolic content of samples were varied in the range of 4.40-4.87% and 14.78-20.37%, respectively. Water activity, solubility, hygroscopicity and bulk density of the samples were varied in the range of 0.21-0.29, 94.76-98.53%, 8.61-13.72% and 0.36-0.48 g/ml, respectively. Color value of tea powder (L^*, a and b) are 30.31-32.84, 1.89-2.59 and 8.61-9.62, respectively. Based on the results it was suggested that spray drying at 210°C with 3% maltodextrin content was produced good properties of green tea powder.

Introduction

Tea is the most consumed beverage in the world after water, which drunk in Asia for more than 4000 years (Gardner *et al.*, 2007). In Thailand, tea is the most popular in terms of cultivation in Chiang Rai province. It contains high content of phytochemicals that have protective or disease preventive properties such as total polyphenols and catechins (Tijburg *et al.*, 1997). Normally, teas can be categorized into three groups: green tea (unfermented), Oolong tea (partially fermented) and black tea (fully fermented) base on tea process. Green tea has been reported as a rich source of catechin and its derivatives that contribute to antioxidant capacity and organoleptic properties (Kupeli *et al.*, 2007). Green tea is consumed as an infusion from dried tea leaves and its preparation is a fairly complex and time-consuming process. Therefore, soluble tea powder produced by spray drying has been introduced.

Spray drying is a well-established and widely used technique to produce powders from liquid food (Goula *et al.*, 2005; Loksuwan, 2007). The drying process can influence some changes in the powder such as phytochemical compounds and physicochemical properties (Barbosa-Canovas *et al.*, 2011). In spray drying application, different drying aids and carrier material used in order to obtain good product recovery and stability (Nadeem *et al.*, 2011). To produce food powders, using maltodextrins as a drying carrier is a popular method nowadays (Bhandari *et al.*, 1997). Maltodextrins have many functionalities including usage as wall material, dispersing aid, flavor carrier and bulking agent. They are mainly used in materials that are difficult to dry such as fruit juices, flavorings, and sweeteners and to reduce stickiness, thereby improving the product stability (Bhandari *et al.*, 1993; Bhandari *et al.*, 1997; Roos, Karel, 1991). The objectives of this study were to investigate the effects of spray drying temperature and maltodextrin content on chemical and physical properties of green tea powder on a lab scale of drying and to find the suitable drying condition for producing green tea powder.

Materials and Methods

Sample preparation

Dried green tea leaves (*Camelia sinensis* var. Oolong No.12) were supplied by Boon Rawd Farm Co., Ltd., Thailand. The leaves were ground using hammer mill and then passed through 5 mm mesh. The ground leaves (1 kg) was extracted with 20 L acidified water (pH was controlled at 5.0 using citric

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acid) at 90°C for 60 minute. All of the solids were filtered off and the extract was concentrated by vacuum evaporator to give solutions contained 10% total solid. The concentrated extracts were mixed with maltodextrin (DE=19) with the ratio of 3, 5 and 7% (w/v), respectively. Finally, it was stored in a container at 4°C until required.

Spray drying

A JMC-mini LAB spray dryer equipped with two-fluid nozzle was used in the spray drying process. In all experiments, the blower speed, the feed temperature and the outlet temperature were kept at 2500 rpm, 60°C and 80°C respectively. In order to investigate the effect of inlet air temperature with different maltodextrin content, three different inlet air temperatures (170, 190 and 210°C) and three different moltodextrin content (3, 5 and 7% (w/v)) were used. The products from separated runs were weighed and sealed in aluminum foil bags at room temperature and kept for physical and chemical analysis.

Moisture content

The moisture content was determined based on AOAC method (AOAC, 2000). Triplicate samples of green tea powder (2 g) were weighed and dried in oven at 105ºC until its weight is constant.

Water activity

Water activity was analyzed using a water activity meter (Novasina AWC500, Switzerland).

Color characteristics

The color of tea powder sample was determined using ColorQuestXE (Hunter Lab, USA).

Bulk density

Two g of powder were transferred into a 10 ml graduated cylinder. The bulk density was calculated by dividing the mass of the powder by the volume occupied in the cylinder (Goula and others 2004).

Solubility

The solubility was determined according to the reported procedures (Cano-Chauca *et al.*, 2005), with some modification. One gram of triplicate samples was added to 100 ml of distilled water at ambient temperature and the mixture was agitated with a magnetic stirrer at 600 rpm for 5 min. Twenty ml of supernatant was transferred to pre-weighed petri dishes and dried in an oven at 70°C until weight is constant. The solubility was calculated by weight difference and expressed in dry basis, considering the moisture content of each sample.

Hygroscopicity

The procedure for determined of hygroscopicity following a modified version of the method of Papadakis (2006). A saturated solution of ammonium sulphate salt (equilibrium relative humidity is 80% at 20°C) was kept in glass wash bottle having 2 passages for air inlet and outlet. A diaphragm type vacuum pump was used to suck the air through the salt solution. Take filter paper in Buchner funnel and weigh it until constant weight. Add 0.5 g of tea powder and spread it on the filter paper and then turn on the pump. The increasing weight of sample was recorded every 15 min until the weight of the sample is constant. The hygroscopicity was calculated by the following equation:

$$\%Hygroscopicity = \frac{(\%WI + \%FW) \times 100}{100 + \%WI} \quad (1)$$

$$\%WI = \left(\frac{c-b}{b-a}\right) \times 100 \quad (2)$$

Where: % *FW* is percentage of free water, *a* is weight of plate (g), *b* is weight of plate and tea powder (g), *c* is weight of plate and tea powder in equilibrium (g)

Determination of total polyphenol content

The total polyphenol content was determined according to the method described by the ISO 14502-1(2005), using gallic acid as a standard. 1.0 ml of diluted sample extract was transferred into tubes containing 5.0 ml of 10% v/v Folin-Ciocalteu's reagent. Then, 4.0 ml of 7.5% w/v sodium carbonate solution was added. The mixture was left at room temperature for 1 h and then measured the absorbance at 765 nm using water as blank. The TPC was expressed as gallic acid equivalents (GAE) in g/100 g extract.

Statistical analysis

All data were analyzed by analysis of variance (ANOVA) and Duncan's Multiple Range using SPSS software (version 16.0) at $p<0.05$.

Result and Discussion

Water activity (a_w)

Water activity is an important index for spray-dried powder because it can greatly affect the shelf life of the powder produce (Fennema, 1996). Water activity is different from moisture content as it measures the availability of free water in a food system that is responsible for any biochemical reaction. Generally, food with aw < 0.6 is considered as microbiologically stable and if there is any spoilage occur, it is induced

Table 1. physical properties of spray-dried green tea powder

Maltodextrin (%)	Inlet temp (°C)	a_w	L*	a*	b*	Solubility (%)	Hygroscopicity(%)	Bulk density (g/mL)
3	170	0.21 ± 0.07^{a}	31.61 ± 0.05^{c}	2.38 ± 0.02^{ab}	8.68 ± 0.21^{cd}	97.64 ± 0.76^{ab}	9.68 ± 0.21^{e}	0.48 ± 0.01^{a}
	190	0.28 ± 0.07^{ab}	30.31 ± 0.01^{e}	1.89 ± 0.03^{c}	8.72 ± 0.24^{bcd}	98.20 ± 0.56^{a}	11.62 ± 0.47^{c}	0.44 ± 0.02^{a}
	210	0.24 ± 0.07^{c}	32.87 ± 0.17^{a}	2.59 ± 0.48^{a}	9.62 ± 0.47^{a}	96.21 ± 1.68^{bcd}	8.61 ± 0.24^{f}	0.37 ± 0.04^{bc}
5	170	0.26 ± 0.07^{c}	30.36 ± 0.09^{e}	2.22 ± 0.06^{abc}	8.61 ± 0.24^{d}	97.78 ± 0.52^{ab}	10.43 ± 0.26^{d}	0.44 ± 0.01^{a}
	190	0.23 ± 0.07^{d}	30.87 ± 0.02^{d}	2.39 ± 0.01^{ab}	9.40 ± 0.51^{abc}	95.50 ± 1.07^{d}	12.40 ± 0.10^{b}	0.42 ± 0.02^{ab}
	210	0.29 ± 0.03^{a}	31.84 ± 0.15^{c}	2.38 ± 0.01^{ab}	9.43 ± 0.26^{ab}	96.56 ± 0.1^{cd}	13.62 ± 0.10^{a}	0.37 ± 0.01^{bc}
7	170	0.28 ± 0.01^{ab}	30.70 ± 0.08^{d}	2.05 ± 0.04^{bc}	9.55 ± 0.22^{a}	98.53 ± 0.28^{a}	12.57 ± 0.24^{b}	0.47 ± 0.03^{a}
	190	0.29 ± 0.07^{a}	31.82 ± 0.15^{c}	2.29 ± 0.07^{abc}	9.57 ± 0.24^{a}	96.15 ± 0.25^{bcd}	13.55 ± 0.22^{a}	0.44 ± 0.01^{a}
	210	0.26 ± 0.04^{bc}	32.14 ± 0.19^{b}	2.29 ± 0.06^{abc}	9.62 ± 0.10^{a}	94.76 ± 0.46^{d}	13.72 ± 0.24^{a}	0.36 ± 0.01^{c}

Values are mean ± SD (two replicate) after statistical analysis.
The value in the same column followed by different superscript were significantly different ($p<0.05$)

by chemical reactions rather than by micro-organism. From the results (Table1), the water activities of the powders were in the range of 0.21-0.29. This means that the spray-dried powders produced were relatively microbiologically stable. The maltodextrin content did not significantly affect on the value of water activity, nor did inlet temperature. However, interaction between maltodextrin content and inlet temperature affected the value of water activity resulting in significant different among the samples. The highest aw value was found in tea powder produced from 5% maltodextrin with 210°C inlet air temperature and 7% maltodextrin with 190°C inlet air temperature. The lowest was found in tea powder produced from 3% maltodextrin with 170°C inlet air temperature.

Color characteristics

Color is one of the important sensory attributes of food and a major quality parameter in dried food product. From Table 1, the highest L-value which means the brightest color of tea powder, obtained from the condition of 3% maltodextrin with 210°C inlet air temperature. In contrast, the lowest L-value was found in the powder produced from 3% maltodextrin with 190°C inlet air temperature. Moreover, the powder produced from 3% maltodextrin with 210°C inlet air temperature and 7% maltodextrin with 210ºC inlet air temperature has the highest b-value, the most yellowish but the lowest b-value was found in the powder produced from 5% maltodextrin with 170°C inlet air temperature. It can be concluded from the result that the green tea powder obtained from this experiment has greenish yellow color. Increasing drying temperature resulted in increasing *L*, *a* and *b* value. Similar results were also found in spray-dried watermelon powders (Quek *et al.*, 2007).

Bulk density

Bulk density is one of food powder properties. The bulk density of tea powder is in the range of 0.36-0.48 g/ml. Increasing drying temperature also decreased the bulk density. This result is in agreement with the result reported by Goula and Adamopoulos (2008), increased inlet air temperature produces a decrease in bulk density due to an increase in particle size and a greater tendency for the particles to be hollow. The former can be caused by particle inflation and 'ballooning or puffing' (Walton, 2000)

Solubility

Solubility describes feasibility of powder to be dissolved in water. From Table1, the result shows that solubility of tea powder is in the range of 94-98%. The highest solubility was found in the powder produced from 7% maltodextrin with 170°C inlet air temperature. . The lowest was found in tea powder produced from 7% maltodextrin with 210°C inlet air temperature. The maltodextrin content did not significantly effect on solubility of powder while the inlet air temperature affected the solubility. At higher inlet air temperature, a hard surface layer might be formed over the powder particle; this could prevent water molecules from diffusing through the particle; decreased the wettability of the particle and reducing the solubility of the powder (Quek, 2007).

Hygroscopicity

Hygroscopicity is the ability of food powder to absorb moisture from high relative humidity environment. The results show that the highest hygroscopicity was found in the powder produced

Table 2. Chemical properties of spray-dried green tea powder

Maltodextrin (%)	Inlet temp (°C)	Moisture content (% wb)	Total polyphenol (% db)
3	170	4.68±0.02^{c}	19.47±0.16^{b}
	190	4.62±0.01^{d}	20.37±0.09^{a}
	210	4.42±0.02^{f}	20.15±0.56^{a}
5	170	4.53±0.02^{e}	16.98±0.21^{c}
	190	4.52±0.03^{e}	17.16±0.11^{c}
	210	4.40±0.02^{f}	16.01±0.35^{d}
7	170	4.79±0.02^{a}	14.91±0.19^{ef}
	190	4.87±0.02^{a}	14.78±0.18^{f}
	210	4.50±0.01^{b}	15.27±0.16^{e}

Values are mean ± SD (two replicate) after statistical analysis.
The value in the same column followed by different superscript were significantly different ($p<0.05$)

from 7% maltodextrin with 210ºC inlet air temperature. The lowest was found in tea powder produced from 3% maltodextrin with 210°C inlet air temperature. The value of hygroscopicity of tea powder varied between 8.96-13.72%. The result shows that increasing the concentration of maltodextrin and the inlet air temperature leads to higher hygroscopicity. Different observation was confirmed during spray drying of cactus pear juice (Rodroguez-Hernundez *et al.*, 2005) and betacyanin pigments (Cai and Corke, 2000), suggesting that maltodextrin is an efficient carrier agent in lowering hygroscopicity of dried material. The present study was in disagreement with the above findings where maltodextrin greatly influenced the hygroscopicity of the spray-dried green tea.

Moisture content

Moisture content describes water composition in food. From Table 2, the result showed the moisture content of spray-dried green tea powder varied in range of 4.40-4.87%. The moisture content of the powder decreased with the increase inlet air temperature. Similar results were observed for spray-dried acai powder; (Tonon *et al.*, 2008). This is because at higher inlet air temperature, the rate of heat transfer to the particle is greater, providing greater driving force for moisture evaporation (Hong and Choi, 2007).

Total polyphenol content

Total polyphenol content was analyzed using gallic acid as standard. The result showed that the amount of total polyphenol content in tea powder varied in the range of 14.78-20.37%. The highest value was found in the powder produced from 3% maltodextrin with 190ºC inlet air temperature. The powder produced under the condition of 7% maltodextrin with 190°C inlet air temperature provided the lowest phenolic content. Increasing maltodextrin content resulted in decreasing phenolic content. Nadeem *et al*. (2011) also reported a decrease in the total polyphenol content of the spray–dried mountain tea water extract by increasing concentration of the carrier material.

Conclusion

The spray drying condition caused chemical and physical changes of green tea powder. The Inlet air temperature was affected the moisture content, solubility, bulk density and color characteristic. When increased inlet air temperature (170 to 210°C), the moisture content, solubility, bulk density were decreased but all the color (*L, a*, and *b*) value was increased. On the other hand, the maltodextrin content affected only the total polyphenol content. When we increased the maltodextrin content, total polyphenol content was wecreased. The result suggest that the suitable condition for producing good properties of green tea powder was added 3% matodextrin in feed and drying at 210°C inlet air temperature. This condition provided low water activity, good color characteristic, high solubility and low bulk density. In addition, the powder also contained low moisture content and high total polyphenol content.

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References

AOAC. 2000. Official method of analysis.14th edn. Washindton,DC: Association of official Analytical Chemists.

Barbosa-Canovas, G. V. and Juliano, p. 2005. Physical and chemical properties of food powder. In Charles, O. (Ed.). Encapsulated and powdered foods, p. 40-66. CRC Press.

Bhandari, B.R., Datta, N. and Howes, T. 1997. Problems associated with spray drying of sugar-rich foods. Drying Technology 15(20): 671-684.

Bhandari, B.R., Snoussi, A., Dumoulin, E.D. and Lebert, A. 1993. Spray drying of concentrated fruit juices. Drying Technology 11(5): 1081-1092.

Cai, Y. Z. and Corke, H. 2000. Production and properties of spray-dried Amaranthus betacyanin pigments. Journal of Food Science 65: 1248-1252.

Cano-Chauca, M., Stringheta, P. C., Ramos, A. M. and Cal-Vidal, J. 2005. Effect of carriers in the microstructure of mango powder obtained by spray drying and its functional characteristic. Innovative Food Science and Emerging Technologies 6: 420-428.

Fennema, O. R. 1996. Water and ice. In Fennema, O. R. (Ed), Food Chemistry, p. 42-49. 3rd edn. New York: Mareel Dekker Inc.

Gardner, E. J., Ruxton, C. H. S. and Leeds, A. R. 2007. Black tea – helpful or harmful?. A review of the evidence. European Journal of Clinical Nutrition 61(1): 3-18

Goula, A. M., Adamopoulos, K. G., and Kazakis, N. A. 2004. Influence of spray drying condition on tomato powder properties. Drying Technology 22: 1129-1151.

Goula, A. M. and Adamopoulos, K. G. 2005. Spray drying of tomato pulp in dehumidified air. Journal of food engineering 66: 35-42.

Goula, A. M. and Adamopoulos, K. G. 2008. Effect of maltodextrin addition during spray drying of tomato pulp in dehumidified air. Drying Technology 26: 726-737.

Hong, J. H. and Choi, Y. H. 2007. Physico-chemical properties of protein-bound polysaccharide from *Agaricus blazei* Murill prepared by ultrafiltration and spray drying process. International Journal of Food Science and Technology 42(1): 1-8.

ISO 14502-1. 2005. Determination of substance characteristic of green tea and black tea - Part 1: Content of total polyphenols in tea – Calorimetric method using Folin – Ciocalteu reagent.

Kupeli, E., Sahin, F. P., Calis, I., Yesilada, E., and Ezer, N. 2007. Phenolic compounds of *Sideritis ozturkii* and their *in vivo* anti-inflammatory and antinociceptive activities. Journal of Ethnopharmacology 112: 356-360.

Nadeem, H.S., Torun A.M. and Ozdemir, F. 2011. Spray drying of the mountain tea *(Sideritis stricta)* water extract by using different hydrocolloid carriers. LWT Food Science and Technology 44: 1626-1635.

Papadakis, S. E., Gardeli, C. and Tzia, C. 2006. Spray drying of raisin juice concentrate. Drying Technology 24: 173-180.

Quek, S. Y., Chok, N. K., and Swedlund, P. 2007. The physicochemical properties of spray-dried watermelon powders. Chemical Engineering and processing 46: 386-392.

Rodriguez-Hernandez, G. R., Gonzalez-Garcia, R., Grajales-Lagunes, A., Ruiz-Cabrera, M. A. and Abud-Archila, M. 2005. Spray-drying of cactus pear juice *(Opuntia streptacantha)*: effect on the physicochemical properties of powder and reconstituted product. Drying Technology 23(4): 955-973.

Roos, Y. and Karel, M. 1991. Applying state diagrams to food processing and development. Food Technology 45: 66–71.

Tijburg, L. B. M., Wiseman, S. A., Meijer, W. G. and Weststrate, J. A. 1997. Effects of green tea, black tea and dietary lipophilic antioxidants on LDL oxidizability and atherosclerosis in hypercholesterolaemicrabbits. Atherosclerosis 135(1):37-47

Walton, D. E. 2000. The morphology of spray-dried particles: a qualilative view. Drying Technology 18: 1943-1986.