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Research Article

Optimization of alcohol extraction and spray-drying conditions for efficient processing and quality evaluation of instant tea powder from lotus and green tea leaves

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Abstract

Lotus and Green Tea leaves are two frequently used medicinal plants in Vietnam, utilized as food, drink, or in traditional treatments to help with weight loss and cholesterol reduction. The study's major goal is to determine the parameters of the process preparation in order to generate instant tea powder that satisfies quality criteria for customer demand. Twenty experiments are conducted using the D-optimal model to evaluate the cause-effect relationship and optimize the production process of instant tea powder. Four independent variables are selected for the survey namely alcohol concentration (40%; 50%; 60%), carrier mass (10 g; 20 g; 30 g), inlet air temperature (160 °C; 170 °C) and flow rate (4 rpm/min; 5 rpm/min). The instant tea powder is effectively created and met quality parameters, with a drying performance, moisture content, total phenol and flavonoid content of 29.15%, 4.83%, 45.29 mg GA/g, and 70.68 mg QE/g, respectively. In conclusion, the optimal parameters of the preparation process were identified, which included an alcohol content of 60%, a carrier mass of 10 g, an inlet air temperature of 165 °C, and a flow rate of 4 rpm/min.

Keywords

instant tea powder, lotus leaves, green tea leaves, spray-drying

Introduction

Lotus (*Nelumbo nucifera* Gaertn.) is a water plant of the Nelumbonaceae family produced in various regions in Vietnam for food and medicinal, with many different components used such as the leaf, seed, plumule, and stamen (Wang 2021). Lotus leaves contain alkaloids, polyphenols, terpenoids, steroids, glycosides, flavonoids, organic acids, and vitamin C, which are responsible for the plant's various biological and pharmacological activities, such as antioxidant, anti-inflammatory, immune-modulatory, antiviral, hepatoprotective, cardioprotective, and hypoglycemic properties, and have been widely used in folk remedies with the effect of sedative-hypnotic and anxiolytic effect, support of weight loss treatment, reduction of lipid levels, therapy for fatty liver, blood pressure (Tungmunnithum et al. 2018; Wan-Li and Wen-Chuan 2020) and anti-cancer (Bishayee et al. 2022).

Green tea (*Camellia sinensis* L. Kuntze.) is a plant in the Theaceae family that contains approximately 4,000 bioactive components with antioxidant properties, weight loss support, lipid reduction, blood pressure regulation, cancer risk reduction, tumor growth prevention, and increased human life expectancy (Ramadon et al. 2018). Green tea is a non-fermented beverage that includes more catechins, epigallocatechin (EGC), epicatechin gallate (ECG), epigallocatechin gallate (EGCG), caffeine, amino acids, and water-soluble vitamins (Zokti et al. 2016).

Spray drying is the process of transforming a liquid (solution, suspension, emulsion, or gel) into dried particles by spraying it into a dryer chamber with enough hot air to evaporate liquid droplets (Rahmati et al. 2018; Santos et al. 2018; Gunjal and Shirolkar 2020). It reduces weight, improves powder stability, extends shelf life, and protects against microbiological and oxidative deterioration (Gunjal and Shirolkar 2020). Despite the high temperature used to dry in spray dryers, the particles sprayed owing to moisture loss remain at a lower temperature and for a very short period, reducing thermal damage to the product (Yatsu et al. 2011). Spray-drying powders were widely employed in the food and pharmaceutical industries for purposes other than instant tea powder (Verma and Singh 2015; Pinto et al. 2021; Thamkaew et al. 2021).

Many recent research on instant tea powder by spray-drying technology, such as Latifi et al. (2020), Eroglu et al. (2018), Dao et al. (2021), Tuyen et al. (2022),... have been current forms capable of meeting market demands, convenient and easy to use. There has been no optimization of alcohol extraction and spray-drying conditions from lotus and green tea leaves for effective processing and evaluation of instant tea powder quality. The goals of this study are analysis of the characteristics of the instant tea powder preparation process and evaluation of the finished product quality.

Materials and methods

Materials

Lotus leaf (moisture content of 12%), green tea leaf (moisture content of 11%) provided by Dai Nam company (Ho Chi Minh city, Vietnam).

Process of preparing instant tea powder

Accurately weight about 60 g of lotus leaves (size 1.0–1.6 mm) and 60 g of green tea leaves (size 1.0–1.6 mm) into 2000 mL Erlenmeyer flask, extracts by heat reflux method at a temperature of 60 ± 2 °C in 60 minutes in two times and medicinal herbs/solvent ratio was 1:15. All extracts are combined, concentrated to the liquid extract (1:8) and dried by Labplant spray-drying equipment to obtain instant tea powder. The parameters of the independent and dependent variables are presented in Table 1.

Table 1. Variables in experimental design.

Independent variables	Level 1	Level 2	Level 3
X_1: alcohol content (%)	40	50	60
X_2: carrier mass (g)	10	20	30
X_3: inlet air temperature (°C)	160	170	–
X_4: flow rate (rpm/min)	4	5	–
Dependent variables		Constraints	
Y_1: drying performance (%)		Maximum	
Y_2: moisture content (%)		Minimum	
Y_3: total phenol content (mg GA/g)		Maximum	
Y_4: total flavonoid content (mg QE/g)		Maximum	

Effects of variables on drying performance (Y_1)

The performance of spray dryer for each experiment is calculated as the ratio of the weight of the instant tea powder obtained and the initial total solids (raw material and carrier mass) in the suspension prepared (Eroğlu et al. 2018).

Effects of variables on moisture content (Y_2)

The moisture content of the sample is gravimetrically determined with a moisture analyzer MA35 (Sartorius AG, Germany) at 105 °C. The moisture content should not be more than 10% (Lee et al. 2017; Eroğlu et al. 2018).

Effects of variables on total phenol content (Y_3)

Total phenol content is determined by the Folin-Ciocalteu (FC) method and gallic acid is used as standard material (Eroğlu et al. 2018; Gunjal and Shirolkar 2020). FC 10% reagent is diluted with distilled water. The sample powder is diluted in methanol solution with a concentration of 1,000 μg/mL. 1 mL of the sample, 6 mL of distilled water and 0.5 mL of FC reagent are added in a 10 mL volumetric flask and shake well. After 5 min, add 1.5 mL Na_2CO_3 20%, shake well and add distilled water until the total volume is 10 mL. Keep the samples in the dark at ambient temperature for 30 min, the absorbance of samples is determined by a Shimadzu UV2100 spectrophotometer at 760 nm. The total polyphenol content in instant tea powder is expressed as mg GA per g of instant tea powder (mg GA/g) and calculated by the formula:

$$Y_3 = \frac{C \times V}{m},$$

in which:
C: x value from calibration curve with gallic acid (mg/mL);
V: volume of test solution (mL);
m: mass of instant tea present in volume V (g)

Effects of variables on total flavonoid content (Y_4)

Total flavonoid content is determined by the aluminum chloride colorimetry method and quercetin is used as the standard material (Rahmati et al. 2020). Powder sample is diluted in methanol solution with a concentration of 1,000 µg/mL. 1 mL of the sample and 4 mL of distilled water are added in a 10 mL volumetric flask. Then, add 0.3 mL NaNO2 5%, 0.3 mL AlCl3 10% and 2 mL NaOH 1M, shake well and add distilled water to bring volume to 10 mL. The absorbance of samples is determined with the wavelength of 510 nm. The total flavonoid content in instant tea powder is expressed as mg QE per g of instant tea powder (mg QE/g) and calculated by the formula:

$$Y_4 = \frac{C \times V}{m},$$

in which:
C: x-value from the calibration curve with quercetin (mg/mL);
V: volume of test solution (mL);
m: mass of instant tea present in volume V (g)

Characterization of instant tea powder

Bulk density, tapped density

The bulk and tapped density are determined following the method described in USP 43 – NF 38. (The United States Pharmacopoeia Convention 2020)

Scanning electron microscopy (SEM)

The surface features and morphology of optimum samples are analyzed by using scanning electron microscopy (SEM) (JSM-IT100, JEOL, Tokyo, Japan). A thin layer of each sample is placed on a carbon double-sided adhesive tab, mounted onto a brass sample holder and sputter-coated with gold practicals and observed under the microscope. The SEM images are taken with 3,000× and 10,000× magnification (Ding et al. 2020; Thumthanaruk et al. 2021).

Evaluation quality of instant tea powder

Some criteria have been evaluated are appearance, moisture content, microbiological contamination and active ingredient content, in which, total phenol content and total flavonoid content are determined with the formula for Y_3 and Y_4 that has been illustrated above.

Optimizing the preparation process of instant tea powder

Twenty experimental (F_1-F_{20}) are designed according to the D-optimal model using Design Expert software (version 6.0.6, Stat-Ease Inc., Minneapolis, USA). The data are analyzed by BCPharSoft software to investigate the cause-effect relations and optimized preparation process. The optimized process is experimentally repeated in triplicate for further validation. The predicted data created by BCPharSoft software are compared with the observed response data from the optimized process using SPSS version 26.0 (SPSS, Inc., Chicago, IL, USA).

Results and discussion

Process of preparing instant tea powder

The preparation process of instant tea powder was designed by Design Expert software including 20 experiments. These results corresponding to the experiments were summarized in Table 2.

Analyzing the cause-effect between the conditions of the preparation process and the properties of instant tea powder. The data in Table 2 were used as inputs for BCPharSoft to investigate the cause-effect relations and optimize the process.

Table 2. The independent variables of 20 experiments (F1-F20) and their responses.

Run	Independent variables				Dependent variables			
	X_1 (%)	X_2 (g)	X_3 (°C)	X_4 (rpm min)	Y_1 (%)	Y_2 (%)	Y_3 (mg GA/g)	Y_4 (mg QE /g)
F_1	50	20	160	5	23.09	5.99	29.34	55.01
F_2	40	10	160	5	30.75	4.33	24.10	38.19
F_3	40	20	170	5	20.80	5.77	23.63	34.04
F_4	40	20	160	4	22.50	5.53	23.27	38.62
F_5	50	10	160	5	21.08	5.36	31.52	56.36
F_6	60	20	170	4	26.44	4.81	43.38	69.64
F_7	50	10	170	4	27.77	5.00	32.84	55.75
F_8	60	30	160	4	21.40	5.74	42.87	63.87
F_9	50	20	170	5	17.49	5.75	32.48	57.58
F_{10}	60	30	170	5	19.89	5.35	42.98	62.00
F_{11}	60	10	160	5	24.06	5.87	45.40	69.45
F_{12}	40	30	170	5	25.03	5.24	20.66	35.47
F_{13}	60	20	160	5	22.87	5.38	43.10	69.97
F_{14}	60	10	170	5	24.95	5.15	45.22	67.19
F_{15}	60	10	160	4	25.58	4.86	45.96	71.32
F_{16}	50	30	170	4	21.75	4.91	29.14	52.36
F_{17}	40	10	170	4	27.99	5.11	24.31	39.35
F_{18}	40	30	160	4	27.05	5.67	21.05	31.66
F_{19}	50	30	160	5	25.59	5.79	29.34	49.70
F_{20}	50	20	160	5	21.54	4.86	31.05	57.64

The results of the accuracy of model statistics from BCPharSoft outputs were presented in Table 3.

Table 3 demonstrates that all R_2 training and R_2 test values were more than 0.9, indicating that the models were extremely reliable. These models have the potential to be utilized for multivariate optimization.

For a better understanding of the cause-effect linkages between the independent and dependent variables, three-dimensional (3D) response surface plots of the fit models were displayed. Each 3D figure depicted the impacts of two independent factors on the dependent variables at the same time while keeping the third variable constant.

Table 3. Model statistics from BCPharSoft outputs.

Dependent variables	Y_1	Y_2	Y_3	Y_4
R_2 training	99.8	99.8	99.8	99.8
R_2 test	99.6	99.6	99.6	99.6

Effects of variables on drying performance (Y_1)

With the ideal circumstances as shown in Table 1, drying performance (percent) – Y_1 has to be as high as feasible. When all X factors are considered in the 3D diagram in Fig. 1, it can be seen that the alcohol content – X_1 is high (level 3- 60%), the carrier mass (g) – X_2 needs to be low (10 g), the inlet air temperature (°C) – X_3 has little effect on drying performance (percent), but X_3 should not be low, and the flow rate (rpm/min) – X_4 uses at a low level (4 rpm).

Water or alcohol with concentrations ranging from 10% to 90% were commonly used in the extraction of therapeutic plants. However, alcohol is the most commonly used solvent because it can dissolve a wide range of bioactive chemicals and has a good storage stability (Tungmunnithum et al. 2018; Abubakar and Haque 2020; Wan-Li and Wen-Chuan 2020). The solvent used is determined by the kind of plant, the section of the plant to be extracted and the nature of the bioactive chemicals. Polar solvents like water and alcohol are used to extract polar chemicals, whereas nonpolar solvents like hexane and dichloromethane were used to extract non-polar compounds (Li et al. 2018). The bioactive components in lotus and green tea leaves are polar compounds, and alcohol concentrations of 40%, 50%, and 60% are utilized in the extraction of lotus and green tea leaves. Table 2 shows that the drying performance of instant tea powder ranged from 17.49% to 30.75%. As the alcohol concentration rises, so does the drying performance (Y_1), as shown in Fig. 1.

Increasing the carrier mass reduces the ability of the drying chamber walls to stick, resulting in improved drying performance (Erolu et al. 2018; Sidlagatta et al. 2020). Recent research has revealed that if the carrier mass is too large, raising the viscosity reduces drying performance (Erolu et al. 2018). This is also true for the research findings in Fig. 1a, d, e.

The drying performance and the input air temperature are in the proportional relationship. If the input air temperature is too high, the completed product melts and sticks to the product receiver, limiting drying performance (Lee et al. 2017; Li et al. 2018; Özdikicierler et al. 2019; Gunjal and Shirolkar 2020; Thumthanaruk et al. 2021). However, if the inlet air temperature is too low, it will be difficult to dry the extract. Fig. 1b, d, and f indicate that the selected temperature levels of 160–170 °C has minimal influence on drying performance, but the input air temperature (X_3) is chosen to be 165 °C to have little effect on other dependent variables.

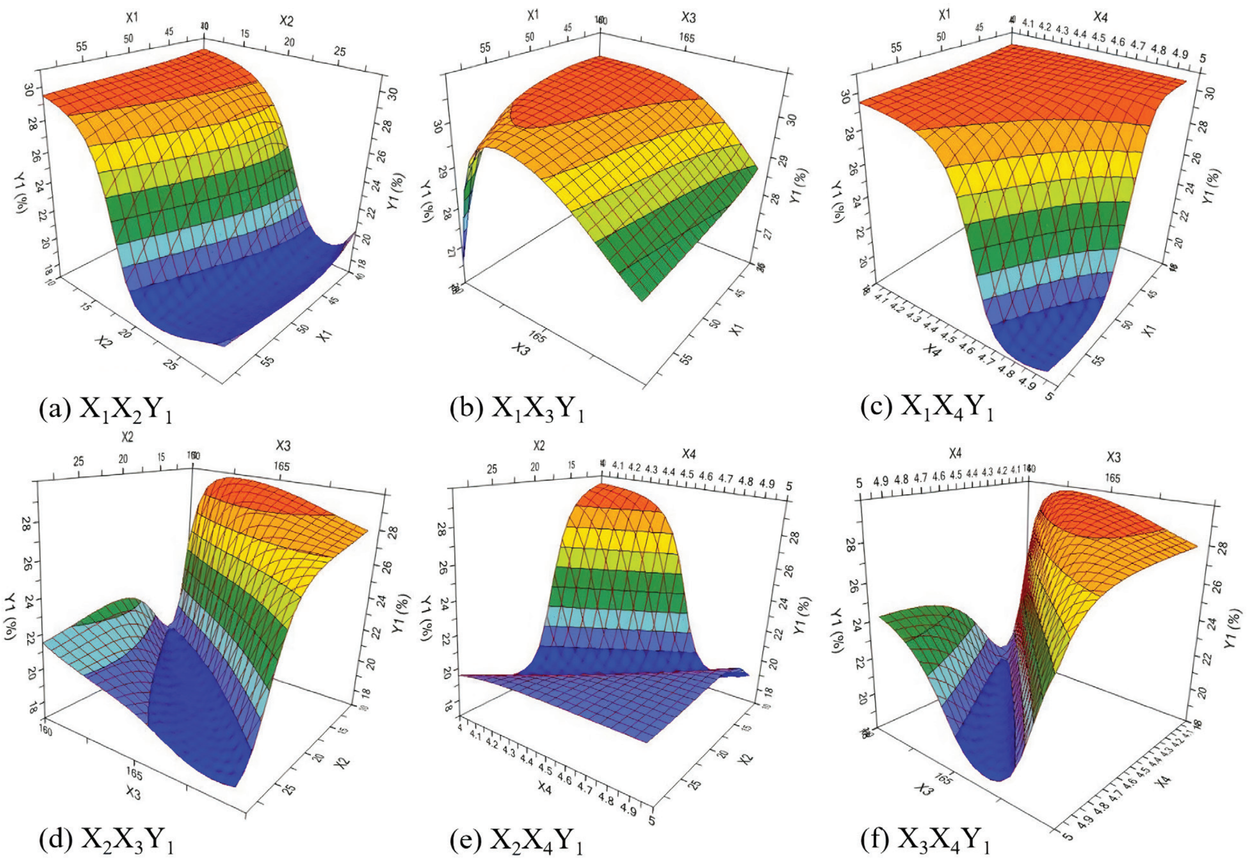

Figure 1. Response surface plots showing the effects of (**a**) alcohol content (X_1) and carrier mass (X_2); (**b**) alcohol content (X_1) and inlet air temperature (X_3); (**c**) alcohol content (X_1) and flow rate (X_4); (**d**) carrier mass (X_2) and inlet air temperature (X_3); (**e**) carrier mass (X_2) and flow rate (X_4); (**f**) inlet air temperature (X_3) and flow rate (X_4) on drying performance (Y_1).

Fig. 1c, e, f illustrate that when the flow rate decreases, the efficiency of extract evaporation increases, lowering the likelihood of particles clinging to each other and to the chamber wall and therefore boosting drying performance (Saha et al. 2019; Latifi et al. 2020). Increasing the cycle speed, on the other hand, reduces drying performance. This is similar to the findings of Dhritiman Saha et al.

Effects of variables on moisture content (Y2)

Moisture content (percent) – Y_2 should be as low as feasible under the required conditions shown in Table 1. If all X factors are taken into account in the 3D diagram in Fig. 2, the alcohol content value – X_1 is at a high level (level 2 – 50% or 3 – 60%), the carrier mass (g) – X_2 needs to be around 10 g, the inlet air temp (°C) – X_3 is around average 165 °C, and the flow rate (rpm/min) – X_4 is at a low level (4 rpm).

Moisture content is a significant aspect in instant tea processing, and it is connected to drying performance (Rahmati et al. 2020). The moisture content is in inverse proportion with the drying performance. At the same time, moisture content has a significant impact on final tea quality measures such as flow, stickiness, stability, and oxidation reaction (Özdikicierler et al. 2019; Rahmati et al. 2020). According to Saha et al. (2019), at low moisture content, the flavor and aroma of the finished tea may be diminished or lost, but at excessive moisture content, the finished product may be sticky or inappropriate for long-term storage. Table 2 shows that the moisture level of instant tea powder made from lotus leaves and green tea leaves ranges between 4.33 and 5.99%. Fig. 2 shows that all independent factors have a substantial impact on moisture content. Fig. 2a–c indicate that a high alcohol level of 50–60% leads in a low moisture content. This can be explained by employing high alcohol concentration to enhance the active component content of the extract or increasing the number of solids in the extract, hence lowering moisture content (Lee et al. 2017; Sidlagatta et al. 2020).

Simultaneously, increasing the carrier mass in the extract increases total solids while decreasing the quantity of water available for evaporation and the moisture content (Fig. 2a, d, e). Because a large carrier mass clogs the spray gun during preparation (Lee et al. 2017), the carrier mass (X_2) should be as low as 10 g for a lower moisture (Y_2) value (Fig. 2d). According to Zokti et al. (2016), when the moisture level of instant tea increases, the stability of the completed product improves. The moisture content of soluble tea generated when dries at various input air temperatures is shown in Table 2. According to Lee et al. (2017), the temperature of the inflow air rises, resulting in higher heat transfer to the grain and increased evaporation rate. At high intake air temperatures, there is a temperature difference between the spray droplet and the drying air, which

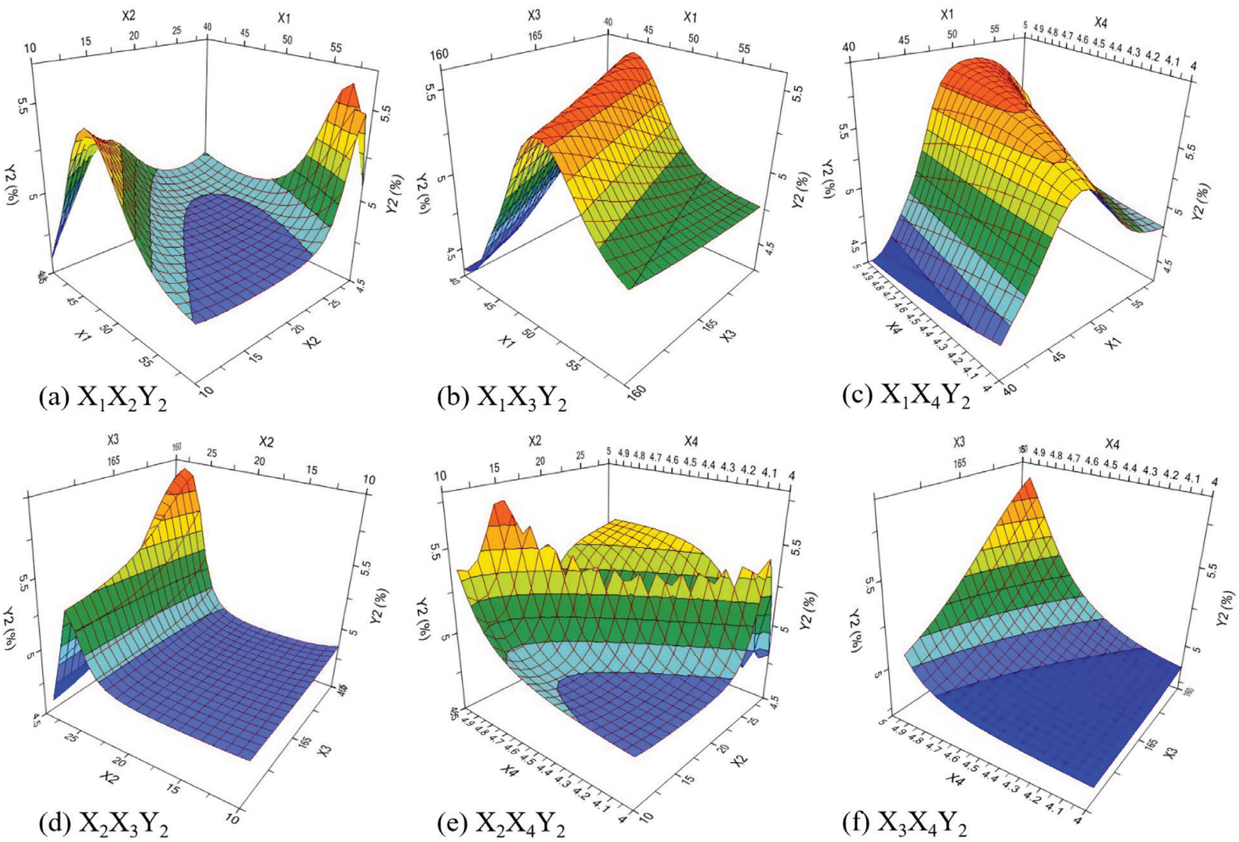

Figure 2. Response surface plots showing the effects of (**a**) alcohol content (X_1) and carrier mass (X_2); (**b**) alcohol content (X_1) and inlet air temperature (X_3); (**c**) alcohol content (X_1) and flow rate (X_4); (**d**) carrier mass (X_2) and inlet air temperature (X_3); (**e**) carrier mass (X_2) and flow rate (X_4); (**f**) inlet air temperature (X_3) and flow rate (X_4) on moisture content (Y_2).

improves the dynamics of water evaporation (Gunjal and Shirolkar 2020). Normally, the air temperature ranges between 150 and 220 °C. Lee et al. (2017) and Saha et al. (2019) As seen in Fig. 2 f, the moisture content decreases as the incoming air temperature and flow rate rise. However, when the inlet air temperature is low, the drying performance is also low because the extract has not yet dried. On the contrary, the extract is dried before being placed in the collecting jar (Lee et al. 2017; Huaman-Castilla et al. 2019).

Effects of variables on total phenol content (Y3)

To achieve desired conditions in Table 1, the total phenol content (mg GA/g) needs to be as high as possible. X factors are considered in the 3D diagram in Fig. 3, which can be seen that the alcohol content (X_1) is on level 3 (60%), the carrier mass (X2) is around ≥ 10 g, inlet air temperature (X3) is set at about 165 °C, and the flow rate (X4) is on a low level (4 rpm/min) giving the increase of total phenol content (mg GA/g).

The total phenol content of instant tea powder ranged from 20.66 to 45.96 mg GA/g, as shown in Table 2. The relationship between alcohol content and the total phenol content is proportional. (Huaman-Castilla et al. 2019). The carrier mass also affects the properties of instant tea, when the carrier mass is low, a sticky instant tea powder can be obtained, if the carrier mass is high, the total phenol content in the finished product can be reduced (Eroğlu et al. 2018). Fig. 3a, d, e show a suitable carrier mass of 10 g bringing high economic efficiency. On the other hand, the total phenol content is less affected by inlet air temperature (Fig. 3b, d, f), however the inlet air temperature should not be too low because it is difficult to dry the extract, so the inlet air temperature (X_3) is selected around 165 °C. When the inlet air temperature is too high, it leads to a change in the structure of the finished tea powder and the decomposition of phenolic compounds and reduces the total phenol content (Lee et al. 2017; Drozłowska et al. 2021). When the flow rate is increased, the size of the particles is increased, but the efficiency of the evaporation process, the drying performance and the total phenol content are reduced (Fig. 3c, e, f) (Aute and Shirsand 2019).

Effects of variables on total flavonoid content (Y4)

According to conditions in Table 1, total flavonoid content (mg QE/g) also needs to be as high as possible. The value of alcohol content (X1) is used on level 2–3 (50- 60%), the carrier mass (X2) needs to be around ≥ 10 g, inlet air temperature (X3) is about average 165 °C, while the flow rate (X4) also on a low level (4 rpm/min), which increased total flavonoid content (Y4).

Total flavonoid content of instant tea powder ranged from 31.66 to 71.32 mg QE/mg as shown in Table 2.

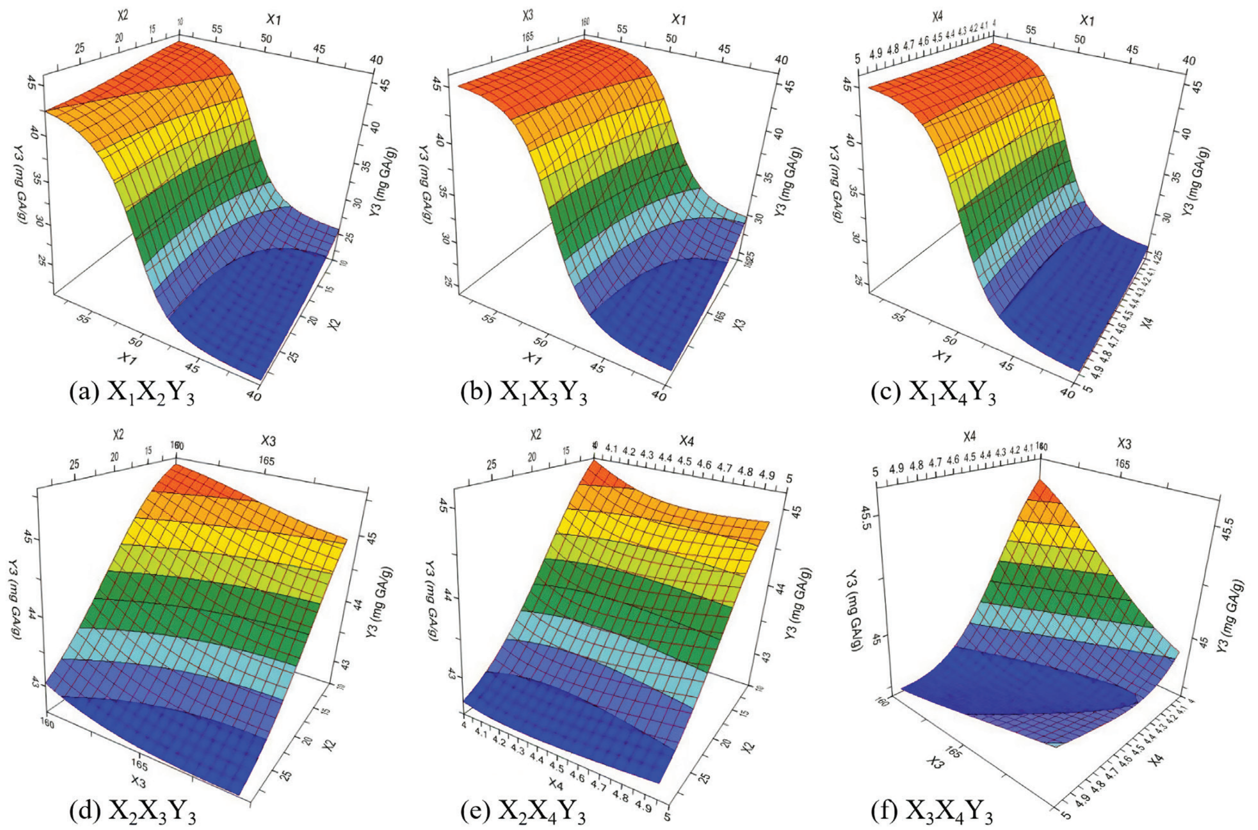

Figure 3. Response surface plots showing the effects of (**a**) alcohol content (X_1) and carrier mass (X_2); (**b**) alcohol content (X_1) and inlet air temperature (X_3); (**c**) alcohol content (X_1) and flow rate (X_4); (**d**) carrier mass (X_2) and inlet air temperature (X_3); (**e**) carrier mass (X_2) and flow rate (X_4); (**f**) inlet air temperature (X_3) and flow rate (X_4) on total phenol content (Y_3).

Similar to total phenol content, total flavonoid content increased with the increase of the alcohol content (Fig. 4a), this is similar to the results of study of Bansal et al. (2014), but it is inversely proportional to the carrier mass as the results shown in Fig. 4d, e. Increasing the inlet air temperature did not increase the total flavonoid content (Fig. 4f), but to avoid affecting other dependent variables in the preparation process, the inlet air temperature should be selected around 165 °C. At the same time, the flow rate (X_4) should be selected as low as 4 rpm to ensure other optimal conditions.

Optimizing the preparation process of instant tea powder

BCPharSoft program optimizes the preparation process by setting variables X_1, X_2, X_3, and X_4 to 60%, 10g, 165 °C, and 4 rpm/min, respectively. Three replicated batches of the improved method are created to confirm the validity of the optimization approach. Table 4 displays the experimental outcomes.

To compare observed and predicted data, the statistical program SPSS 26 (SPSS, Inc., Chicago, IL, USA) is utilized. A one-sample T-test reveals no statistically significant difference between the anticipated and observed data ($p > 0.05$), indicating that the ideal findings are compatible with the results predicted by the BCPharSoft program.

Determining the extraction and spray drying parameters in the instant tea powder manufacture process is deemed crucial for the development of medicinal herb products. The modeling of experiments is critical in the preparatory procedure. Most formulas/procedures are formerly based on randomly altering variable values while holding other variables constant to analyze the effect of certain variables of the procedure, however this strategy is incorrect. Today, the introduction of intelligent software in process optimization assists in overcoming the aforementioned shortcomings.

Table 4. Comparison of the predicted and observed responses (n = 3).

Responses	Y_1 (%)	Y_2 (%)	Y_3 (mg GA/g)	Y_4 (mg QE/g)
Predicted	29.46	4.81	45.17	70.54
Observed	29.15 ± 0.17	4.83 ± 0.02	45.29 ± 0.01	70.68 ± 0.02
P-values	0.319	0.786	0.120	0.194

BCPharSoft OPT program optimizes the following parameters: 60% alcohol percentage, 10g carrier mass, 165 °C inlet air temperature, and 4 rpm flow rate. The R_2 test and R_2 train values are used to examine the cause-effect relationship. In general, if the R_2 training value is more than 95% and the R_2 test value is greater than 70%, the model is acceptable. If the R_2 test value is greater than 100%, the model's predictability is improved (Singh B et al. 2005). According to Table 3, the values Y_1, Y_2, Y_3, and Y_4 exhibited high compatibility based on the R_2 test (R_2 training = 99.8% > 95%). The values Y_1, Y_2, Y_3, and Y_4 have strong predictability (R_2 test = 99.6 percent > 85 percent) based on the value of R_2 test.

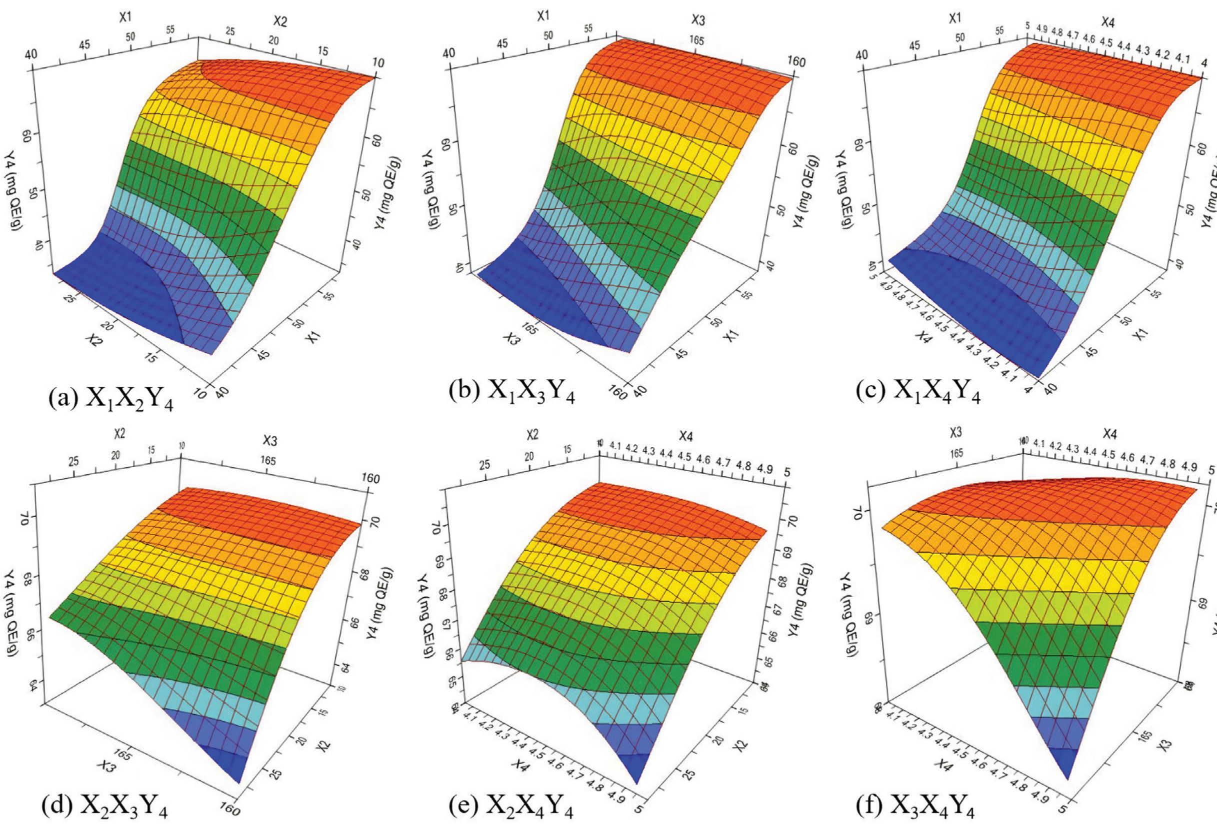

Figure 4. Response surface plots showing the effects of (**a**) alcohol content (X_1) and carrier mass (X_2); (**b**) alcohol content (X_1) and inlet air temperature (X=); (**c**) alcohol content (X_1) and flow rate (X_4); (**d**) carrier mass (X_2) and inlet air temperature (X_3); (**e**) carrier mass (X_2) and flow rate (X_4); (**f**) inlet air temperature (X_3) and flow rate (X_4) on total flavonoid content (Y_4).

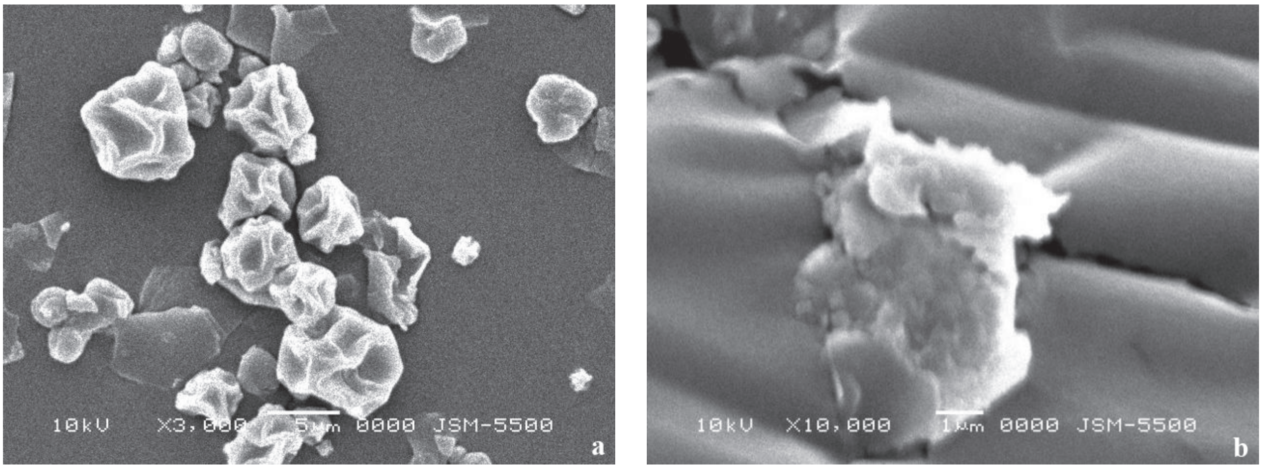

Figure 5. SEM images of the optimization of instant tea powder. (**a**) x3000, (**b**) x10000.

Table 5. Characterization of instant tea powder.

	Batch 1	Batch 2	Batch 3	Average
Bulk density (g/mL)	0.26	0.26	0.27	0.26 ± 0.001
Tapped density (g/mL)	0.47	0.48	0.48	0.48 ± 0.001

Characterization of instant tea powder

The bulking properties of a powder are dependent upon the preparation, treatment, and storage of the sample, i.e., how it was handled. The tapped density is an increased bulk density attained after mechanically tapping a container containing the powder sample. Bulk density and tapped density of instant tea powder in 3 analytical batches are in a good precision with the averages, which are 0.26 ± 0.001 g/mL and 48 ± 0.001 g/mL, respectively. The detailed results are shown in Table 5.

The surface features and morphology of optimum samples are determined by SEM, illustrated in Fig. 5.

Evaluation quality of instant tea powder

Appearance

The final product is homogeneous light yellow powder, with pleasant smell, sweet taste, absorbing moisture while leaving outside for a long time and easily being soluble in water, forming a pale yellow solution.

Moisture content

The average moisture content of instant tea powder is 4.83 ± 0.02% (Lee et al. 2017; Eroğlu et al. 2018).

Microbiological contamination

The results are figured out in Table 7.

Active ingredient content

According to results are shown in Table 8, the averages of total phenol content and total flavonoid content are analyzed from 3 batches have a small oscillation range with each test's result, at 45.29 ± 0.01 mg GA/g for total phenol content and 70.68 ± 0.02 mg QE/g for total flavonoid content. Those are also close to the data of the total contents presented in the preparation process, proving the repeatability of the procedure.

Table 6. Moisture content results.

	Batch 1	Batch 2	Batch 3	Average
Moisture content (%)	4.82 ± 0.06	4.97 ± 0.11	4.71 ± 0.09	4.83 ± 0.02

Table 7. Microbiological contamination results.

Microbiological contamination	Batch 1	Batch 2	Batch 3	Average
Amounts of aerobic mesophilic bacteria (CFU/g)	3,4.103	3,5.103	3,6.103	3,5.103
Amounts of mold and yeast (CFU/g)	< 10	< 10	< 10	< 10
E. Coli (CFU/g)	< 10	< 10	< 10	< 10
Salmonella (10g/mL)	Negative	Negative	Negative	Negative

Table 8. Results of total phenol content and total flavonoid content.

Active ingredient content	Batch 1	Batch 2	Batch 3	Average
Total phenol content	45.25	45.38	45.24	45.29 ± 0.01
Total flavonoid content	70.64	70.86	70.55	70.68 ± 0.02

Conclusions

Instant tea powder from lotus and green tea leaf had been successfully prepared by spray-drying method. The finished tea met quality specifications from the optimized parameters of the process. Therefore, this instant tea powder process can be manufactured on an industrial scale.

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