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Development of Powdered Mixed Green Tea and Okra Beverage Product by Spray Drying

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Abstract

Thai herbal juices tend to lose nutrients during heat processing. Spray-drying has been one of the most well-known methods of powder production, which involves the transformation of liquid material into dried particles. The study performed the suitable conditions of spray drying for green tea and okra powder qualities. Maltodextrin as a carrier at concentrations of 10, 20, and 30 percent were added to mixed green tea and okra powder. Three inlet and fixed outlet temperatures of 150, 160, 170 and 75 ºC, respectively, were also analysed. Physicochemical properties such as colour, moisture, water activity, pH, yield percentage total phenolic and antioxidant inhibition percentage (DPPH, FRAP and ABTS assay) were assessed, while sensory tests were also performed. The inlet temperature of 150 ºC, maltodextrin 10% showed the highest values of the three assays in terms of antioxidant inhibition percentage (DPPH, ABTS (VEAC), (TEAC) and FRAP assays) and total phenolic compound were 0.235%, 0.974 mM/g, 0.696 mM/g, 0.962 mM Fe^{+2} /g and 0.235 ppm, respectively. A sensory test of each product's overall acceptability was performed by 30 untrained panelists using the ranking test. The results revealed that the inlet temperature of 150 ºC, maltodextrin 30% was the most accepted (the highest yield percentage), while the inlet temperature of 170 ºC, maltodextrin 30% was the least accepted. The information obtained describes the most exceptional advantages of the spray-drying method for the production of food particles. Further, the potential of this technique and more advanced equipment to develop processes and industrial-scale processes is essential to the bench-to-bedside translation of innovative instant powdered herbal Thai beverage products.

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Introduction

Tea, such as green tea, is a preferred herbal drink consumed globally. Tea comes from the plant (*Camellia sinensis*) and is drunk in various forms globally, such as green tea or black tea. The health benefits of polyphenol compounds found in green tea have been broadly studied for at least fifteen years. The consumption of green tea has also been associated with protection from many types of illnesses, i.e. cancer. The composition of the chemical compounds in green tea include complicated proteins, whose enzymes have major components in amino acid forms, i.e. theanine (5-N-ethylglutamine), serine and glutamic acid, carbohydrate compounds such as homopolysaccharide (cellulose), pectin, sucrose and minor elements i.e. chromium and calcium. A few contents of pigments such as chlorophyll as well as carotenoid, fat or lipid (linoleic versus α-linolenic acids), vitamin E (fat-soluble), vitamin as well as C (water soluble), as well as compounds of volatile are essential components.[1] Lady's fingers (okra) (scientific name *Abelmoschus esculentus* L.), are normally recognized as similar to okra. Lady's fingers are a fully farmed food crop that is accepted internationally for its use in delicious food products. The modification of herbs such as okra is broadly consumed in the fermented food product industry, such as pickles.[2] Spray-drying is one of the most popular procedures practised to efficiently gain sugar and acid-abundant food by using different drying agents under optimal processing conditions to obtain powdered foods with the benefits of heat short contact time, microbial growth inhibition, and storage stability.[3] The major variables of spray-drying, such as rate of feed and hot air temperature, are essential to the properties of spray-dried food products such as total soluble solids, total insoluble solids, size of particles, moisture level, intensity, and average wettability time. The carrier substance normally used in the spray-drying of food is maltodextrin because of its low viscosity as well as high solubility, which are essential situations for the spray-drying method.[3,4,5,6] There are several factors influencing the quality parameters of dried products. Some chemical and biochemical reactions such as browning reactions and lipid oxidation might alter the final colour change.[7] Most recently, work has been done to shorten the duration time of drying in order to get better efficiency from the energy of the process of drying versus the qualities of the dried product. The quality of dried products could be enhanced by reducing either the drying time or drying temperature.[8] For example, two related pieces of research on spray-dried products found the concentrated green tea extract was then blended with maltodextrin at ratios of 3, 5 as well as 7% (w/v), serially, then spray dried, i.e. inlet temperature at 170, 190 as well as 210°C and fixed with outlet temperature at 80°C, serially.

The total phenolic level versus moisture level of examples was changed from the limit of 14.78-20.37% as well as 4.40-4.87%, serially. Hygroscopicity, solubility, water activity as well as the bulk intensity of these examples were modified on the scale of 8.61-13.72%, 94.76-98.53%, 0.21-0.29 and 0.36-0.48 g/ml, respectively.[9] Previous work proposed analysis of the appropriate conditions for spray drying in terms of the maximal polyphenol levels of the product. The optimum conditions, i.e. input flow rate, suitable inlet temperature and whey protein isolate level were analysed at 136 ºC and 10.3% (on dry bases), serially.

The achieved green tea powder products, which got EGCG, total polyphenol level (TPL) value as well as caffeine level of 11.4%, 322.06 mg GAE/g and 2.8% (on dry bases), serially.[10]

The lack of continuing knowledge and techniques about the production of herbal drinks means knowledge is still limited. However, the absolute proportion formula such as mixed green tea and okra beverage products have not been reported in previous studies. Food powders from Thai herbs are essential products because of their prolonged shelf life under normal temperatures, ease of consumption and low portage charge. Mixed green tea and okra powder can be consumed as an instant drink in powdered form or used as a flavouring additive. Several workers reviewed that Thai herbal aliquot drying could make the powdered form dissolve more quickly to an elaborate particular look like the initial aliquot. This is because the product temperature is infrequently increased above 100ºC through the process of drying. However, there are several obstacles in the steps for drying techniques at the mixed herbal aliquot versus major bioactive or antioxidant level, at high humidity and temperatures occurring their employment in difficulty and packaging type.[11] This study emphasized the use of green tea and okra as principal raw materials that are highly available and inexpensive, resulting in subsequent spray-drying steps to convert products in powdered form. In addition, this work focused on the processing of Thai herbal drinks into powdered form. As a result, the advantages of this raw material are enhanced health and essential bioactive compounds. Based on the results of the research, the concept of blending with other types of various Thai herbal could be used to further develop the SME business in Thailand. It would also help farmers earn more income from agricultural products and serve as an alternative for entrepreneurs to further expand commercially.[11] The main purposes of this research were to determine the appropriate conditions such as various maltodextrin concentrations and inlet temperature of spray drying as well as the mixed green tea and okra powder qualities by maltodextrin as a carrier substance. The using of maltodextrin as physicochemical qualities in terms of water activity, yield percentage, brightness and colour (L, a* and b* values) moisture content, percentage of antioxidant inhibition as DPPH, ABTS, FRAP assay, total phenolic compound and sensory evaluation.[11]

Materials and Methods

Raw Material Preparation

Dried green tea and fresh okra (lady's finger) samples which had roughly identical diameters and lengths were purchased at the Rangsit Market in Pathum Thani Province, Thailand. The selected green tea and lady's finger samples were washed with piped water to conduct examples independent from unknown raw materials as well as dirt contaminants and then soaked in 4,000 ml of cold water at between 12-20°C for about 16-20 hours to get moisture equilibrium. The prepared mixtures (green tea and okra ratio 1:1) were diluted in optimum ratio and filtered with a colander and then thin white cloth before the spray-drying operation.[11]

The maltodextrin DE 10-12 was supplied from Chemical Bangkok Co., Ltd in Bangkok, Thailand.[11]

All chemicals for analysis used in this research were analytical reagent grade.[11]

Determination of Suitable Spray Drying Temperature for Mixed Green Tea and Okra Powder Production

The samples prepared by the method explained in the section on raw material preparation were spray-dried using a Spray Drier (Model SD-Basic Lab Plant Scale). The maltodextrin content was put into 3,000 ml of hot water so that the soluble maltodextrin levels were 10, 20 and 30 percent (calculate as total soluble solid 10, 20 and 30°Brix, respectively) of hot water with homogeneous aliquot. The maltodextrin content of 10, 20 and 30 percent of the feed aliquot can be about changed to green tea and okra proportions (based on total soluble solids) until dissolved homogenous aliquot. The drying experiments were carried out using three maltodextrin content levels (10, 20 and 30 percent) and three inlet temperatures (150, 160 and 170°C) to maintain an outlet drying air temperature of about 75°C and flow rate of 0.3 litres per hour. At the end of drying, the mixed green tea and okra powders were collected, weighed, and kept in a laminated bag in a dark, cool and dry place for determination of the physicochemical and sensory evaluation quality.[11]

Physicochemical Quality of Mixed Green Tea and Okra Powder

Spray-dried powder mixed with green tea and okra powder was also analysed for moisture content following the hot-air oven method.[11] Triplicate powder samples (approximately 4 g each in a dried moisture can) were dried at 100-105°C for 3 hours. The change in weight after the experiment caused by water loss was expressed in per cent by weight and then recorded for data. The average of triplicate samples was calculated using equation (1) below.[12]

$$\text{Moisture level percent} = W_b - W_a \times 100 / W_b \quad ...(1)$$

W_b = sample weight before drying (g)
W_a = sample weight after drying (g)

The brightness and colour of the samples were determined using a Mini Scan XE colourimeter from Hunter Laboratory (Hunter Associates, Reston, VA) in the L*, a*, b* values. L* presents brightness ($0 \leq L \leq 100$), when a*(-), a*(+), b*(-) and b*(+) present as greenness, redness, blueness as well as yellowness, serially.[11,12] Triplicate powder samples (approximately 3-4 g each) were placed on the calibrated plate and recorded as L*, a* and b* values.[12] A_w (water activity)[11] was analysed by applying an apparatus of aw and recorded as a value.[12] Triplicate powder samples (approximately 3-4 g each) were placed on a sample cup covered with a lid until a loud signal and recorded as water activity and temperature value.[12] The yield percentage of the powder[11] for all dried products treated was computed by using the formula (2) below.[13]

% yield percentage =
Solid weight of powder after spray drying x 100 / Total solid weight before spray drying ...(2)

The pH was measured by a pH meter[11] (model HI98103, Hanna, USA). First, approximately 30 ml each of pH 7.00 and 4.00 buffers were poured into separate 50 ml beakers. Use these two beakers as rinse beakers during calibration, the pH electrode was rinsed first with deionized water and then the electrode was placed in the calibration beaker. The pH electrode was re rinsed again, first with deionized water, and then the electrode was placed in the sample to record the obtained results.[12]

The total phenolic quantity (TPQ)[11] was analysed by performing the Folin Ciocalteu phenol reagent assay. The 1 ml of extracted sample was pipetted and added with 1 ml of 95 % ethanol aliquot, 5 ml of distilled water versus 0.5 ml of 50 %v/v of reagent of Folin Ciocalteu phenol, then mixed and left for 5 minutes. The 5 %w/v of a sodium carbonate 1 ml was added to the sample solution and then the sample was left in a dark place for 1 hour. The recorded value as sample absorbance was evaluated at a selected wavelength of 725 nm. TPQ was calculated against the standard curve of gallic acid, while the equation below was followed (equation 3).[14]

TPQ = c x v/m ...(3)

Where TPQ = total phenolic quantity in the extracted sample (ml / g of extracted sample)

c = gallic acid concentration obtained from the graph of the extract (mg/ml)
v = volume of the extracted sample (ml)
m = weight of the extracted sample (g)

Percentage of antioxidant inhibition as DPPH assay.[11] The powdered samples were prepared in different ways before analysis. For the dried sample, dried green tea and fresh okra examples which have around the same diameter versus length were mixed. The amount of mixed green tea and okra was 2 g and mixed with 20 ml of 95 % ethanol. The sample was shaken with a shaking incubator (NB-205V, N-Biotek, Korea) under conditions including 25ºC, 2,000 rpm for 3 days. Afterwards, it was centrifuged at a velocity of 4,000 rpm for 20 mins (D-78532, Hettich, Germany). The clear aliquot was stored in a light protective glass bottle at 4ºC before evaluation. For powder as a sample, 1 g of powder versus 10 ml of 50 % ethanol was weighed and then mixed in a centrifuged tube. The sample was then prepared with the same method. Antioxidant capacity analysis of 2,2-diphenyl-1-picryhydrazyl by DPPH assay was examined by the following method. The extracted sample was pipetted 100 µl and mixed with 3 ml of 60 µM DPPH, then left in a dark place for 10 mins. The abs (absorbance) of the sample was evaluated at a wavelength of 517 nm. The control sample used 100 µl of 95 % ethanol instead of extracted sample. The antioxidant capacity was computed as an inhibition percentage by evaluation of equation 4.[15]

Percent of inhibition =
(control abs- sample abs) x 100 / control abs ...(4)

Antioxidant inhibition percentage (FRAP) assay.[11] A centrifuge was applied to evaluate the assay of FRAP. Firstly, a pipet of 300 ml of newly prepared FRAP reagent was heated to 37ºC, as well as a reagent blank recording (M1), which was obtained at 593 nm, a pipet of 10 ml of powdered example was therefore filled, though with 30 ml of water. The last example dilution in the reaction portions was 1/34 Abs (absorbance) readings, which were measured after 0.5 sec as well as every 15 seconds after that throughout the observation interval. The modified value in abs (∆A593nm) between the last reading specified value and the M1 reading was computed for each sample and correlated to ∆A593nm of a Fe^{2+} std (standard) aliquot experimented in correspondent.[16]

Percentage Antioxidant inhibition as ABTS assay.[11] The analysis was adjusted slightly as observed for 2, 2 azobis, 3 ethyl benzothiozoline-6-sulphonic acid (ABTS) activity of radical cation scavenging. The ABTS (7 mM) aliquot was treated with 2.45 mM potassium persulfate and stored for 1 day (overnight) in a dark place for the generation of dark-coloured ABTS radicals. For this analysis, the aliquot was diluted with 50 % ethanol for the first abs (absorbance) value of 0.7 at 745 nm. The activity was analysed by filling 100 µl fractions of other serial dilutions with 1 ml of ABTS aliquot in a cuvette (glass). The reduction in abs value was evaluated after 1 min and 6 mins of blending. The change value was computed and correlated with the control sample. Inhibition per cent was computed using equation 5.[17]

% ABTS scavenging effect = (abs of control-abs of fraction) x 100 / abs of control ...(5)

Sensory Evaluation

A ranking test was selected for the sensory evaluation of mixed spray dried green tea and okra powders. A total of nine samples were served to thirty panellists. The mixed green tea and okra powder was reconstituted with water at a 1:1 weight ratio before serving to the 30 untrained panellists. Subsequently, each panellist ranked all samples from the highest to lowest scores (1-9) of overall acceptability.[11,13,18]

Statistical Analysis

The complete randomized design (CRD) was used for study in this experiment, but the sensory experiment used RCBD (Randomized Complete Block Design) as an experimental design. DMRT (Duncan's new multiple range tests) and ANOVA (Analysis of variance method) were used to analyse data with a 0.05 level of confidence. All treatments were studied in triplicate, and data were expressed as the obtained values. The variance analysis and the mean differences of treatments were conducted using PASW statistics version 18.[11,18,19]

Results and Discussion

All instant mixed green tea and okra powder samples and spray-drying yields were represented in Table 1-12.

Table 1: Yield percentage of instant mixed green tea and okra powder by variation of 3 inlet temperature

Maltodextrin (%)	Yield percentage inlet Temperature (°C)*		
	150°C	160°C	170°C
10	8.03^{g}	7.01^{h}	10.26^{f}
20	10.20^{fg}	14.03^{cd}	16.97^{b}
30	11.80^{e}	14.43^{c}	17.44^{a}

N.B: The other superscript alphabets (a-h) from identical column indicate significant variation at 0.05.

The mixed green tea and okra with maltodextrin at 30%w/v and an inlet temperature of 170ºC gave the highest yield. The yield percentage indicated that whole conditions of drying offered elevated recovery of powder in the limit of 8.03-17.44 percent. Although these values were very low, they revealed that the concentration of maltodextrin at 30 percent provided a significantly higher powder recovery percentage in the range of 10 percent. The low recovery of measurement level was because of the maltodextrin addition level being less than 20 percent that followed the non-tough products as well as low product quantity size in the drying chamber and cyclone.[20,21,22] The addition of maltodextrin and high temperature could enlarge the total dissolved particle contents in juice and reduce the moisture content of the powder product. Maltodextrin is a modified starch extracted from plants such as chicory root, artichoke, etc. Maltodextrin is approved as a good encapsulant that entraps low molecular weight such as sugars and acids, thereby facilitating spray drying and reducing the stickiness of the spray-dried product.[5,23] The trend of yield percentage was near the increasing maltodextrin concentrations.

The results of the research related that spray-dried banana puree gave the highest dried product yield (51.50%) which was operated at an inlet temperature of 150 °C with 30% (w/w) of maltodextrin.[24] The calculated yield was also not positively affected by maltodextrin quantity due to expansion on the aliquot value of viscosity. Powder hygroscopicity decreased with the addition of maltodextrin quantity.[22,25] This occurrence might be described by the means of application for the collection of powder. In this work, the whole powders (each treatment) were kept in a cyclone. Nevertheless, the drying chamber was occasionally cracked by a rubber hammer through processing to maintain the powder on the drying chamber surface and keep its apparatuses as low as possible. Even though the yield percentage was very low for the whole drying process, there were higher contents of powder attached in the drying system for the conditions of drying, which had many total soluble solids in the inlet feed aliquot (added more maltodextrin concentration) because of the limitation of using hammer force in the powder collection procedure.[26] In contrast, the trend of yield percentage might be varied from the original characteristic if at the end of the drying process, while the powder on the drying chamber surface was polished manually and merged with those kept at another part of the cyclone.[27]

Table 2: Water activity values of instant mixed green tea and okra powder by variation of 3 inlet temperature

Maltodextrin (%)	Water activity Inlet Temperature (°C)*		
	150°C	**160°C**	**170°C**
10	0.200[de]	0.293[a]	0.158[f]
20	0.201[de]	0.168[e]	0.202[d]
30	0.252[bc]	0.269[b]	0.257[c]

N.B: The other superscript alphabets (a-f) from identical column indicate significant variation at 0.05.

The net result revealed that the water activity of the powdered forms was within the limit of 0.158-0.257. Consequently, the inlet temperature of the hot air increased, resulting in the value of water activity increasing; the inlet temperature of 170°C at 30 percent maltodextrin was the highest value of 0.257. In this study, it was found that the a_w of green tea powder mixed with okra fluctuated slightly when increasing the amount of maltodextrin.[11,12] There were no value trends among maltodextrin concentrations or different inlet temperatures.[13] As a result, the addition of maltodextrin affects increasing solid content and maltodextrin binds with the water part, which corresponded with the decreasing of a_w value.[5] The definition of a_w value is the partial vapour pressure in matter divided by the standard state partial vapour pressure of water. In the related scope of science, i.e. food science and technology, this criteria condition is frequently described as the partial vapour pressure of pure water at an identical temperature. Most food has a value of a_w over 0.95 and will offer an adequate level of moisture to encourage the growth of mould and yeast as well as bacteria.[28]

The moisture content of the powdered sample (Table 3) produced from maltodextrin concentration of 10 percent and inlet temperature at 170°C resulted in the highest moisture (possibly due to the increase in solid contents of feed material leading to the reduction of water proportion in the feed). The added inlet temperatures and maltodextrin level represented the lower moisture-dried products. The high inlet temperature caused the elevated temperature difference at the upper surface of feed droplets. This directly expressed the rate of heat transfer and also the moisture evaporation from the aliquot droplets in the drying chamber, resulting in the low moisture level of the product in dry form. Moreover, maltodextrin can entrap the sugars in the powdered example that has a highly hygroscopic nature from absorbing the moisture in enclosed air.[29] Higher temperatures cause the water in the product to evaporate more quickly and more than lower inlet temperatures. By considering the influence of inlet temperature, it was found that the humidity percentage will decrease as temperature rises. As a result, the temperature rises, the water in the product evaporates more quickly and more than the temperature of the hot air inlet is lower.[30] At the same time, it was found that the moisture content of the product tended to decrease when the amount of maltodextrin was increased. Maltodextrin has important properties as a drying aid. It will reduce the moisture absorption characteristics towards date palm powder products by using 30 percent maltodextrin for moisture content lower than 20 per cent and 10 per cent maltodextrin, respectively.[5,31]

Table 3: Moisture content values of instant mixed green tea and okra powder by variation of 3 inlet temperature

Maltodextrin (%)	Moisture content (%) Inlet Temperature (°C)*		
	150°C	**160°C**	**170°C**
10	2.00^{c}	2.06^{bc}	3.76^{a}
20	1.72^{e}	1.14^{ef}	1.99^{cd}
30	0.85^{f}	2.26^{h}	1.99^{cd}

N.B: The other superscript alphabets (a-h) from identical column indicate significant variation at 0.05.

Table 4: Brightness values of instant mixed green tea and okra powder by variation of 3 inlet temperature

Maltodextrin (%)	Brightness Inlet Temperature (°C)*		
	150°C	**160°C**	**170°C**
10	92.54^{b}	92.90^{c}	93.12^{ab}
20	93.16^{bc}	93.12^{ab}	90.49^{c}
30	92.17^{d}	92.53^{bc}	92.47^{bc}

N.B: The other superscript alphabets (a-d) from identical column indicate significant variation at 0.05.

Table 5: Greenness values of instant mixed green tea and okra powder by variation of 3 inlet temperature

Maltodextrin (%)	Greenness Inlet Temperature (ºC)*		
	150ºC	**160ºC**	**170ºC**
10	-0.34^{df}	-0.29^{de}	-0.06^{b}
20	-0.27^{de}	-0.12^{d}	-0.11^{c}
30	-0.30^{e}	-0.27^{a}	-0.69^{f}

N.B: The other superscript alphabets (a-f) from identical column indicate significant variation at 0.05.

Table 6: Yellowness values of instant mixed green tea and okra powder by variation of 3 inlet temperature

Maltodextrin (%)	Yellowness Inlet Temperature (ºC)*		
	150ºC	160ºC	170ºC
10	7.66[d]	7.52[de]	8.15b[c]
20	6.43[f]	6.81[ef]	7.13[e]
30	9.33[b]	8.95[c]	10.62[a]

N.B: The other superscript alphabets (a-f) from identical column indicate significant variation at 0.05.

Regarding the brightness (L*) and colour (+b* including*-a*) values, (Table 4-6) it was revealed that the mixed green tea and okra powder lightness, yellowness versus greenness were significantly different. The L* value is the whiteness of the sample, and an inlet temperature of 150°C, maltodextrin 20% offered the most whiteness. In general, the powders had more brightness than the greenness, and yellowness was higher. However, the intensity of the aroma of mixed green tea and okra powder decreased with the increasing of maltodextrin level.[32] The cause of the lower brightness was that a small proportion of powder could not dissolve completely in the solution. As the temperature rises, it results in a browning reaction in the powdered mixed green tea and okra.[33] The other reasons for the brightness decrease could be the browning reactions (non-enzymatic) happening during spray-drying. More green and yellow colours in the powder forms may also be a result of some browning reactions (non-enzymatic), such as Maillard and caramelization reactions occurring throughout the drying process. These reactions could occur because of the sugar levels in the finished mixed green tea and okra as well as the heat obtained in the drying chamber from the aliquots.[20,34] Maltodextrin has a white powder.[5] when using higher maltodextrin concentrations; mixed green tea and okra increased the brightness. Furthermore, maltodextrin concentration is another original source of changes in terms of colour variations between the reconstituted, finished and fresh mixed green tea and okra. Nevertheless, colour variations among reconstituted examples did not show obvious trends because the powdered examples were not concentrated in water as distilled before analysis. In addition, the effects of drying temperatures on the product colour were not clear because the feed rate was also extended at higher inlet temperatures.[13,21]

Table 7: pH values of instant mixed green tea and okra powder by variation of 3 inlet temperature

Maltodextrin (%)	pH Inlet Temperature (ºC)*		
	150ºC	160ºC	170ºC
10	5.20[a]	4.51[cd]	4.72[c]
20	4.74[bc]	4.36[d]	4.61[bc]
30	4.80[b]	4.43[cd]	4.11[e]

N.B: The other superscript alphabets (a-e) from identical column indicate significant variation at 0.05.

The pH in the fresh sample was closed to neutrality, with values higher than 6.0. For powdered samples, the pH of all treatments was in the range of 4.11-5.20. The effect of maltodextrin on pH in the sample was not found.[13] There were no value trends between pH and maltodextrin changes. In powders obtained by convective drying, the pH values tended to fluctuate as the drying temperature increased.[35] The other reason might be that mixed green tea and okra products did not contain some food additives or contained minimal food ingredients.[11,22,23]

Table 8: DPPH (%Inhibition) values of instant mixed green tea and okra powder by variation of 3 inlet temperature

Maltodextrin (%)	DPPH (%Inhibition) Inlet Temperature (ºC)*		
	150ºC	160ºC	170ºC
10	0.235[a]	0.208[c]	0.195[e]
20	0.221[ab]	0.205[d]	0.193[f]
30	0.218[b]	0.204[de]	0.208[bc]

N.B: The other superscript alphabets (a-f) from identical column indicate significant variation at 0.05.

Table 9: ABTS (VEAC) values of instant mixed green tea and okra powder by variation of 3 inlet temperature

Maltodextrin (%)	ABTS (VEAC) (mM/g) Inlet Temperature (ºC)*		
	150ºC	160ºC	170ºC
10	0.974[a]	0.873[ab]	0.789[d]
20	0.851[b]	0.790[cd]	0.719[de]
30	0.792[c]	0.672[ef]	0.624[f]

N.B: The other superscript alphabets (a-f) from identical column indicate significant variation at 0.05.

Table 10: ABTS (TEAC) values of instant mixed green tea and okra powder by variation of 3 inlet temperature

Maltodextrin (%)	ABTS (TEAC) (mM/g) Inlet Temperature (ºC)*		
	150ºC	160ºC	170ºC
10	0.696[a]	0.695[ab]	0.518[de]
20	0.675[b]	0.595[d]	0.495[e]
30	0.620[c]	0.518[de]	0.426[f]

N.B: The other superscript alphabets (a-f) from identical column indicate significant variation at 0.05.

Table 11: FRAP values of instant mixed green tea and okra powder by variation of 3 inlet temperature

Maltodextrin (%)	FRAP (mM Fe^{+2} /g) Inlet Temperature (ºC)*		
	150ºC	160ºC	170ºC
10	0.962[a]	0.855[b]	0.755[d]
20	0.839[c]	0.503[f]	0.708[e]
30	0.693[ef]	0.757[cd]	0.562[ef]

N.B: The other superscript alphabets (a-f) from identical column indicate significant variation at 0.05.

Table 12: Total phenolic compound values of instant mixed green tea and okra powder by variation of 3 inlet temperature

Maltodextrin (%)	Total phenolic compound (ppm) Inlet Temperature (ºC)*		
	150ºC	160ºC	170ºC
10	0.235a	0.136b	0.135bc
20	0.101e	0.105de	0.114d
30	0.121cd	0.105de	0.124c

N.B: The other superscript alphabets (a-e) from identical column indicate significant variation at 0.05.

Table 13: Overall acceptance values of instant mixed green tea and okra powder by variation of 3 inlet temperature from ranking test

Rank of overall acceptance	condition
1	Inlet temperature 150ºC , maltodextrin 30%
2	Inlet temperature 150ºC , maltodextrin 20%
3	Inlet temperature 160ºC, maltodextrin 10%
4	Inlet temperature 150ºC , maltodextrin 10%
5	Inlet temperature 160ºC , maltodextrin 30%
6	Inlet temperature 170ºC , maltodextrin 10%
7	Inlet temperature 160ºC , maltodextrin 20%
8	Inlet temperature 170ºC , maltodextrin 20%
9	Inlet temperature 170ºC , maltodextrin 30%

For powdered samples, three percentages of antioxidant inhibition assays DPPH, FRAP, ABTS and total phenolic compounds were studied (Table 8-12). The inlet temperature of 150°C, maltodextrin 10% revealed the highest values of three assays of antioxidant inhibition percentage and total phenolic compound. Otherwise, the increasing Inlet temperature of 170°C, maltodextrin 30% indicated the lowest values among them.[5,11,13,22] It was found that the amount of maltodextrin increased by decreasing the antioxidant value of mixed green tea and okra, and will decrease further according to the higher temperature used for drying.[5,11,13,22]

According to Table 13, the ranking test results showed that an inlet temperature of 150°C, maltodextrin 30% was the most accepted while an inlet temperature of 170°C, maltodextrin 30% was the least accepted. Inlet temperature of 150°C, maltodextrin 10% gave the highest amount of antioxidant capacity compared to others. This might be caused by mixed green tea and okra having no food additives or minimal food ingredients.[11] However, an inlet temperature of 150°C, maltodextrin 10% might be the best treatment in this research because it revealed very high antioxidant capacity among all samples as well as high acceptable preference (4th rank).[11,13,36] The use of a higher or lower inlet temperature indicated low acceptance scores from the panelists.[11,22,23,36]

Conclusion

The results presented the practicability of producing mixed green tea and okra powders and aliquots of maltodextrin using the spray-drying method. The mixed green tea and okra powders were reconstituted in distilled water; the best concentration of maltodextrin was 30 percent for spray-dried products, while an inlet temperature of 150°C was the most accepted (highest yield percentage) and an inlet temperature of 170°C, maltodextrin 30% was the least accepted.

Because of some of the advantages in data about powdered products from Thai herbs in the previous study, the results of this study could help develop Thai herbal food powders with good solubility. This research is preliminary research to establish the optimum conditions from Thai herbal powder with both high yield and stability. Further study could apply the results to launch new products. In addition, research can also be done to study the application of these raw materials by selecting other appropriate Thai herbs that develop processes and industrial-scale processes that are essential to the bench-to-beside translation of innovative instant powdered fruit and vegetable beverage products.

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Conflict of Interest

The author does not have any conflict of interest.

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