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Development of Spray Drying of Powdered Oolong Tea Incorporated with Chinese Jujube Beverage

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Abstract

One useful economic crop which is utilized worldwide is Chinese jujube. It offers both nutritional and therapeutic benefits. Meanwhile, Oolong tea is a semi-oxidized form of tea which has a flavour that falls somewhere between black tea and green tea. Finally, spray-drying is an important technique used in food preservation. This current study sought to assess the most suitable use of Chinese jujube along with appropriate levels of maltodextrin when creating a mixed Oolong tea which incorporates Chinese jujube and is subsequently processed via spray-drying. Oolong tea served as the control sample, while evaluations were carried out on 60%, 70% and 80% blends of Chinese jujube with maltodextrin which served as a carrier agent at concentrations of 20 g, 30 g, 40 g and 50 g. These solutions underwent spray-drying where the respective inlet and outlet temperatures were 190°C and 80°C, respectively. An evaluation of the physico chemical, microbiological and sensory evaluation were performed. There was evidence of an increase in the total phenolic compounds, whereas in contrast there was a decline in antioxidant activity. *L** and *+a** showed no statistically significant difference, although for *+b** a statistically significant difference was found. For products with mixed Chinese jujube and Oolong tea, the moisture, water activity and pH values were shown to be lower, although there was an increase in total soluble solids. In the evaluation, flavour and overall acceptability for Treatment 4 (80% Chinese jujube) achieved the highest respective ratings at 8.17 and 8.13 on the 9-point hedonic scale. This demonstrates that spray-drying can be beneficial in the context of powdered particles. The combination of Chinese jujube and powdered Oolong tea provides good antioxidant properties and offers strong potential for applications in the food sector.

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Introduction

Chinese jujube is a healthy fruit which has a pleasant taste, but a majority of its benefits are derived from the peel and the pulp, which are the main source of bioactive components. It has been reported that Jujube contains a high concentration of bioactive components including triterpenic, phenolic and amino acids, flavonoids, minerals and polysaccharides.[1]

Oolong tea is popular in China, where it is sometimes referred to as semi-fermented tea, and across much of Asia. It can be consumed hot or cold, and is easily obtained from shops, restaurants and vending machines throughout the region. It is usually consumed with its health benefits in mind, however, rather than simply a means of quenching one's thirst.[2]

At present, there is continuous growth in technology leading to increased convenience in people's lives. This in turn results in a decrease in the body's energy consumption, with obesity or excess weight being a significant contributing factor to the onset of various diseases and illnesses. Currently, a wide variety of health drinks are available to consumers, which are gaining popularity because they are delicious, affordable and easy to consume. The product formats are typically either ready-to-drink or powdered form which means they can often be stored for a long time. There are several drying methods for such powdered drinks, including, for example, spray drying.[3]

Spray-drying is a common food preservation technique for powdered food products since it is fast, inhibits the growth of microbes, and provides stability under storage conditions as long as the food is dried under optimal conditions, which allows food products to be obtained which are rich in acids and sugars.[4] The product quality for spray-dried food is related to total insoluble solids and total soluble solids, which in turn are controlled by spray-drying process factors such as the feed rate and the inlet temperature. Spray-drying often makes use of maltodextrin as the carrier since it is highly soluble and offers low viscosity, which are important considerations.[4] Four related studies examined related products. Firstly, chestnut and red dates were used as raw materials for fruit juice processing. Chestnut was mixed with jujube juice after preparation. The effects of mixing ratio, sour agent ratio, sweetener ratio and stabilizer ratio on the taste of the product were investigated by single factor experiment. Taking the taste of the beverage as the main evolution criteria, the results showed the best ingredient: addition of chestnut juice to red jujube juice was 5:1, sweetener (white sugar) was 10%, acidifiers (citric acid) is 0.08% and stabilizer (monoglyceride) were 0.4%. In this ratio, the drink was moderately sweet and sour and the taste was delicate.[5] Next, in particular, some of the operating variables affecting the dried powder qualities for the spray drier were examined, including Ber powder qualities such as the capacity of the feed pump (9, 12, 15, 18 and 21%), the capacity of the aspirator blower (40, 50, 60, 70 and 80%), inlet temperature (170, 180, 190, 200 and 210°C) and also the parameters of the feed processing including total soluble solids of the feed and encapsulating materials, citric acid (0.25%), aerosil (1.0%) and maltodextrin (4, 6, 8, 10 and 12%) to determine the effects upon the resulting physical properties of the powder, including colour, hygroscopicity and packed density. For Ber powder, quality was maximized at a feed pump capacity of 15%, with aspirator blower capacity of 60%, inlet air temperature at 190°C, and encapsulating material of 8% having considered the main physical attributes such as packed density (0.45 g/mL) and hygroscopicity (0.17 g/g dry matter).[6] Next, this research examined a combination of powdered green tea and okra with maltodextrin concentrations of 10%, 20% and 30% the optimal spray-drying conditions. Experiments were performed at various inlet and outlet temperatures (150, 160, 170 and 75°C), with the outcome that an input temperature of 150°C and maltodextrin and 10% resulted in total phenolic compounds at 0.235 ppm and the DPPH assay at 0.235%. Thirty non-trained assessors then conducted the sensory evaluation using the ranking scale. The highest level of acceptance for yield percentage was achieved at an input 150°C with maltodextrin at 30%, while the lowest level came for a temperature of 170°C with maltodextrin at 30%.[7] The latest research studied the spray-dried Ber powder was also examined, using the four parameters for the spray-drier of aspirator blower capacity (40, 50, 50, 70 and 80%), maltodextrin (4, 6, 8, 10 and 12%), inlet temperature (170, 180, 190, 200 and 210°C), and feed pump capacity (9, 12, 15, 18 and 21%), remained unchanged as 32 trials were conducted. When the conditions comprised aspirator capacity at 60%, maltodextrin at 8%, inlet temperature at 190°C and feed pump capacity at 15% it was possible to achieve the best Ber powder quality (ascorbic acid 38.4 mg/100g, acidity 0.55% moisture content 3.9%).[8]

From the research examples above, it is apparent that while some researchers had studied the drying of jujube powder and green tea, there had been no research information related to mixing jujube with Oolong tea by spray drying. It is important that the researcher should focus on these ingredients in particular. On the basis of these works, the author takes the view that spray-drying is a helpful technique, in that it allows the dried powder to maintain its nutrient value and is a quick and simple process. Moreover, Chinese jujube and Oolong tea both offer medicinal properties which can alleviate a number of symptoms since they contain various antioxidants and other bioactive ingredients. The drying process can cause a decline in the physical and chemical qualities of a product, so the pace on this decline is critical in dried or powdered foods.[9] Accordingly, this study considers the amounts of total soluble solids in Oolong tea, Chinese jujube and maltodextrin in order to investigate how the chemical, physical and microbiological qualities of the product are affected by this factor and to examine the effect upon the sensory evaluation outcomes. Both Chinese jujube and Oolong tea are easy to find and inexpensive ingredients are available throughout the season. They also contain important bioactive substances that are beneficial to the body. From liquid form, they can then undergo spray-drying to form the powder, which offers health benefits due to the bioactive chemicals in the raw materials. To maximize the utility of the product, the optimal drying conditions must be used in line with the study findings. Combinations of different local raw materials in this style may prove beneficial for Thailand's SME sector, while providing valuable opportunities for entrepreneurs and giving farmers a means of earning higher incomes from their agricultural crops.[9,10]

This research had the principal aim of investigating the ideal drying conditions, taking into account the various concentrations of maltodextrin and content levels of Chinese jujube, when utilizing spray-drying while maltodextrin served as a carrier material. An examination of the various chemical, physical and microbiological properties was carried out which involved recording the water activity, yield, colour, brightness, moisture, DPPH, total phenolic compounds, sensory evaluation outcome and total plate count.

Materials and Methods

Raw Material Preparation

The Big C supermarket at Fashion Island in Bangkok, Thailand, supplied the dried Oolong tea and Chinese jujube used for the experiments in this study. The mature stages of fresh Oolong tea and ripe Chinese jujube were picked (3-4 young top leaves) in the morning, dark brown, respectively. These samples initially underwent cleansing in pure water to remove microbes, dirt or other pollutants. The maltodextrin DE 15 was supplied by Chemical Bangkok Co., Ltd. (Thailand). All chemicals used during the course of this research were of analytical reagent grade (Sigma brand and high purity of 99.8%).

To prepare the Oolong tea, 1,300 mL of clean water was first be maintained at a temperature of 80-90^{o}C. In the next step, 15 g of Oolong tea was dissolved in the water before boiling for 3-4 minutes. Finally the Oolong tea should be filtered through a white cloth. The Chinese jujube was then be prepared at different weights for different treatments as shown below:

Treatment 1: control (Oolong tea)
Treatment 2: with 60% Chinese jujube
Treatment 3: with 70% Chinese jujube
Treatment 4: with 80% Chinese jujube

The Chinese jujube was mixed with the Oolong tea to form a suitable blend in the hot water at 80-90^{o}C. After 4-5 minutes, the mixture was filtered through the white cloth.[6,11]

Determination of Suitable Conditions for Mixed Oolong Tea and Jujube Powder Production

A spray-drier (Model SD-Basic Lab Plant Scale from China) (Set consisting of an atomizer, drying chamber, feed pump, cyclone and product chamber) was used to produce the samples in line with the process explained in the section on raw material preparation. This required 3000 mL of hot water to be combined with maltodextrin to obtain the specific solutions for different maltodextrin concentrations:

Treatment 1: with 20 g maltodextrin (control)
Treatment 2: with 30 g maltodextrin
Treatment 3: with 40 g maltodextrin
Treatment 4: with 50 g maltodextrin

(Calculations were performed on the basis of homogeneous aliquots as the total soluble solids in hot water at 20%, 30%, 40% and 50%).

The feed aliquot comprised a blend of Oolong tea and Chinese jujube, whereby the proportions were adjusted until a dissolved aliquot (sometimes found sediments using a Whatman filter instrument (the filter set consisting of a suction flask and a vacuum pump)) which was homogeneous was obtained. To ensure that the outlet temperature was maintained at approximately 80°C with a flow rate of 0.3 litres per hour, the drying procedure was carried out with an inlet temperature of 190°C for approximately 3 hours. After drying, the powdered Chinese jujube and Oolong tea was collected and weighed before being stored using a laminated bag, which was kept in dark, cool and dry conditions prior to evaluating the physicochemical properties and conducting the sensory evaluation.[7]

Physicochemical Quality of Mixed Oolong Tea and Chinese Jujube Powder

The brightness and colour of the samples were evaluated using a Mini Scan XE (Hunter Associates, Reston, VA) to determine brightness (*L*)*, redness (+*a**) and yellowness (+*b**).[12] The hot-air oven technique was then employed to determine the moisture content of the Chinese jujube and Oolong tea combination.[12] Finally, water activity (a_w) was assessed and assigned a value.[12]

The yield of the powdered samples for powder products was calculated by using the equation.[12]

% yield = Solid weight of powder after spray drying / Total solid weight before spray drying x 100 ...(1)

The pH values were measured using a pH meter,[12] while a hand refractometer was employed to determine the total soluble solids.[12] Meanwhile, total phenolic compounds were evaluated using Folin-Ciocalteu method,[13] and the DPPH assay was performed to obtain the antioxidant inhibition percentage.[13,14]

Microbiological Quality of Instant Powder of Mixed Oolong Tea and Chinese Jujube

The total plate count, which is a means of assessing the number of microorganisms, allows determination of the microbiological properties.[12]

Sensory Evaluation

A 9-point hedonic scale was employed to quantify the sensory qualities of the combination of spray-dried Oolong tea with Chinese jujube powder. A panelist of 30 respondents who had not received guidance or training assessed all of the sample, which had first been reconstituted using water at a ratio of 1:1. Each treatment was then given a score on the 9-point scale by each panel member.[15]

Statistical Analysis

This study used a completely randomized design (CRD) rather than the more experimental approach of a randomized complete block design (RCBD). Differences in the treatments were assessed by both Duncan's New Multiple Range Tests and Analysis of Variance (ANOVA) with the confidence level set at 0.05. The data were shown in the form of the measured values, and examinations of each treatment were carried out in triplicate with PASW statistics version 18.[15]

Results and Discussion

All instant powders of the mixed Oolong tea and Chinese jujube were represented in Tables 1-5.

While brightness and redness were similar, the results revealed a significant difference in yellowness when comparing blended Oolong tea and powdered Chinese jujube, as shown in Table 1. Treatment 1 (control) *L**, +*a** and +*b** which did not contain Chinese jujube had the highest recorded levels for whiteness, redness and yellowness. In powder form, Treatment 1 offered greater brightness, redness and yellowness than was the case for other powders.[6,7,8] The increase in maltodextrin did, however, cause a decrease in the aroma of the Chinese jujube and Oolong tea combination.[6,7,8] Lower intensity for red and yellow might have arisen due to small amounts of the powder from the Chinese jujube and Oolong tea combination failing to become completely dissolved. As the temperature is increased, the powdered Chinese jujube and Oolong tea combination tends to start browning reaction.[6,7,8] It is possible that the pigments in the Chinese jujube and Oolong tea combination are damaged at increased temperatures as a result of a change in the hue angle.[8] The browning reaction which is not attributable to enzymatic action which occurs during the process of spray-drying might also exacerbate the decline in brightness, redness and yellowness. Where red and yellow hues are observed in the powdered forms, these might result from browning events which are not related to enzymatic activity in the drying procedure, such as the Maillard reaction and caramelization reaction. Such reactions can take place in the final blended product for the Chinese jujube and Oolong tea combination due to the presence of both sugars and amino acids, promoted by the lower inlet temperature which is maintained within the drying chamber as the drying period is extended.[7,8] Maltodextrin powder is white colour[7,8] and as its concentration increases, it causes a decrease in the levels of brightness, redness, and yellowness of the Chinese jujube and Oolong tea combination. The amount of maltodextrin used can be considered the main reason for chemical changes causing differences in the red and yellow hues when comparing Chinese jujube with reconstituted, finished Oolong tea. The use of higher maltodextrin concentrations affected powdered qualities and sometimes caused a loss of nutrients.[7] However, prior to the addition of water to dilute the concentrations, the powdered forms will exhibit only minor trends in terms of the colour differences.[6,7,8]

Table 1: Brightness, redness, yellowness and yield percentage of instant powder of mixed Oolong tea and Chinese jujube

Treatment	$(L^*)^{ns}$	$(+a^*)^{ns}$	$(+b^*)^*$	yield (%)*
1	86.59+1.52	2.75+0.59	18.28+0.11^{a}	5.11+0.88^{c}
2	86.19+0.14	2.59+0.18	17.70+0.56^{ab}	8.32+0.65^{b}
3	84.73+1.04	1.59+0.77	17.22+0.24^{bc}	11.98+1.47^{a}
4	84.42+0.78	1.92+1.40	16.92+0.39^{c}	12.25+2.11^{a}

N.B: *The other superscript alphabets (a-c) from identical column indicate significant variation at 0.05, ns means non significant.
Treatment 1 Oolong tea (control)
Treatment 2 Oolong tea and 60% Chinese jujube
Treatment 3 Oolong tea and 70% Chinese jujube
Treatment 4 Oolong tea and 80% Chinese jujube

The yield trend was shown in Table 1, measuring from 5.11% to 12.25% as the concentration of maltodextrin rises. In the findings, when spray-dried banana puree was mixed with 30% maltodextrin while the input temperature was 150°C, the yield was maximized at 51.50%. Treatment 4 generated the highest total solids when maltodextrin was at its highest.[6,7,8] Maltodextrin quantities did not affect yield predictions due to the expansion of the viscosity of the aliquot value. The addition of maltodextrin caused a decline in powder hygroscopicity,[6,7,8] which could be attributed to the method employed for powder collection. In this research, a cyclone contained all of the different powders, or treatments. It was apparent that if the powder on the surface of the drying chamber underwent manual polishing following the drying procedure, followed by blending with powders from another part of the cyclone,[7,8] there might be a difference in the resulting yield trend.[7,8]

Since it crucially affects product shelf-life, water activity is a very important parameter when examining spray-dried powders. Different to moisture content, measuring water activity offers a means to determine how much free water exists within a particular food system. Such water is vital in many biological responses.[9] The water activity of the powders was measured in the range of 0.31-0.41, with the outcomes presented in Table 2 under net water activity. Consequently, the value for water activity rose with increases in the inlet temperature.

The highest value, at 0.41 was recorded in Treatment 1. It was shown in this study that water activity in the combination of Oolong tea with Chinese jujube could be reduced by the addition of more maltodextrin.[7,9] This addition also leads to an increase in solid content which duly binds with the water component, thus lowering water activity accordingly.[7,9] Most foods are considered microbiologically stable when the value for water activity does not exceed 0.60. In such circumstances, spoiling would be the result of chemical processes instead of microorganisms. This study was carried out in line with Sornsomboonsuk (2018)[16] in order to investigate three formulas (Bael powder product; 1C, 2C, and 3C) whose water activity values were around 0.29-0.32. The moisture of the powdered product can also be decreased by increased temperatures and higher maltodextrin content, while simultaneously increasing the dissolved particle content in the solution, although this was increased less than the maltodextrin content. Maltodextrin derived from plants is a modified type of starch. It is known to be a useful encapsulant capable of trapping substances with low molecular weights, including sugars and organic acids. This makes the process of spray-drying much easier and avoids the problem of spray-dried products which are sticky.[6,7,8]

Table 2: Chemical properties of instant mixed Oolong tea and Chinese jujube powder

Treatment	Water activity*	Moisture* (%)	Total soluble solid* (Brix)	pH*
1	0.41+0.01^{a}	3.96+0.15^{a}	2.13±0.05^{c}	5.52±0.17^{a}
2	0.36+0.00^{b}	3.74+0.18^{a}	2.26±0.05^{b}	5.00±0.02^{b}
3	0.33+0.01^{c}	3.24+0.06^{b}	2.46±0.05^{a}	4.69±0.16^{c}
4	0.31+0.01^{d}	2.48+0.25^{c}	2.56±0.05^{a}	4.54±0.10^{c}

N.B: The other superscript alphabets (a-d) from identical column indicate significant variation at 0.05.
Treatment 1 Oolong tea (control)
Treatment 2 Oolong tea and 60% Chinese jujube
Treatment 3 Oolong tea and 70% Chinese jujube
Treatment 4 Oolong tea and 80% Chinese jujube

The moisture parameter describes the water component of the overall food composition.[9] The powdered sample (Table 2) produced from Treatment 1 exhibited the highest moisture content at 3.96%. Another study assessing the moisture content of powder products found that values lower than 4%, lead to excellent powdered products with good water.[7] Powdered products with moisture content lower than 10% indicated that they are microbiologically safe.[16,17] However, in general, the moisture of powder products obtained from spray drying has a value lower than 5%, which helps to preserve its for a longer extended shelf life time.[16,17] From this research, it was found that increasing the amount of maltodextrin from 20, 30, 40 and 50 g resulted in a statistically significant difference in the moisture content of Oolong tea mixed with Chinese jujube powder ($p \leq 0.05$), which was between 2.48-3.96% (Table 2) according with the work of Sornsomboonsuk (2018)[16] found that increasing the amount of maltodextrin studied for the development of instant Bael powder products by spray drying from 12, 15 and 18% resulted in a statistically significant decreased in the moisture content with Wirivutthikorn (2022)[7] concluded that the moisture content of the powdered sample produced from maltodextrin concentration of 30% and inlet temperature at 170^{o}C resulted in the lowest moisture (1.99%). The moisture content of the spray-dried powder decreased when more maltodextrin was added.[18] In a spray-drying system, the water content of the feed has an effect on the final moisture content of the powder produced.[18] Addition of maltodextrin to the feed prior to spray drying increased the total solid content and reduced the amount of water for evaporation, resulting in decreased moisture content of the powder. This meant that powders with lower moisture content could be obtained by increasing the percentage of added maltodextrin.[8] However, if the proportion of maltodextrin was very high, the powder produced would be of lower quality because the nutrients from the Calamondin juice would be diluted with water (lower total soluble solid).[18] Pino *et al*. (2018)[19] concluded that moisture content of concentrated orange juice powder varied from 3.63 to 4.69% wet basis in their study. The increase in maltodextrin content also caused a significant decrease in powder moisture. This can be explained by the fact that the addition of coating material leads to a higher amount of total soluble solids in the feed and less water to be evaporated.[7] The addition of maltodextrin reduced the stickiness of the products and altered the physicochemical properties of the spray dried powders.[6] This occurs because the addition of a coating material leads to more solids in the feed and a decline in evaporative water. It was also found that rising quantities of maltodextrin from 20 g to 30 g, 40 g and 50 g leads to significantly greater total soluble solids content in Oolong tea mixed with Chinese jujube powder, measuring 2.13-2.56 (^{o}Brix). Total soluble solids tend to rise as more maltodextrin is added, with Hansapan (2021)[20] observing that the addition of 30% maltodextrin served to obtain the greatest soluble solids value than 10 and 20% when tests were performed in Calamondin.

The sample pH, for which the reading were around 6.0, was near to neutral, as shown in Table 2. For all of the powdered samples, the pH values were found to be in the range of 4.54 to 5.52,[20] while pH values for Chinese jujube were 5.85–6.54 and for Oolong tea they were 6.0–6.5.[20] It has been shown that if the concentrations of Chinese jujube and maltodextrin are raised in each of the treatments, the products comprising Oolong tea mixed with Chinese jujube might have a slightly lower pH at around 4.5–5.52. It may also be the case that particular food additives are not present in products made from Chinese jujube mixed with Oolong tea.[20]

Percentages for the DPPH assay and total phenolic compounds were investigated for the powdered samples, with the outcomes shown in Table 3. The highest DPPH assay values were reported for Treatment 4, at 65.86 mg Trolox eq/g, while the highest phenolic compound levels were also recorded for Treatment 4, this time at 29.26 mg gallic acid eq/g. Total phenolic compounds and DPPH assay could be increased by using more Chinese jujube, in concurrence with the work of Donlao and Thepakorn (2011)[21] who examined the optimal spray-drying conditions for green tea. It was also reported that rising total solid content within the concentrated extracts could lead to a rise in both total phenolic content and DPPH assay. The nature of the links between total phenolic content and antioxidant properties in the powdered Oolong tea mixed with Chinese jujube was not, however, immediately apparent,[7] since total phenolic content is not dependent upon all of the antioxidants which are in the extract. For this reason, the total phenolic content for powdered Oolong tea mixed with Chinese jujube showed no difference, although the values for antioxidant capacity were different. Moreover, the antioxidant capabilities of an antioxidant are reliant upon the chemical structure of that antioxidant as well as its concentration and the way it interacts.[7,8] Total phenolic content, however, could be changed by increasing the temperature or adding more maltodextrin, as a rise in temperature served to increase total phenolic content at various maltodextrin percentages. Furthermore, the drying temperature could also enhance the antioxidant capacity. One reaction which can be observed is the Maillard reaction, which offers a high capacity for antioxidants,[6,7] with the product offering excellent antioxidant properties.[6,7] Furthermore, according to Nadeem *et al*. (2011),[22] the total polyphenol content in spray-dried tea was shown to decline as the concentration of the carrier material rose. Different extraction times were investigated by Prathumwan *et al*. (2023),[23] who reported that both total phenolic contents and antioxidant activity were significantly different. Chinese dates, with 45 minutes for extraction, produced the greatest level of total phenolic contents (40,677.40±553.21 mg GAE/g) and antioxidant capacity (19.724±0.372 mg/mL). It was further explained by Rattanapun *et al*. (2022)[11] that by using 800 watts for 1 minute of heating, it was possible to maximize the phenolic compounds (0.43 mg of gallic acid/100 g) in roselle juice mixed with Chinese jujube, while the antioxidant properties were also maximized at 85.53 μM T.E/100 g). Horuz *et al*. (2012)[24] found that phenolic compounds are usually heat labile, but even though certain phenolic compounds are able to withstand heat, any structural break down or rearrangement will inevitably change the concentration and activity of the compound. Phenolic structure changes might lead to a change in their solubility when they are dissolved in the extraction solvent, potentially affecting their quantification. Moreover, in contrast to the raw material, when moisture is removed in some cases, this can change the concentration of the bioactive chemical components. The extent to which phenolic chemicals are broken down depends upon the food matrix and processing parameters. For instance, the application of heat might be sufficient to break the phenolic and sugar glycosidic links, creating phenolic aglycones which react vigorously with Folin-Ciocalteu method and lead to an increase in phenolic content levels. Accordingly, the way phenolic acids respond to heat might determine the nature of changes in phenolic concentrations and their antioxidant properties. Oxidation sometimes takes place during the drying procedure, causing oxidized polyphenols to exhibit greater antioxidant activity than non-oxidized polyphenols. Furthermore, at high temperatures it is more likely that Maillard reactions will take place, generating Maillard products, which may have antioxidant properties, or can combine with phenolic compounds to form effective antioxidants. As a result, in some cases, DPPH readings might increase despite a fall in the phenolic content overall.[24,25,26] There was no exact relationship between the DPPH assay and total phenolic, but they may have been some technical errors in the experiment. There may be other caused for the analysis results that did not conform to the theory, in addition to errors that occurred from the experiment, such as the consistency of the raw materials used in this research.

Table 3: Total phenolic compound and DPPH of instant mixed Oolong tea and Chinese jujube powder

Treatment	total phenolic compound^{ns} (mg gallic acid eq/g)	DPPH* (mg Trolox eq/g)
1	27.76±1.96	64.53±0.00b
2	28.60±0.72	64.37±0.00c
3	29.13±1.35	64.41±0.00c
4	29.26±0.13	65.86±0.08a

N.B: The other superscript alphabets (a-c) from identical column indicate significant variation at 0.05,
ns means non significant.
Treatment 1 Oolong tea (control)
Treatment 2 Oolong tea and 60% Chinese jujube
Treatment 3 Oolong tea and 70% Chinese jujube
Treatment 4 Oolong tea and 80% Chinese jujube

Table 4: Microbiological properties of instant mixed Oolong tea and Chinese jujube powder

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

N.B: Treatment 1 Oolong tea (control)
Treatment 2 Oolong tea and 60% Chinese jujube
Treatment 3 Oolong tea and 70% Chinese jujube
Treatment 4 Oolong tea and 80% Chinese jujube

Table 4 confirms that all treatments reported finding values lower than $1x10^4$ CFU/mL of bacteria. The products which had low pH values in the range of 4.54 to 5.52 served to inhibit bacterial growth, as shown in Table 2. The water activity value in each of the treatments did not exceed 0.60 and therefore indicated product stability and safety in terms of inhibiting microorganism growth.[7] Since the growth of bacteria in mixed juices appeared to be inhibited, this could be attributed to completion of the pasteurization process by the juice manufacturer under good hygienic conditions in line with GMP specifications.[7] This study was in concurrence with the work of Hemathulin *et al*. (2022)[27] who reported that in heat-treated and unheated rice germ powder samples, the total microbial count stood at <10 CFU/g, while there was reportedly no contamination from mold or yeast. Rattanapun *et al*. (2022)[11] stated further that total yeasts and molds, and total viable count could be considered undetectable in the context of a roselle juice mixed with Chinese jujube using four different heating approaches. The findings matched those of Carneiro Maranhão Ribeiro *et al*. (2019)[28] who claimed that spray-dried seriguela and acerola displayed excellent sanitary and hygienic conditions. No microorganisms were found.

Table 5: Liking scores of instant mixed Oolong tea and Chinese jujube powder

Treatment	Liking scores			
	colour[ns]	odour*	taste*	overall acceptability*
1	7.67±0.84	8.03±0.72[a]	6.97±0.93[c]	6.83±0.87[c]
2	7.53±0.97	7.93±0.74[ab]	7.43±1.01[bc]	7.33±0.96[b]
3	7.53±0.82	7.63±0.81[bc]	7.63±1.00[b]	7.63±0.72[b]
4	7.60±0.89	7.33±0.92[c]	8.17±0.75[a]	8.13±0.68[a]

N.B: The other superscript alphabets (a-c) from identical column indicate significant variation at 0.05 , ns means non significant.
Treatment 1 Oolong tea (control)
Treatment 2 Oolong tea and 60%Chinese jujube
Treatment 3 Oolong tea and 70%Chinese jujube
Treatment 4 Oolong tea and 80%Chinese jujube

Table 5 presents findings related to the sensory evaluation which is the principal means of determining whether a product containing Chinese jujube is acceptable.[29] Prior to conducting sensory analysis, the evaluators discovered that the acerola and seriguela reconstituted juice mix powder had been reconstituted using water. The juice was reported, however, to be slightly astringent.[28] Using the 9-point hedonic scale, it was found that Treatment 4 achieved the highest levels of acceptance in flavour and overall acceptability. In comparison to the other treatment samples, Treatment 4 also achieved the highest levels for antioxidant properties and DPPH. This might be attributed to the absence of food additives in the Oolong tea and Chinese jujube combination.[7] Since Treatment 4 also exhibited high phenolic compound levels along with high phenolic compounds and antioxidant properties, it can be considered the best of the treatments studied. The concentrations of Chinese jujube and the question of increasing maltodextrin content were shown to be unrelated to the evaluation panel acceptance scores.[19] It is possible for heightened maltodextrin content to change the sensory qualities of the final product. Consumer opinions concerning the various metrics were governed by the sensory qualities of the powder.[19,30] Some members of the evaluation panel reported an astringent taste for the reconstituted powder, but this powder was produced with a maximum of 80% Chinese jujube.

Conclusion

This research procedure involved conducting four treatments to evaluate the powdered tea products resulting from the combination of Oolong tea and Chinese jujube and maltodextrin concentrations of 20, 30, 40 and 50 g when a spray-drying process was employed with fixed both an inlet temperature of 190°C and an output temperature of 80°C. Differing mixtures of Oolong tea powder with Chinese jujube were analyzed to assess the various chemical and physical properties including antioxidant abilities and total phenolic content. The results for the DPPH assay and total phenolic content ranged from 64.37 to 65.86 mg Trolox eq/g and from 27.76 to 29.26 mg gallic acid eq/g, respectively. In assessing the colour, there was no statistically significant differences between the different mixtures in terms of L^* and $+a^*$, but for $+b^*$ there was a statistically significant difference. For L^*, $+a^*$, and $+b^*$ the values were found to be in the respective ranges of 84.42-86.59, 1.59-2.75 and 16-92-18.28. The various Oolong tea and Chinese jujube combinations exhibited low levels of moisture, water activity and pH values, but total soluble solids were found to be significantly higher. The evaluators reported the highest level of acceptability using the 9-point hedonic scale for Treatment 4 (80%Chinese jujube), which scored 8.17 for flavour and 8.13 for overall acceptability. For future studies of other types of Thai herbal juice should focus on researching the types of substances that enhance the solubility of Thai herbal juice powder, such as modified starch, etc., which could be used for the development of Thai herbal juice products that continue to use Thai herbal juice.

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Conflict

The author does not have any conflict of interest.

Authors' Contribution

Wattana Wirivutthikorn created this research. I worked on this research as one student. Sudarat Thaweesri (4th student in Bachelor degeree in Food Science and Technology) contributed to the initial and final work.

Data Availability

This manuscript incorporates all datasets examined throughout this research study.

Ethics Approval Statement

Not applicable.

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