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Physicochemical properties and sensory evaluation of mandarin (*Citrus unshiu*) beverage powder spray-dried at different inlet air temperatures with different amounts of a mixture of maltodextrin and corn syrup

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Abstract This study aimed to investigate the effects of varying mixtures of maltodextrin and corn syrup on the physicochemical characteristics and sensory evaluation results of mandarin beverage powder under different spay drying conditions including inlet air temperature and concentration of carrier agents. Higher inlet air temperatures increase in the a* value, pH, and WSI while decreasing the moisture content, L* value, b* value, vitamin C content, and bulk density. Increasing carrier agent concentration caused increases in the L* value and pH along with decreases in the moisture content, a* value, b* value, WSI, vitamin C content and bulk density. Water activity and WAI showed no significant differences among samples. Drying yield was maximized when the inlet air temperature reached 135°C and the carrier agent concentration was 35%. In sensory evaluation, as the concentration of the carrier agents increased, the taste received a higher preference rating, while the color was less preferred.

Keywords: mandarin, spray drying, citrus fruit, beverage powder

Introduction

Since ancient times, the mandarin has been known not only for its fresh taste but also for its beneficial effects on gastroenteric problems, asthma detoxification, and lack of appetite. It is also widely used as medicine. The mandarin includes nutrients such as glucose, fructose, vitamin C, vitamin E, and dietary fiber, along with functional components such as flavonoids and carotenoid (1). However, it has been constantly noted that there are many problems in the preservation and processing of the mandarin due to its limited production period (2).

The higher the moisture content, the higher the water activity, which activates enzyme activity and microbial growth, eventually inducing greater quality loss in fruits. Thus, to maintain the quality of fruits, it is desirable to reduce the moisture content and water activity. Since ancient times, people have used drying methods that remove moisture and reduce water activity to preserve food. Many drying techniques such as spray drying, freeze drying and hot air drying were introduced to increase productivity and product quality. Among these, spray drying is broadly used drying method for producing fruit juice powder (3). In the food industry, spray drying is used to dehydrate various products to form dry powders and agglomerates. Additionally, this method improves the hygienic conditions of the process and has economic benefits by reducing operational costs and contact time (4,5). Diverse factors in spray dryer operating systems determine the quality of spray-dried foods.

The effects of the concentration of maltodextrin and corn syrup on spray-dried mandarin beverage powders have been studied in previous work. Using maltodextrin as the carrier agent resulted in higher drying yield, but less preference in sensory evaluation. Using corn syrup as the carrier agent resulted in the highest scores for color, taste and overall acceptability but lower drying yield compared to the use of maltodextrin (6). Hence, this study aimed to investigate the effects of a mixture of maltodextrin and corn syrup on the physicochemical characteristics and sensory evaluation scores of mandarin beverage powder when used as the carrier agent for spray drying at different inlet air temperatures.

Materials and Methods

Materials Mandarin (*Citrus unshiu*) beverage (50% mandarin juice, vitamin C, citric acid, enzymatically modified stevia glucosyl stevia, fluid fruit sugar, water, Lotte, Anseong, Korea), maltodextrin MD-20

(Corn Products, Daesang, Icheon, Korea) with 20DE and corn syrup (55% maltose, 9% glucose, 17% maltotriose, 19% maltotetraose, Ottogi, Icheon, Korea) were purchased from a local market.

Spray drying The spray drying experiments was performed using a pilot-scale spray dryer (MH-8; Mehyun Engineering, Anyang, Korea) with a rotary disc atomizer. The sample mixture was fed into the main chamber through a peristaltic pump and the feed flow rate was controlled by the pump rotation speed. The atomizer speed and feed rate were 9,860 rpm and 16 mL/min. The ratio of maltodextrin to corn syrup in the mixture used as the carrier agent was set as 5:5. Different inlet air temperatures and different amounts of carrier agents were selected in order to obtain the highest drying yield. The inlet air temperature ranged from 120 to 150°C and the amount of carrier agents ranged from 30 to 40%.

Drying yield Drying yield was determined by dividing the weight of the solid mass collected from the product collector and the main chamber of the spray dryer by the total mass of solids in the sample fed into the spray dryer (7).

Bulk density Bulk density (g/mL) was determined by gently adding 2 g of mandarin beverage powder to an empty 10 mL graduated cylinder and holding the cylinder on a vortex vibrator for 1 min. The ratio of the mass of the powder and the volume in the cylinder determines the bulk density value (8).

Moisture content The moisture content of mandarin beverage powder (5 g) was determined gravimetrically by drying in an oven at 105°C until constant weight (9).

Water activity The water activity of mandarin beverage powder (5 g) was determined by a thermoconstanter (TH-200; Novasina, Lachen, Switzerland) (10).

Color measurement The color of mandarin beverage powder (5 g) was determined using a colorimeter (CM-3500d; Minolta Co., Ltd., Tokyo, Japan). The results were expressed as L*, a*, and b* values (11).

pH Five grams of mandarin beverage powder with 45 mL of distilled water was mixed with a homogenizer (T25 BASIC; IKA® Works, Inc., Wilmington, NC, USA) and centrifuged (UNION32R plus; Hanil Scientific Co., Ltd., Gimpo, Korea) at 2,016× *g* for 15 min. Then, the pH of the supernatant was measured using a pH meter (Model 8000; ORION, Rockford, IL, USA) (12).

Water solubility index (WSI) and water absorption index (WAI) WSI and WAI were determined according to the method described by Anderson (13). A small sample of dry powders (2.5 g) was added to 30 mL of water at 30°C in a 50 mL centrifuge tube, stirred intermittently for 30 min, and then centrifuged for 10 min at 2,016× *g*. The supernatant was carefully poured off into a petri dish and oven-dried overnight. The amount of solid in the dried supernatant as a percentage of the total amount of dry solid in the original 2.5 g sample gave an indication of the WSI. Wet solid remaining after centrifugation was dried in an oven (105°C) overnight. WAI was calculated as the weight of dry solid divided by the amount of dry sample.

Vitamin C content Vitamin C content was determined according to a slightly modified method described by Doner and Hickts (14). Mandarin beverage powder (2 g) was mixed with 100 mL of 5% metaphosphoric acid solution, and extracted by vortexing at room temperature for 1 min. The mixture was centrifuged for 15 min at 2,016× *g* and the supernatant was filtered using a 0.45-μm PVDF syringe filter; 20 μL of this sample was injected into the HPLC (PU-980 PUMP and UV-970 detector; JASCO, Tokyo, Japan). Vitamin C was separated by an ODS C18 column (4.6×250 mm, YMC Inc., Kyoto, Japan) using a mobile phase of acetronitrile: 0.05 M KH_2PO_4 (60:40, v/v) (A) and water (B), at a flow rate of 1 mL/min. The detection wavelength was 254 nm.

Sensory evaluation Sensory evaluation was conducted with 50 semi-trained (panelists) who were students at the Department of Food Science and Technology, Chonnam National University. The mandarin beverage powder was evaluated on color, flavor, taste and overall acceptability using the seven-point hedonic scale method (15). The scale ranged from 1 to 7, with 1 representing 'dislike very much' and 7 representing 'like very much'.

Statistical analysis All experiments were conducted twice and all the measurements were performed in triplicates (unless stated otherwise) and presented as mean±standard deviation. The statistical significance of the data obtained was analyzed by one-way Analysis of Variance (ANOVA) followed by Duncan's multiple-range test using SPSS version 18.0. The level of significance was considered at $p<0.05$.

Results and Discussion

Drying yield The drying yield of the spray-dried mandarin beverage powders is shown in Fig. 1. The maximum yield was obtained when the inlet air temperature reached 135°C and the concentration of the carrier agent was 35%. During the drying process, powder is deposited on the upright walls inside the drying chamber at low temperatures. If the droplets/particles are not dried sufficiently, the particles may adhere to the walls, forming moistened deposits and reducing the yield of powder. This has been widely observed in pilots and spray-dryers on the production scale (16). An increase in inlet air temperature is measured to improve production yield. When the

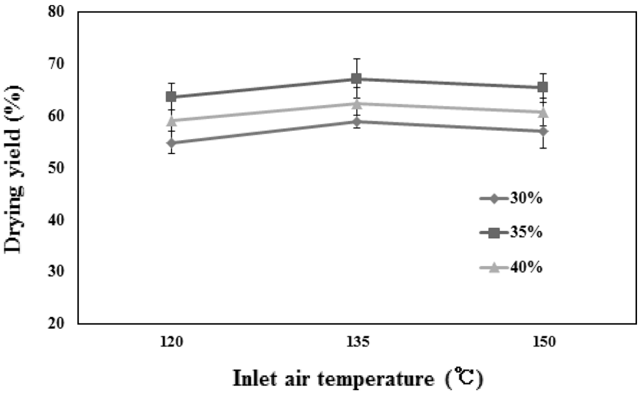

Fig. 1. Drying yield of mandarin (*Citrus unshiu*) beverage powder with different amounts of a mixture of maltodextrin and corn syrup and spray-dried at different inlet temperatures.

Table 1. Bulk density of mandarin (*Citrus unshiu*) beverage powder with different amounts of a mixture of maltodextrin and corn syrup and spray-dried at different inlet temperatures (unit: g/mL)

Carrier agent (%)	120°C	135°C	150°C
30	0.54±0.02$^{1)Bb}$	0.55±0.01^{Bb}	0.56±0.01^{Ab}
35	0.55±0.01^{Bb}	0.56±0.01^{Bb}	0.58±0.02^{Aab}
40	0.58±0.02^{Ba}	0.59±0.01^{ABa}	0.61±0.01^{Aa}

$^{1)}$Values represent means±standard deviation.

$^{a\text{-}c}$Means followed by different letters in each column are significantly different ($p<0.05$).

$^{A\text{-}C}$Means followed by different letters in each row are significantly different ($p<0.05$).

temperature inside the drying chamber is high, droplets/particles are sufficiently dried before they contact the walls. However, the powder yield decreased with higher inlet air temperature. The powder yield from the production of tower/cyclone deposits decreases because of the increasing temperature of the walls inside the machine (17). In this research, drying yield was found to be reduced when the temperature increased to a certain degree.

Fazaeli *et al.* (18) reported that increasing the carrier agent concentration in black mulberry juice significantly increased the drying yield. However, Tonon *et al.* (19) showed that increasing maltodextrin concentration decreased the process yield due to increasing the mixture viscosity. The drying yield for mandarin beverage powders was found to decrease when the carrier agent concentration increased to a certain degree.

Bulk density The bulk density results for mandarin beverage powders with different levels of carrier agent and spray-dried at different inlet temperatures are shown in Table 1. The bulk density decreased as inlet air temperature and carrier agent concentration increased. Tonon *et al.* (19) reported that with increasing inlet temperature, the bulk density decreased. High temperature may induce efficient formation of dried coating on the droplet surface and reduce particle size. Thus, at higher temperatures, skinning over or case-hardening of the droplets may occur. Consequently, vapor-resistant layers are formed over the droplet surface, creating vapor bubbles that eventually expand the droplets (19–22). When the drying air temperature increases, the bulk particle density decreases and particles are more likely to be hollow (23). At high inlet temperatures, products form a more absorptive and disintegrated structure to produce mandarin beverage powders with lower density.

Kwapinska and Zbicinski (24) also reported that the carrier agent reduces the viscosity of thermoplastic particles, which is related to a high bulk density. Air originating from the liquid feed or absorbed during atomization is desorbed, creating air bubbles inside particles. These bubbles comprise skin-forming materials that are spray-dried. In general, as the volume of air trapped inside increases, the observed particle density, upon which the powder bulk density depends, decreases. Similar observations were reported when maltodextrin concentration increased, accompanied by decreases in the bulk density in tomato juice powder and orange juice powder (8). Consequently, increasing carrier agent concentration reduces the bulk density of the particles, which eventually affects the bulk density of the mandarin beverage powders. This suggests that the powder bulk density is directly associated with the size and distribution of powder particles, supporting the results of previous studies (8). It can be expected that carrier concentration would affect the particle size of mandarin beverage powders.

Moisture content Table 2 shows the moisture content of mandarin beverage powders containing different levels of carrier agent and spray-dried at different inlet air temperatures. The moisture content ranged from 1.13 to 1.79% as the inlet air temperature decreased and the concentration of carrier agent increased. The temperature gradient between the atomized feed and drying air is larger at higher inlet air temperatures. Accordingly, the evaporation of water is expedited, producing dryer powders (19). Hence, the moisture content in the mandarin beverage powders decreased. Similar observations with watermelon juice and sweet potato puree were reported by Quek and Grabowski *et al.* (25,26), respectively.

The amount of carrier agent affected the moisture content of the powders. The total soluble solid content of the mandarin beverage was increased by increasing the amount of carrier agent. For this reason, the amount of evaporable water decreased, eventually the moisture content of the produced powders decreased (27). Consequently, increasing the amount of carrier agents leads to a decrease in the moisture content of mandarin beverage powders. The above result suggest that after spray drying, the processed powders have a stable moisture content under 2%, and that in the spray drying system, the inlet air temperature and concentration of the carrier agent are the variables that have the greatest influence on the moisture content of powders.

Water activity The water activity of the mandarin beverage

Table 2. Moisture content and water activity of mandarin (*Citrus unshiu*) beverage powder with different amounts of a mixture of maltodextrin and corn syrup and spray-dried at different inlet temperatures

Carrier agent (%)	Moisture content (%)			Water activity		
	120°C	135°C	150°C	120°C	135°C	150°C
30	1.79±0.03$^{1)Aa}$	1.52±0.06^{Ba}	1.36±0.11^{Ca}	0.16±0.00^{NS}	0.16±0.00	0.16±0.00
35	1.75±0.05^{Aa}	1.42±0.09^{Bb}	1.27±0.05^{Ba}	0.16±0.01	0.16±0.00	0.16±0.00
40	1.48±0.02^{Ab}	1.29±0.10^{Bc}	1.13±0.05^{Cb}	0.16±0.00	0.16±0.01	0.16±0.00

$^{1)}$Values represent means±standard deviation.

$^{a\text{-}c}$Means followed by different letters in each column are significantly different (p<0.05).

$^{A\text{-}C}$Means followed by different letters in each row are significantly different (p<0.05).

^{NS}Not significant at p<0.05.

Table 3. Color of mandarin (*Citrus unshiu*) beverage powder with different amounts of a mixture of maltodextrin and corn syrup and spray-dried at different inlet temperatures

	Drying temperature (°C)	30%	35%	40%
L*	120	84.64±0.12$^{1)Ca}$	85.33±0.45^{Ba}	86.17±0.18^{Aa}
	135	82.45±0.23^{Bb}	84.01±0.20^{ABb}	84.59±0.17^{Ab}
	150	81.51±0.41^{Cc}	82.63±0.14^{Bc}	83.61±0.23^{Ac}
a*	120	5.16±0.34^{Ac}	5.15±0.21^{Ac}	5.11±0.28^{Bc}
	135	5.27±0.22^{Ab}	5.25±0.31^{Bb}	5.24±0.50^{Bb}
	150	5.61±0.14^{Aa}	5.57±0.22^{Ba}	5.56±0.41^{Ba}
b*	120	35.77±0.09^{Aa}	35.10±0.44^{Ba}	34.78±0.37^{Ca}
	135	34.93±0.17^{Ab}	34.81±0.15^{Bb}	34.68±0.81^{Ca}
	150	34.10±0.25^{Ac}	33.98±0.34^{Bc}	33.77±0.08^{Bb}

$^{1)}$Values represent means±standard deviation.

$^{a\text{-}c}$Means followed by different letters in each column are significantly different (p<0.05).

$^{A\text{-}C}$Means followed by different letters in each row are significantly different (p<0.05).

powders is shown in Table 2. There was no significant difference among samples. Water activity is related to moisture content and is responsible for biochemical reactions (25). Water activity values under 0.6 are generally considered microbiologically stable (25) and the values between 0.20 and 0.40 indicate that the product is stable against browning and hydrolytic reactions, lipid oxidation, auto-oxidation and enzymatic activity (28). The water activity values of the mandarin beverage powders were found to be 0.156–0.159. The spray-dried mountain tea powders showed higher water activity (0.276–0.331) than the mandarin beverage powders. The mountain tea water extract powders were spray-dried under three different conditions: inlet temperatures of 145, 155, and 165°C and carrier concentrations of 0, 3, and 5%, and with four different carriers: β-cyclodextrin, arabic gum, MD12 and MD19 (29). They were also lower than those of watermelon powders (0.2–0.29) (25).

Color The effects of different levels of carrier agent and inlet air temperature on the color of spray-dried mandarin beverage powders are shown in Table 3. The L* value (lightness) ranged from 81.51 to 86.17, the a* value (redness) ranged from 5.11 to 5.61, and the b* value (yellowness) ranged from 33.77 to 35.77 (Table 3). In general, the color values (L*, a*, and b*) for the spray-dried mandarin beverage powders were significantly influenced by the carrier agent concentration and inlet air temperatures. It was found that when the carrier agent concentration increased, the L* values increased but the a* and b* values decreased. Similar observations were made while drying the water extract of mountain tea (29). Additionally, because of the non-enzymatic browning reaction, the color of dried products changes at higher air temperatures. Consequently, as the concentration of the carrier agent increased, the L* value of mandarin beverage powders also increased, while the a* value and b* value decreased. Also, the a* value and b* value decreased with increasing inlet air temperature. The color of products is important because it indicates the sensory attractiveness and quality of the powders (25). Accordingly, the powder color should be consistent through and after the process enabling consumers to recognize the original product. Therefore, since the colors of the product differs according to the concentration of the carrier agent and inlet air temperature, careful design taking into consideration the dry condition is required to minimize the loss of quality characteristics.

pH The pH value of the mandarin beverage was 3.10 and those of the mandarin beverage powders with different levels of carrier agent and spray-dried at different inlet air temperatures ranged from 3.12–3.25 (Table 4). These values were similar to but slightly higher than the pH of the mandarin beverage. The same result was also found by Bayram *et al.* (30). The study revealed that carrier agent concentration significantly influences the pH of the mandarin beverage powders (p<0.05). The pH of maltodextrin was 4.85, and that of corn syrup was 4.25, so it can be concluded that higher concentrations of the carrier agents affected the mandarin beverage powders. In contrast, Kha *et al.* (31) observed no significant effects of increasing the amount of maltodextrin on the pH of gac fruit aril powders.

The pH values of the mandarin beverage powders were found to significantly depend on inlet air temperature. The result for guava fruit juice powders by Mahendran (32) was similar, wherein some acids were lost by evaporation during the spray-drying of the guava fruit juice powder. Therefore, increasing the temperature over a long period of time accelerates decreases in the acid content, thus, increasing the pH values in the mandarin beverage powders.

Table 4. Vitamin C content and pH of mandarin (*Citrus unshiu*) beverage powder with different amounts of a mixture of maltodextrin and corn syrup and spray-dried at different inlet temperatures

Carrier agent (%)	Vitamin C content (mg/100 g)			pH		
	120°C	135°C	150°C	120°C	135°C	150°C
30	106.83±1.60$^{1)Aa}$	105.01±0.62^{Aa}	99.93±0.53^{Ba}	3.12±0.01^{Cc}	3.19±0.01^{Bb}	3.22±0.01^{Ab}
35	104.08±1.80^{Aa}	94.02±1.64^{Bb}	90.17±0.42^{Cb}	3.13±0.01^{Cb}	3.19±0.01^{Bb}	3.22±0.01^{Ab}
40	97.22±1.53^{Ab}	88.60±2.09^{Bc}	87.22±1.11^{Bb}	3.15±0.01^{Ca}	3.21±0.01^{Ba}	3.25±0.01^{Aa}

[1)] Values represent means±standard deviation.

[a-c] Means followed by different letters in each column are significantly different (p<0.05).

[A-C] Means followed by different letters in each row are significantly different (p<0.05).

Table 5. WSI and WAI of mandarin (*Citrus unshiu*) beverage powder with different amounts of a mixture of maltodextrin and corn syrup and spray-dried at different inlet temperatures (unit: %)

Carrier agent (%)	WSI			WAI		
	120°C	135°C	150°C	120°C	135°C	150°C
30	90.34±0.13$^{1)Ca}$	91.77±0.21^{Ba}	92.38±0.21^{Aa}	0.05±0.01^{NS}	0.05±0.01	0.05±0.01
35	89.29±0.33^{Bb}	91.54±0.02^{Aab}	91.76±0.14^{Ab}	0.05±0.00	0.05±0.01	0.05±0.00
40	88.36±0.16^{Cc}	90.75±0.14^{Bb}	91.72±0.33^{Ab}	0.05±0.00	0.05±0.01	0.05±0.01

[1)] Values represent means±standard deviation.

[a-c] Means followed by different letters in each column are significantly different (p<0.05).

[A-C] Means followed by different letters in each row are significantly different (p<0.05).

[NS] Not significant at p<0.05.

Vitamin C The vitamin C contents of the mandarin beverage powders varied from 106.83 to 87.22 mg/100 g and decreased with higher inlet air temperatures and amount of carrier agent (Table 4). The vitamin C content also decreased with the increase of temperature and the concentration of carrier agent. This may have resulted from disintegration of ascorbic acid at high air temperature. Additionally, the comparatively long drying time in the air drying method causes severe loss of vitamin C (33). Moreover, according to Timoumi *et al.* (34), an expeditious drying process at high temperature may cause deterioration of vitamin C in apple slices. Again, the addition of carrier agent decreased the overall mandarin beverage solids and thus the amount of vitamin C in those powders. A similar observation was also reported by Grabowski *et al.* (35) who studied spray-dried sweet potato powders. Therefore, mandarin beverage powders showed a significant loss of vitamin C concentration with increased inlet temperature and higher concentration of carrier agent. Further research on preventing vitamin C loss during spray drying is required.

Water Solubility Index (WSI) and Water Absorption Index (WAI) The effects of different levels of carrier agent and inlet air temperatures on the WSI and WAI of the mandarin beverage powders are shown in Tables 5. The WSI and WAI ranged from 88.36 to 92.38 and 0.050 to 0.054, respectively. WSI increased as inlet air temperature increased, and decreased as the concentration of the carrier agent increased. As the powder becomes drier, the rate of dissolution increases; powder solubility depends on the dryness of the powder. Thus, high inlet air temperatures and carrier agent form dryer mandarin beverage powder, thereby decreasing the powder solubility.

The WAI of the samples in this study was not influenced by different drying conditions (p>0.05). A similar observation was reported by Phoungchandang and Sertwasana (36) who studied spray-dried ginger powders. The range of WAI for the samples in this study was 0.050 to 0.054. These values were lower than the results for spray-dried ginger powders, which ranged from 1.507 to 5.049. This result for the WAI of mandarin beverage powders could be due to the high values of WSI. Therefore, very low phase separation was observed after centrifugation, resulting in the very low values for WAI in this study.

Sensory evaluation Sensory evaluation of the mandarin beverage powders with different levels of carrier agent and spray-dried at different inlet air temperatures was conducted and the results are shown in Table 6. Sensory attributes such as color, taste, flavor and overall acceptability were assessed. Sensory evaluation was conducted using the hedonic scale method with a scale from 1 to 7 (1=dislike very much and 7=like very much). It was found that both the drying temperature and the concentration of the carrier agent affected the results. The sensory evaluation panelists did not like the color of mandarin beverage powders produced with high inlet air temperature and carrier agent concentration. The score for taste ranged from 4.5 to 5.8 and increased as the concentration of the carrier agent increased, but showed no significant difference with changes in the inlet air temperature. Flavor preference showed no significant difference. Overall acceptability was from 5.1 to 6.3, and decreased as the inlet air temperature increased but increased as carrier agent concentration increased. As the concentration of the

Table 6. Sensory characteristics of mandarin (*Citrus unshiu*) beverage powder with different amounts of a mixture of maltodextrin and corn syrup and spray-dried at different inlet temperatures

Drying temperature (°C)	Carrier agent (%)	Color	Taste	Flavor	Overall acceptability
120	30	6.3±0.5[1)a]	4.7±1.0[c]	5.3±1.1[NS]	5.3±1.5[b]
	35	6.1±0.4[a]	5.2±0.7[b]	5.2±0.7	5.7±1.4[b]
	40	5.9±0.4[b]	5.8±0.7[a]	5.0±0.8	6.3±1.4[a]
135	30	6.3±0.7[a]	4.7±0.8[c]	5.1±1.0	5.1±1.4[b]
	35	5.8±0.4[b]	5.1±0.5[b]	5.3±0.8	5.5±1.5[b]
	40	5.8±0.8[b]	5.5±0.8[a]	5.3±0.8	6.1±1.3[a]
150	30	6.0±0.5[ab]	4.5±0.8[c]	4.9±0.9	5.1±1.7[b]
	35	5.3±0.8[b]	5.1±0.5[b]	5.3±0.8	5.4±1.1[b]
	40	5.2±0.7[b]	5.6±0.5[a]	5.1±0.9	5.8±2.1[b]

[1)] Values represent means±standard deviation.

[a-c] Means followed by different letters in each column are significantly different ($p<0.05$).

[NS] Not significant at $p<0.05$.

carrier agents increased, the preference for taste increased while the preference for the color decreased.

In summary the effect of spray drying conditions, inlet air temperature, and carrier agent concentration on the physicochemical properties and sensory evaluation results for mandarin beverage powders were studied. Higher temperatures caused increases in the a* value, pH and WSI decreases in the moisture content, L* value, b* value, vitamin C content, and bulk density. Increasing the carrier agent concentration caused increases in the L* value and pH decreases in the moisture content, a* value, b* value, WSI, vitamin C content and bulk density. Water activity and WAI showed no significant differences among samples. Drying yield was maximized when inlet air temperature reached 135°C, and carrier agent concentration was 35%. In sensory evaluation, as the carrier agent concentration increased, the taste preference increased, while the color was less preferred.

Although the sensory evaluation results at 35% carrier agent and 135°C inlet air temperature were not the highest, this condition produced the highest drying yield. Therefore, 35% carrier agent was chosen as the most appropriate amount of carrier agents while 135°C was selected as the most appropriate inlet air temperature to produce the highest drying yield.

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