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Effects of Stevia Syrup on Powdered Drink Products from Pumpkin Carrot and Lemongrass by Foam Mat Drying

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Abstract

One simple approach which allows water to be removed from blended fruits and vegetables is foam mat drying. In this process, the liquid sample is changed into foam form. The research was performed to study the production of pumpkin, carrot and lemongrass powder using both egg albumen and carboxymethyl cellulose (CMC) as the foaming agent and to determine the effects of different amounts of stevia syrup (0, 20, 30, and 50 mL) upon the foam mat drying qualities. Each treatment contained the ratio of pumpkin juice: carrot juice: lemongrass juice: salt as 55: 140: 55: 0.1. The foam was prepared from mixed pumpkin, carrot and lemongrass by adding two types of foaming agent (12 g of egg albumen and 6 g of CMC) and whipping for 5 minutes. It was found that foam density, stability and overrun were significantly ($p \leq 0.05$) influenced by the quantity of stevia syrup. The 2 mm thick foam was spread on a flat aluminum tray (25 cm × 25 cm) and hot air dried following the conditions obtained from the preliminary study at 70°C for 90 minutes. The physicochemical and microbiological properties of the products included color, solubility, foam density, foam stability, moisture, water activity, moisture, protein, fat, ash, DPPH, β-carotene and total plate count. The sensory properties included the taste, texture, odor, color and general level of acceptability. The findings revealed that the physicochemical results were significantly different ($p \leq 0.05$). A reduction in stevia syrup caused increasing in the protein, fat and ash values. For Treatment 4 produced the best results, the foam density, foam stability percentage, overrun percentage, and yield percentage were 0.72 g/mL, 72.25%, 80.59% and 15.29%, respectively. As the amount of stevia syrup decreased, the foam density also decreased, but the foam stability percentage, overrun percentage and yield percentage

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all significantly increased ($p \leq 0.05$). The microbiological results revealed that the quality of the mixed pumpkin, carrot and lemongrass powder met the required safety standards. The sensory attributes of mixed pumpkin, carrot and lemongrass exhibited no significant difference ($p > 0.05$) with the exception of taste, which was influenced by the amount of stevia syrup. The mixed pumpkin, carrot and lemongrass obtained from Treatment 4 required optimization in order to create the foam mat powder. It can therefore be argued that the approach of foam mat drying using egg albumen, CMC and stevia syrup is a food production technique worthy of further investigation.

Abbreviations

CMC carboxymethyl cellulose
GMS glyceryl monostearate
SBI soybean isolate
CRD completely randomized design
RCBD randomized complete block design
ANOVA analysis of variance
DMRT Duncan's new multiple range tests

Introduction

Although pumpkins (*Cucurbita* spp.) are widely grown as vegetable crops worldwide, there is a notable disparity between the amount produced and the amount consumed because they are not widely used as a food source. Numerous studies have documented the potential significance of pumpkin fruits, seeds, pulp and flowers for their nutritional value, medicinal properties, and pharmacological aspects. This is because pumpkins are high in protein, carbohydrates and vitamins, particularly antioxidants and phytochemicals.[1]

The Apiaceae family includes many flowering plants, notably including carrots (*Daucus carota* L.), among other root vegetables and herbs. Carrots are heavily consumed worldwide, and can be eaten raw, cooked, in pulp, powder or juice. The carrot is adored for its rich nutrients, superior flavor and revitalizing mouthfeel. It is added to a variety of other foods because it contains a high concentration of carotenoids, fibers, vitamins, antioxidants and other minerals. Carrots are recommended for uterine pain and are beneficial in addressing kidney illnesses and dropsy, while also acting as nervine tonics and aphrodisiacs.[2]

Thailand has traditionally utilized lemongrass (*Cymbopogon citratus*), a member of the Poaceae family, for culinary and medicinal purposes. Beneficial characteristics of this plant include anti-inflammatory, antifungal, antinociceptive and antioxidant actions. Lemongrass essential oil has been shown in animal experiments to have sedative, anticonvulsive and anti-anxiety properties. A recent human study showed that when male volunteers are exposed to an artificial anxiogenic scenario, inhaling lemongrass essential oil has anxiolytic benefits and lowers subjective stress.[3]

One useful naturally occurring sweetener which can be beneficial to health through its various properties, including anti-inflammatory effects, is stevia syrup (*Stevia rebaudiana*), which contains valuable steviol glycosides.[4] Stevia is an alternative sweetener which is low in calories and often finds a role as a dessert ingredient. For example, it is sometimes used in jam without sugar.[4]

There are many different health drinks on the market at present and they are becoming more and more popular since they taste good are reasonably priced and are conveniently packaged. Since the products are usually in powdered or ready-to-drink form, they can be kept in storage for an extended period of time. For these powdered drinks, there are various drying techniques available, such as hot air oven, spray drying, drum drying and foam mat drying.[5]

Food products are frequently preserved using foam mat drying, which offers advantages such as shortening the drying time with hot air and better preservation of the dried food quality.[6]

In the foam mat drying process, a stable foam is produced from the original food in liquid (or semi-liquid) form, which is then hot air dried resulting in a dried powder.[7] The benefits of employing such a drying method are that the drying procedure takes place more quickly and at cooler temperatures because the porosity of the foam ensures that the surface area which is open to the air is much larger, thus allowing an increase rate of drying. The approach is also appropriate when used with foods which might be highly viscous, high in sugar, or simply sensitive to heat, for which alternative drying approaches are not suitable.[8] The foam characteristics can be described in terms of stability and expansion, which is the ability to form the foam.[9] There are several factors affecting foam characteristics such as whipping time and whipping temperature and the type including the amount of foaming and foam stabilizing agent employed. When foaming agents are added along with stabilizing agents, this provides foam stability by reducing the surface tension and causing foaming of the liquid and semi-liquid.[10] Common foaming agents include egg albumen and CMC. At the surface, foaming ability can be enhanced by egg white, which contains globulin, which is a very effective protein in this foaming context.[11] CMC is a hydrocolloid gum used as a foam stabilizing agent. It was possible to enhance the foam stability through an increase in the interfacial viscoelasticity of the foam lamellae.[12] Related products were the subject of four related research studies. Firstly, it was necessary to determine the method of making drinking powder items by employing foam mat drying to generate powdered carrot, orange, and lemon. The ideal proportions of orange, lemon and carrot to create a powder quickly through foam mat drying must also be considered. Six treatments were performed whereby each used a different ratio for the components of orange to lemon to carrot: (1) 100:0:0 (control); (2), 75:20:5; (3) 70:20:10; (4) 50:40:10; (5) 50:45:5, and (6) 62:31:7. For each of the tested samples for the various treatment protocols, there were no substantial changes in brightness, color, or solubility ($p>0.05$), according to the data. Investigations were conducted on the chemical properties, such as total soluble solid, moisture, β-carotene, antioxidant activity, ascorbic acid and pH values. The treatment for which the carrot: orange: lemon ratio was 50: 40: 10 was shown to have the highest amounts of β-carotene at 3.68 mg Trolox eq/g, and antioxidants at 0.14 µg/100 g FW. Using a 9-point hedonic scale for sensory evaluation of taste and overall acceptability, the expert panel members expressed a preference for Treatment 4, awarding scores of 5.70 for taste and 6.33 for acceptability.[6] Next, the impacts of the foaming agents were evaluated for the agent comprising 15% egg albumen and the agent comprising 15% egg albumen plus 10% whey protein isolate. Thin-layer foaming models were assessed at different thicknesses to test the carrot juice drying behavior when foam mat drying was conducted at temperatures of 50, 60 and 70°C. The carrot juice foam drying times were shown to be dependent upon temperature and foam thickness; in this case the drying time was reduced by 25-60% in comparison to the control, which comprised solely carrot juice.[13] Next, the papaya pulp was whipped for 5, 10 and 15 minutes at varying glycerol monostearate concentrations (1%, 2%, 3% and 4% w/w). The pulp concentration including the foaming agent at the 1% level had a substantial impact on the foam expansion. With a 9°Brix pulp content, 3% glycerol monostearate and a 10-minute whipping duration, the highest stable foam formation was 90%. The resultant foams were air-dried inside a batch-type cabinet drier at 2.25 m^3/min air flow at various temperatures (60, 65 and 70°C) along with foam thicknesses (2, 4, 6 and 8 mm). Longer drying times were the result of ticker foams and cooler temperatures for the frying process.[14] One very recent study compared the characteristics of mango powder obtained via the process of foam mat drying with that produced through the utilization of various foaming agents. Fresh Mahajanaka mango puree (*Mangifera indica* L.) from northern Thailand is combined with sugar, GMS and SBI in varying proportions to create foam. The mixture is then dried for five hours at 70°C in a tray drier. There is no correlation between the moisture content, solubility and hygroscopicity values of sugar and GMS at different ratios. The optimal powder quality is achieved by adding 1% GMS and 5% sugar while storing at 90% relative humidity and 38 ± 2°C.[15]

A brief review of the literature as described confirms that while previous studies have examined the drying process in the context of certain fruits and vegetables, no work exists on the subject of mixtures of pumpkin, carrot and lemongrass by foam mat drying.

Considering the advantages of the three types of ingredients, it can be seen that they are inexpensive, simple to find all year round and contain active ingredients that are beneficial to the body. However, the existing studies do underline the importance of foam mat drying, which is relatively quick and allows the powder to retain its nutritional qualities. In addition, there are further advantages associated with the ingredients of pumpkin, carrot and lemongrass which arise due to their antioxidant properties and the various bioactive compounds they contain. One crucial aspect of the drying process is that drying can have adverse consequences for the chemical and physical properties of powdered foods. A quicker process can help to limit the extent of this decline.[16] This study also places emphasis upon the effects on the physicochemical and microbiological qualities of the resulting food product due to varying the quantities of stevia syrup. The influence of the syrup upon the sensory assessment is also an important factor for consideration. It is also advantageous that all of the fruit and vegetable ingredients in addition to the stevia syrup are readily available at reasonable cost, in addition to offering various health benefits for the human body due to their bioactive ingredients. For example, stevia can help in controlling weight and blood sugar levels. Once these ingredients have been turned into liquid foam, they can then be dried via the foam mat process to create a healthy powdered food product. For this product to be at its most effective, it is necessary to optimize the conditions under which the drying process takes place, so these conditions must be determined. Furthermore, the use of combinations of local ingredients found in Thailand can support small and medium-sized businesses in the country, offering opportunities for both farmers and entrepreneurs to profit.[10,11]

Table 1: Composition of each ingredient for mixed pumpkin, carrot and lemongrass production

Contents	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Pumpkin juice (mL)	55	55	55	55
Carrot juice (mL)	140	140	140	140
Lemongrass juice (mL)	55	55	55	55
Stevia syrup (mL)	0	50	30	20
Salt (g)	0.1	0.1	0.1	0.1
Egg albumen (g)	12	12	12	12
Carboxymethyl cellulose (CMC) (g)	6	6	6	6

N.B. Treatment 1 is control

This current study therefore sought to establish the nature of the optimal drying parameters along with the most suitable stevia syrup ratio. Two different foaming agents were tested and the researchers examined the outcomes in terms of physicochemical and microbiological qualities along with measures of the color, odor, water solubility, brightness, foam density, foam stability, overrun, yield, water activity, moisture, protein, fat, ash, antioxidant activity, β-carotene, total plate count outcome and sensory assessment.

Materials and Methods

Raw materials were studied in this research, namely the pumpkins, carrots and lemongrass, which were bought from Talad Nud Khlong 6 in Pathum Thani Province, Thailand and transferred to the laboratory for this research. The study made use of analytical grade chemicals obtained from Sigma with a purity of 99.8% and suitable for use in food products.

Raw Material Preparation

A neutral detergent (H_2O) was used to wash the pumpkins and eliminate dirt from the surface. The pumpkins were then sliced and the 3 cm slices were cooked in boiling water for 1 minute. After cooling, the slices were peeled including an any remaining seeds were removed. A fork was then used to mash the slices to create a puree, which was filtered using cheesecloth and then packaged in pouches of 300 g to 50 mL of water.[16]

Regular tap water was used to wash the fresh carrots and the excess water was then removed. The carrots were then chopped into pieces of size 4 cm, which were peeled. These pieces were introduced to a juice extractor to produce carrot juice containing carrot pulp. The pulp was taken out and the juice was poured into glass bottles which were heated to 95°C in a water bath for 5 minutes. After being allowed to cool to 4°C, the juice was then filtered using cheesecloth.[13]

Regular tap water was used to wash the fresh lemongrass and the excess water was then removed. The lemongrass was then chopped into pieces of size 5 cm and blanched at 80°C for 1 minute before filtering through cheesecloth.[17]

The prepared pumpkin, carrot, and lemongrass along with additional ingredients as shown in Table 1[13,16,17] were mixed together until homogeneous using an electric blender for 5 minutes. After that, they were placed upon an aluminum tray and spread out to dry under hot air in an oven for 6-7 hours (or until completely dry) at a temperature of 70°C.[13,16,17]

Foam Mat Drying of Mixed Pumpkin, Carrot And Lemongrass Powder

The foam of the mixed pumpkin, carrot and lemongrass was prepared from raw materials by mixing fresh egg albumen (12 g) and CMC (6 g) using a food mixer (KitchenAid Model K-5, USA) with a wire whisk at 1,000 rpm (speed setting 10) for 5 minutes. The 2 mm thick foam was spread on a flat aluminum tray (25 cm × 25 cm) and hot air dried following the conditions obtained from the preliminary study at 70°C for 90 minutes. The dried product was scratched, ground using a laboratory blender (Waring blender 7011HS, USA) at 14,000 rpm (speed setting 1) for 15 seconds and vacuum packed in an aluminum foil bag. The foam of the mixed pumpkin, carrot and lemongrass was reconstituted in warm water (60°C) in the ratio of 1:1 (w/v) prior to the determination of the physicochemical, microbiological and sensory attributes.[18]

Physicochemical and Microbiological Quality of Mixed Pumpkin, Carrot and Lemongrass Powder

The characteristics of the dried foam were analyzed using a Mini Scan XE in order to measure the color and brightness of the samples in terms of (L)*, (+a*) and (+b*).[19] In addition, water solubility,[19] moisture content,[19] water activity,[19] protein,[19] fat,[19] ash,[19] antioxidant activity (DPPH assay),[20] β-carotene,[21] foam density,[22] foam stability,[23] overrun (%),[23] yield (%)[23] and total plate count[19] were assessed and assigned a value.

Sensory Evaluation

In order to measure the sensory qualities of the samples, a 9-point hedonic scale was utilized. A panel comprising 30 participants who had received no training in sample evaluation were asked to give their ratings for each of the sample powders, which had undergone reconstitution at a 1:1 ratio using drinking water.[24]

Data Analysis

The study employed a CRD (for physicochemical analysis) instead of a RCBD (for sensory evaluation) which might be used in experimental cases. The differences observed between treatments were evaluated via both ANOVA and DMRT ($p \le 0.05$). Data were presented as the actual values measured as mean+ standard deviation, with each of the treatment investigated in triplicate. The data were computed using PASW Statistics version 18.[24]

Table 2: Foam density foam expansion percentage, overrun percentage and yield percentage of mixed pumpkin, carrot and lemongrass powder

Treatment	Foam density (g/mL)*	Foam stability (%)*	Overrun (%)*	Yield (%)*
1	0.89^{a}±0.14	78.25^{a}±0.52	88.25^{a}±0.52	4.25^{c}±0.10
2	0.46^{c}±0.38	65.11^{d}±0.14	75.12^{c}±0.22	5.82^{c}±0.22
3	0.64^{b}±0.11	69.25^{c}±0.74	78.14^{ab}±0.38	10.12^{b}±0.14
4	0.72^{b}±0.28	72.25^{b}±0.85	80.59^{b}±0.11	15.29^{a}±0.11

N.B: *Items in the same column indicated by letters in superscript (a-d) identify significant differences (p≤0.05).
Treatment 1 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 0 (control)
Treatment 2 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 50
Treatment 3 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 30
Treatment 4 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 20

Table 3: Water activity and moisture of mixed pumpkin, carrot and lemongrass powder

Treatment	Water activity*	Moisture* (%)
1	0.54^{a}±0.00	7.57^{a}±2.23
2	0.48^{b}±0.00	1.08^{b}±0.35
3	0.38^{c}±0.00	0.97^{b}±0.45
4	0.33^{c}±0.01	0.84^{b}±0.17

N.B: *Items in the same column indicated by letters in superscript (a-d) identify significant differences (p≤0.05).

Treatment 1 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 0 (control)
Treatment 2 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 50
Treatment 3 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 30
Treatment 4 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 20

Table 4: Protein, fat and ash of mixed pumpkin, carrot and lemongrass powder

Treatment	Protein (%)*	Fat (%)*	Ash (%)*
1	37.92^{a}±0.32	0.70^{a}±0.60	9.39^{a}±0.37
2	17.73^{d}±0.47	0.87^{ab}±1.00	5.27^{c}±0.71
3	21.46^{c}±0.48	1.65^{ab}±0.11	5.33^{c}±0.11
4	26.69^{b}±0.11	2.44^{b}±1.25	6.21^{b}±0.09

N.B: *Items in the same column indicated by letters in superscript (a-d) identify significant differentces (p≤0.05).

Treatment 1 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 0 (control)
Treatment 2 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 50
Treatment 3 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 30
Treatment 4 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 20

Table 5: β-carotene and DPPH of mixed pumpkin, carrot and lemongrass powder

Treatment	β-carotene^{ns} (µg/100g FW)	DPPH^{ns} (mg Trolox eq/g)
1	0.15±0.21	5.23±0.32
2	0.12±0.18	4.42±0.12
3	0.20±0.11	4.98±0.28
4	0.10±0.09	4.21±0.15

N.B: ns indicates non-significance (p>0.05).

Treatment 1 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 0 (control)
Treatment 2 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 50
Treatment 3 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 30
Treatment 4 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 20

Table 6: Brightness, redness, yellowness and water solubility of mixed pumpkin, carrot and lemongrass powder

Treatment	(*L**)*	(+*a**)*	(+*b**)*	Water solubility (g/L)*
1	$85.07^{a}\pm0.37$	$13.89^{a}\pm0.39$	$35.61^{a}\pm1.40$	$69.08^{a}\pm2.06$
2	$83.48^{a}\pm0.67$	$9.60^{b}\pm2.41$	$34.01^{a}\pm1.08$	$62.17^{b}\pm2.57$
3	$82.54^{b}\pm0.64$	$8.21^{b}\pm2.32$	$31.83^{b}\pm1.13$	$66.14^{ab}\pm4.18$
4	$81.11^{b}\pm0.78$	$7.05^{c}\pm3.92$	$27.58^{c}\pm1.29$	$65.75^{ab}\pm3.83$

N.B: *Items in the same column indicated by letters in superscript (a-c) identify significant differences ($p\leq0.05$).
Treatment 1 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 0 (control)
Treatment 2 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 50
Treatment 3 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 30
Treatment 4 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 20

Table 7: Microbiological properties of mixed pumpkin, carrot and lemongrass powder

Treatment	Values (CFU/mL)
1	$<1x10^{4}$
2	$<1x10^{4}$
3	$<1x10^{4}$
4	$<1x10^{4}$

N.B: Treatment 1 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 0 (control)
Treatment 2 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 50
Treatment 3 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 30
Treatment 4 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 20

Table 8: Sensory scores of mixed pumpkin, carrot and lemongrass powder

Treatment	Colour^{ns}	Odour^{ns}	Taste*	Texture^{ns}	Overall acceptability^{ns}
1	7.30 ± 1.24	6.51 ± 1.36	$6.17^{b}\pm1.02$	6.40 ± 1.28	6.30 ± 1.17
2	7.03 ± 1.07	6.00 ± 1.11	$5.87^{ab}\pm0.94$	6.07 ± 1.17	6.03 ± 1.19
3	7.20 ± 1.10	6.10 ± 1.37	$5.90^{b}\pm1.32$	6.20 ± 1.21	6.30 ± 1.62
4	7.37 ± 1.13	6.53 ± 1.68	$6.30^{a}\pm1.21$	6.40 ± 1.25	6.53 ± 0.99

N.B: *Items in the same column indicated by letters in superscript (a-b) denote significant differences ($p\leq0.05$). ns means non-significant ($p>0.05$).
Treatment 1 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 0 (control)
Treatment 2 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 50
Treatment 3 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 30
Treatment 4 pumpkin: carrot: lemongrass: stevia 55: 140: 55: 20

Results

Tables 2-8 present the outcomes for each of the various properties of the different powders of mixed pumpkin, carrot and lemongrass.

Discussion

All values were significantly different ($p\leq0.05$). Treatment 1 achieved the highest foam density (Table 2). The probable reason was that no stevia syrup was added, so there was no barrier to dissolution, resulting in the highest density. Reducing the amount of stevia syrup results in a higher foam density, leading to a less stable foam. Higher foam density resulted in a prolonged drying time and lower volume expansion, in turn reducing the quality of the product as a consequence of thermal degradation.[25-29]

The process of foam mat drying depends heavily upon the foam stability because the foam must remain mechanically and thermally stable throughout the whole procedure.[32] In this study, Treatment 2 saw the foam stability decrease significantly (65.11 ± 0.14), possibly as a consequence of the high quantities of thin film bubble which were produced during the whipping, whereupon groups of cells are able to coalesce to form a single large cell at a later time. Adding more stevia syrup had less effect on foam dispersion, resulting in a reduced foam stability percentage. The liquid flows between the dispersed cells' bubbles could force them closer together leading to a loss of stability.[25-29]

In considering the foam characteristics, the overrun percentages for mixed pumpkin, carrot and lemongrass powder can be seen in Table 2, where the findings revealed that Treatment 1 exhibited the highest foam overrun percentage (88.25 ± 0.52), followed by Treatments 2, 3 and 4, respectively. The highest foam overrun in Treatment 4 indicated that a large amount of air was entrapped in the bubbles of the foam structure, developing a noticeable foam expansion and considerably decreasing the foam density (0.72 ± 0.28 g/mL). The reduction of density is attributed to the rapid moisture dislocation throughout the drying operation as it provided a great surface area for the drying air.[26-29]

Treatment 1 achieved the highest yield percentage (15.29 ± 0.11). The decreasing stevia syrup will expand the surface area and give a porous structure due to the high amount of air trapped, so that water can evaporate easily and increase the drying rate. The reason was similar to that given for the overrun percentage value. The reduction of stevia syrup resulted in a reduction in total soluble solids, which results in a decrease in solids content, resulting in an increase in the overrun percentage and yield percentage.[26-27]

From Table 3, examination of the chemical properties found that all parameters were significantly different ($p \leq 0.05$). In the context of powders produced via foam mat drying, the water activity is a critical parameter. Water activity is not the same as moisture, but instead acts as a measure of the amount of free water that a food system contains. The water is a critical component permitting various biological activities.[5,6] Values for water activity in the powder ranged from 0.33 to 0.54 as shown in Table 3 and account for the proportion of water within the composition of the food as a whole.[5,6] If the moisture content of a food powder does not exceed 10%, the product can be considered safe in microbiological terms.[5,6] In this case, the trends in the measured values for the water activity and moisture both decreased with decreases in amounts of stevia syrup. The highest value of water activity and moisture were observed in Treatment 1 at 0.54 and 7.57%, respectively. Furthermore, there is a reduction is solid content since this will bind to the water, leading to a reduction in both moisture and water activity.[5,6] If the water activity value does not exceed 0.60, it can be considered that the food is microbiologically stable, from which it can be inferred that if the food spoils, it is not the result of microbiological process but can instead be attributed to chemical changes.[30]

From Table 4, the reduction in the amount of stevia syrup resulted in an increase in the protein, fat and ash values ($p \leq 0.05$). This may be due to the increase in protein values, partly from the addition of egg whites that make the egg white rise, which has protein as the main component. Another part is that the reduction in the amount of stevia causes the solubility to decrease, resulting in an increase in the protein values. The fat values tend to decrease in the same way as the protein values, probably due to the reduction in the amount of stevia syrup causing the fat values to increase. The ash values tend to be the same as the protein and fat values.[31]

Analyses of the DPPH assay and β-carotene were performed and these data are shown in Table 5. Data analysis of both β-carotene and antioxidants showed no statistical differences ($p > 0.05$). The results of β-carotene analysis in all treatments were closed and had no statistical differences ($p > 0.05$). One possible reason is that the starting materials were in the same proportion, resulting in no differences in the measured values from the reduction of stevia syrup. The analyzed values for each treatment were very low, in addition to the same amount of starting raw materials in all treatments. Part of the loss of β-carotene came from the raw material preparation process and the drying process through heating by oxidation or exposure to very high heat, air and sunlight. Therefore, such processing causes losses.[5,6,32] The antioxidant values by DPPH method for each treatment were very similar, for the same reasons as the β-carotene values. Reducing the amount of stevia syrup did not affect the antioxidant values. The samples were shown to have similar links between the antioxidant and β-carotene qualities and while there were no differences in the antioxidant properties, it can be explained that antioxidant capabilities are determined by the concentration and the chemical structure, since these qualities govern the subsequent interactions.[5,6] Moreover, it is also possible to improve the antioxidant activity by adjusting the temperature used for the drying process. Among the reactions of interest, the Maillard reaction can lead to products which exhibit very strong antioxidant qualities.[5,6] Higher drying temperatures increase the likelihood of Maillard reactions, and in turn the likelihood of Maillard products being created, with increased antioxidant potential.[25] In addition, the drying process can also sometimes induce oxidation, which results in increased antioxidant activity from the resulting oxidized polyphenols when compared to the activity of non-oxidized polyphenols.[25]

The reduction of stevia syrup in mixed pumpkin, carrot and lemongrass powder resulted in a tendency to reduce the values associated with redness, yellowness and overall brightness when compared to the control ($p \le 0.05$). Treatment 1 showed the highest brightness, redness and yellowness values because stevia is a pure stevioside crystal particle (white powder). When in liquid form, the product becomes more turbid, which may be due to partial sedimentation of suspended particles in pumpkin, carrot and lemongrass that are not dissolved in the fruit juice. In addition, it is also due to the joint factors of tissue structure and components in the fruit, including pectin compounds that are extracted and suspended in the fruit juice, causing turbidity in the juice, which affects the measurement of the brightness and color values,[34] in concurrence with Carbonell-Capella[35]; Nimitkeatkai and Potaros.[30] Lower intensity for brightness, redness and yellowness can be attributed to decreased amounts of the stevia syrup. The temperature affects the start of the browning reaction in egg white powder.[28] High temperatures may also cause damage to the pigments found within the mixed pumpkin, carrot and lemongrass. It may therefore be the case that the browning reaction can take place during the foam mat drying process and this can in turn accelerate the observed decreases in brightness, redness and yellowness as the stevia syrup content was reduced. Other reactions, including the caramelization and Maillard reactions can occur during drying and inside the final product because the mixed pumpkin, carrot and lemongrass contains sugars and amino acids. The temperatures reached during drying are maintained inside the drying tray and can thus promote these reactions. The mixed pumpkin, carrot and lemongrass powder is a brown orange color.[27,32]

The water solubility was shown in Table 6. The mixed pumpkin, carrot and lemongrass soluble powder in Treatment 2 gave the lowest value for water solubility, while Treatment 1 had the highest water solubility. When the products were blended, dried and sifted into powder, it was found that the powder was crumbly and stuck to the hands. The water solubility was not good. This was because the amount of stevia syrup added affected the drying process. Adding a large amount of stevia syrup reduces the water solubility of the product, causing it to become more turbid.[18]

The findings presented in Table 7 reveal bacteria values not exceeding 1×10^4 CFU/mL for any of the treatments. Meanwhile, no treatment had water activity greater than 0.60, from which it can be inferred that the products were both stable and safe in the context of microorganism growth inhibition.[5,6] It appears that bacterial growth in the mixed juice product is restricted, which may be due to the heat processing in the steps of the raw material preparation and foam mat drying process under good hygienic conditions with GMP.[5,6] This study was in concurrence with Hirunyophat[31] who reported that in pasteurized Chock–Anan raw mango juice, the total plate count showed at <1 CFU/mL.

The outcomes from the sensory assessment using the 9-point hedonic scale can be observed in Table 8. The scores from this scale allow the general level of acceptability of the product to be determined in line with the specified criteria.[31] Data analysis confirmed that no significant differences ($p > 0.05$) could be observed for any of the values with the exception of taste, which was statistically different ($p \le 0.05$). From the results of the study, it was found that reducing the amount of stevia syrup resulted in a higher acceptance scores from the expert panel members, who could clearly distinguish the taste differences. This is because when stevia syrup is added to the product, it causes an astringent and bitter aftertaste. In addition, the results of the study were consistent with Hirunyophat[31] who found that when increasing the amount of stevia syrup in pasteurized Chokanan mango juice products, the overall sensory scores tend to decrease. Onsamlee[36] found that increasing the concentration of stevia extract in young coconut fresh milk pudding products tends to decrease the overall liking score when compared to the control sample. In addition, Yildiz and Karhan[37] reported that the use of stevia extract in beverage products may cause an astringent and bitter aftertaste in the throat, which may affect sensory acceptance. Krasaekoopt and Bhatia[29] reported that the preference scores of flavor, texture and general acceptability in the yogurt powder production using foam mat drying were not significant (p>0.05).

Conclusion

It has been determined that the foam-mat drying process shortens the drying time of mixed pumpkin, carrot and lemongrass by 90 minutes at the same drying temperature. The best conditions for producing mixed pumpkin, carrot and lemongrass powder by using foam mat drying were provided by Treatment 4 as a low calorie sweetener with the mixing time of 5 minutes and drying temperature of 70°C for 90 minutes. The mixed pumpkin, carrot and lemongrass foam had very high foam stability, low foam density, a high overrun percentage and a high yield percentage. Microbiological analysis revealed that quality of the mixed pumpkin, carrot and lemongrass powder met the required safety standards. The sensory score of mixed pumpkin, carrot and lemongrass powder (Treatment 4) was 6.30 for taste. Future studies may focus on the shelf life of the products including other fruits and vegetables, other foaming agents and more suitable packaging for the extension of shelf life.

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Conflict of Interest

The author does not have any conflict of interest.

Data Availability Statement

This manuscript incorporates all datasets examined throughout this research study.

Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required.

Clinical Trial Registration

This research does not involve any clinical trials.

Permission to Reproduce Material from other Sources

Not Applicable.

Author Contributions

The sole author was responsible for the conceptualization, methodology, data collection, analysis, writing and final approval of the manuscript.

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