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Freeze dried quince (*Cydonia oblonga*) puree with the addition of different amounts of maltodextrin: physical and powder properties

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Abstract

This study aims to determine the drying behavior of quince puree and as an adverse effect powdered sugar added quince puree with the addition of maltodextrin. The addition of powdered sugar increases the drying time and the total amount of energy and the same time slightly decreases the moisture content and water activity values. The color values and the properties on these values changed both with the addition of maltodextrin and powdered sugar. The density values, flow properties and reconstitution properties are significantly affected by the amount of maltodextrin in plain or powdered sugar added samples.

Keywords: *quince, freeze-drying, maltodextrin, powder properties.*

1. Introduction

Quince which is rich in vitamins A, B and C, sugar, crude fiber and minerals such as potassium, phosphorus and calcium [1]. Fresh fruits and vegetables are easily deteriorated due to their high moisture content, which can be prevented by a variety of preservation methods and one of these methods is the drying process. The drying process was first initiated by drying in the sun, but due to the lack of long processing times and standard product handling, industrial drying methods have been developed such as freeze-drying. The freeze-drying process is based on the principle of free water sublimation in freezing under low pressure, and desorption removal of bound water. Therefore, the water is removed by the vacuum in the solid phase and the loss of the valuable components such as minerals, vitamins and aromas are minimized in the product structure. Freeze dried products are well known with high nutritional value and having a porous structure.

This study aims to determine the drying behavior of quince puree and as an adverse effect powdered sugar added quince puree with the addition of maltodextrin. In addition, the physical, and powder properties of the obtained quince powders and the energy consumption through the freeze drying operation was also determined.

2. Materials and Methods

2.1. Material

The fresh quince fruits were obtained from a local supermarket in Izmir, Turkey. They were washed, peeled, seeds removed, and grounded into puree by using a home type blender (Tefal Smart, MB450141, Turkey). Maltodextrin (MD) with Dextrose Equivalence (DE) value of 10-12 (AS Chemical Industry and Commerce Limited Company, Turkey) was added directly to puree and to the powdered sugar (PS) containing puree in suitable amounts (4-6-8-10% by weight).

2.2. Methods

2.2.1. Freeze Drying

The experiments were performed in a pilot scale freeze dryer (Armfield, FT 33 Vacuum Freeze Drier, England). The ground powders were stored in aluminum polyethylene packaging material (ALPE) in the dark at 20±1°C.

2.2.2. Analysis applied to powders

The moisture content of the quince puree powders was carried out with 0.5-1 g of samples, which were dried in an oven at 105 °C until reaching a constant weight. The water activity values were measured by using a Testo-AG 400, Germany water activity measurement device. The color (L*, a*, and b* values) values of the quince puree powders were measured with a Minolta CR-400 Colorimeter, Japan and the results were expressed in accordance with the CIE Lab. System. The total color change (∆E), Chroma, Hue Angle (°), Browning (BI), whiteness (WI) and yellowness (YI) index were calculated according to the method of Pathare and Opara, 2012 [2]. For the determination of bulk density, tapped density, flowability and cohesiveness values in terms of Carr index (CI), and Hausner ratio (HR), the average wettability time (s) and solubility of powder were determined with the method of Jinapong, 2008 [3]. The dispersibility, porosity and hygroscopicity values were determined according to Gong et al., 2008, Jinapong 2008 and Cai and Corke, 2000 respectively [3, 4, 5].

2.2.3. Statistical Analysis

Data were analyzed using statistical software SPSS 16.0 (SPSS Inc., Chicago, IL, USA). The data were also subjected to analysis of variance (ANOVA) and Duncan's multiple range test (α=0.05) to determine the difference between means. The drying experiments were replicated twice and all analyses were triplicated.

3. Results and Discussions

The drying time of samples, the energy consumption of the freeze dryer, the moisture content and water activity values of the dried quince puree powders are given in Table 1.

Table 1. The energy consumption, moisture content, and water activity values of the samples

Samples	Energy Consumption (KWH)	Moisture Content (% Wet Basis, wb)	Water Activity
4% MD	8.47 ± 0.01^{xp}	8.61 ± 0.43^{xp}	0.43 ± 0.01^{yr}
6% MD	8.47 ± 0.01^{xp}	8.40 ± 0.44^{xp}	0.41 ± 0.01^{xr}
8% MD	8.47 ± 0.01^{xp}	7.77 ± 0.42^{xp}	0.41 ± 0.01^{xr}
10% MD	8.47 ± 0.01^{xp}	7.72 ± 0.13^{xp}	0.44 ± 0.01^{zr}
4% PS+4% MD	10.06 ± 0.01^{xr}	7.67 ± 0.21^{xp}	0.43 ± 0.002^{tp}
4% PS+6% MD	10.06 ± 0.01^{xr}	7.32 ± 0.57^{xp}	0.40 ± 0.02^{zp}
4% PS+8% MD	10.06 ± 0.01^{xr}	7.05 ± 0.22^{xp}	0.37 ± 0.008^{yp}
4% PS+10% MD	10.06 ± 0.01^{xr}	6.78 ± 0.11^{xp}	0.37 ± 0.01^{xp}

x-t Different letters in the same column indicate a significant difference between the concentration of MD at $P < 0.05$.
p-r Different letters in the same column indicate a significant difference between the samples with MD or 4%PS+MD at $P < 0.05$.

To determine the energy efficiency of drying the energy consumption and the product quality have been identified as the key factors. The first and second sets of samples were dried for 15 hours and 18 hours, respectively.

Considering the energy consumption per hour of drying (0.559 kWh), the highest energy consumption value (10.06 kWh) was in the sample set where MD was added to quince puree with 4% PS. The moisture content of the samples was not significantly different. Dried foods (with water activity values of 0.20-0.40) were considered as stable for browning, microbial growth and enzymatic reactions [6]. According the Table 1, the water activity (aw) values of the powders are very near or slightly higher the upper limit.

The measured color values of the dried samples are given in Figure 1. The highest L (brightness) value was achieved in the samples added with only 4% maltodextrin, while the highest brightness value was attained by addition of maltodextrin at 6% concentration together with the powdered sugar. Positive values of a* and b* indicate redness, yellowness, respectively. The highest values were observed from quince powder with 10% MD. As the amount of added maltodextrin increased, a decrease in L value was observed.

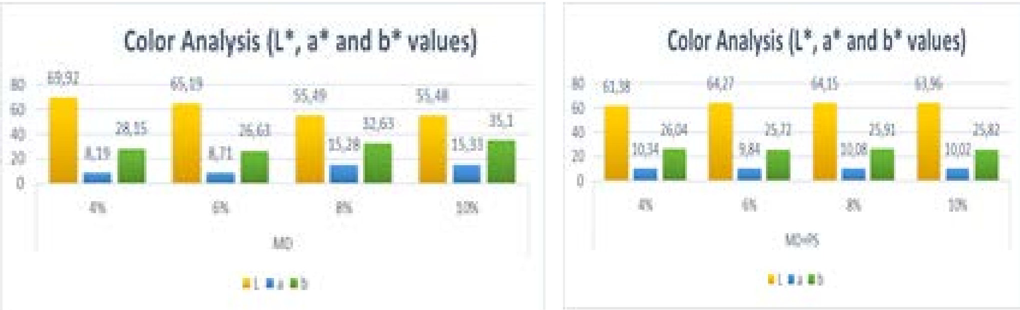

Fig. 1 The color values of quince puree powders.

The properties of the powders based on the color measurement are given in Table 2. Considering the results of color measurement, the highest total color change (ΔE) was detected in samples of added with 8% MD and PS and a significant increase in the total color change was observed as the amount of MD added to the samples increased. In the Hue angle, a significant decrease was observed with the addition of MD to quince puree but no effect was observed for PS containing puree ($P < 0.05$). sample with 10% maltodextrin, which has the highest Chroma value, was accepted as the sample with the highest color intensity perceived by humans. In food products containing powdered sugar, the highest browning index value, which is one of the most common indicators of browning, has been detected on the level of quince with 8% maltodextrin added. The whiteness index (WI), which indicates the degree of discoloration during the drying process, represents the extreme whiteness of food products [7].

Table 2. The total color change, hue angle, chroma values, browning, whiteness, and yellowness index of the powders.

Samples	ΔE	Hue Angle	Chroma	Browning Index (BI)	Whiteness Index (WI)	Yellowness Index (YI)
4% MD	32.18±1.21^{xp}	1.28±0.17^{tr}	29.31 ±0.29^{xp}	58.34±1.54^{xp}	58.62±0.35^{xp}	57.10±0.40^{xp}
6% MD	28.58±1.21^{xp}	1.25±0.00^{zr}	28.01±1.52^{xp}	60.54±3.77^{xp}	54.84±0.79^{xp}	59.95±0.69^{xp}
8% MD	24.58±1.33^{xp}	1.12±0.02^{xp}	36.15±2.75^{yr}	107.58±13.82^{yr}	43.87±0.52^{xp}	78.29±1.83^{xp}
10% MD	26.94±2.05^{xp}	1.17±0.00^{yp}	38.04±1.55^{zr}	109.54±2.34^{zr}	43.03±0.64^{xp}	87.69±0.66^{xp}
4% PS+ 4% MD	32.54±0.79^{yp}	1.19±0.00^{xp}	28.01±0.43^{xp}	65.66±2.26^{tp}	53.08±0.39^{xp}	59.47±0.47^{xp}
4% PS+ 6% MD	35.85±0.84^{zr}	1.20±0.01^{yp}	27.54±0.29^{xp}	60.73±2.97^{zr}	53.47±0.58^{xp}	58.90±0.71^{xp}
4% PS+ 8% MD	36.09±3.38^{tp}	1.20±0.01^{yr}	27.79±0.30^{xp}	61.54±1.67^{xp}	55.15±0.72^{xp}	56.89±0.89^{xp}
4% PS+ 10% MD	31.46±4.45^{xr}	1.20±0.04^{yr}	27.69±0.50^{xp}	61.61±3.52^{yp}	56.25±0.99^{xp}	55.84±1.63^{xp}

x-t Different letters in the same column indicate a significant difference between the concentration of MD at $P < 0.05$.
p-r Different letters in the same column indicate a significant difference between the samples with MD or 4%PS+MD at $P < 0.05$.

As shown in Table 2, as the maltodextrin content increases, a decrease in this value is observed. Yellowness value is related to general product degradation by light, chemical exposure and processing. This value is basically used to measure the amount of such degradation with a single value [8]. The results showed that increasing the MD content resulted in a significant increase in the yellowness value whereas increasing the MD and PS cause decrease in these values (P<0.05).

The results of the powder properties of the freeze dried quince powders are given in Table 3 and 4. The powder properties are important for the functional, economical, and commercial consideration of the powder products [10]. The average wettability and solubility times of the freeze-dried quince powders were found to be as 3 seconds and the amount of maltodextrin and the addition of powdered sugar did not affect the wettability and solubility times of the samples (P>0.05, data was not given.). The highly porous structure and similar residue moisture content may be the reason for the low wettability and solubility times.

Table 3. The powder properties of freeze-dried quince powders

Samples	**Bulk Density (kg/m^3)**	**Tapped Density (kg/m^3)**	**Flowability (Carr Index)**	**Cohesiveness (Hausner Ratio)**
4%MD	109.88 ± 1.40^{xp}	164.03 ± 8.44^{yp}	32.95 ± 2.60^{zr} (Fair)	1.49 ± 0.06^{zr} (High)
6%MD	119.55 ± 15.86^{xp}	146.35 ± 18.41^{xp}	18.35 ± 0.57^{xp} (Good)	1.22 ± 0.01^{xp} (Intermediate)
8%MD	153.57 ± 35.36^{yp}	203.64 ± 33.43^{zp}	25.00 ± 5.05^{yp} (Fair)	1.34 ± 0.09^{yp} (Intermediate)
10%MD	150.00 ± 28.28^{yp}	199.11 ± 18.94^{zp}	25.00 ± 7.07^{yp} (Fair)	1.34 ± 0.13^{yp} (Intermediate)
4%PS+4%MD	182.62 ± 5.72^{yr}	261.00 ± 47.70^{xr}	29.05 ± 5.77^{xp} (Fair)	1.42 ± 0.22^{xp} (High)
4%PS+6%MD	224.05 ± 4.55^{zr}	345.54 ± 46.72^{yr}	34.47 ± 10.18^{xr} (Fair)	1.54 ± 0.24^{xr} (High)
4%PS+8%MD	157.85 ± 15.92^{xp}	248.93 ± 80.08^{xp}	38.30 ± 10.65^{xr} (Bad)	1.65 ± 0.28^{xr} (High)
4%PS+10%MD	194.89 ± 45.80^{yr}	286.80 ± 28.52^{xr}	30.68 ± 8.03^{xr} (Fair)	1.45 ± 0.17^{xr} (High)

x-t Different letters in the same column indicate a significant difference between the concentration of MD at $P < 0.05$.
p-r Different letters in the same column indicate a significant difference between the samples with MD or 4%PS+MD at $P < 0.5$.

The bulk and tapped density values of freeze-dried quince powders with MD significantly increased depending on the increasing amount of (P<0.05). Comparatively higher bulk and tapped density values were observed for the quince powders with powdered PS and MD (P<0.05). It may be due to the higher solid amount of quince puree with 4%PS+MD compared to the quince puree with MD. Cai and Corke (2000) [5] reported that the increase in solid concentration in the feed which makes the particles heavier resulted in higher bulk density. For this reason, the higher bulk density values were obtained at the higher MD concentrations and the 4%PS addition. The flowability and cohesiveness properties of the quince powders in terms of the CI and HR were evaluated, the higher CI and HR values mean that the powder is more cohesive and less able to flow freely. The higher CI and HR values were observed for the sample with 4%MD and 4%PS+6%MD, 4%PS+8%MD, and 4%PS+10%MD. The CI and HR values significantly decreased according to the addition of the amount of MD (P<0.05). The addition of MD to the quince puree improved the flowability of the powders. Comparatively higher CI and HR values were observed for the quince powders with 4%PS and MD (P<0.05). It may be due to lower glass temperature of powdered sugar which causes the stickiness.

Table 4. The other powder properties of freeze-dried quince powders

Samples	Particle Density (kg/m³)	Porosity (%)	Dispersibility (%)	Hygroscopicity (%)
4%MD	1690.50 ± 183.14^{tp}	90.24 ± 1.06^{yp}	75.83 ± 5.12^{xp}	12.93 ± 0.82^{yp}
6%MD	1486.34 ± 21.52^{zp}	88.96 ± 2.29^{yr}	78.66 ± 3.15^{xp}	11.09 ± 1.73^{xp}
8%MD	941.14 ± 14.52^{yp}	82.57 ± 3.10^{xp}	82.41 ± 5.41^{xp}	12.06 ± 0.63^{xyp}
10%MD	746.63 ± 19.21^{xp}	78.03 ± 2.16^{xp}	82.01 ± 2.28^{xp}	11.66 ± 0.55^{xp}
4%PS+4%MD	1977.09 ± 65.59^{tr}	86.03 ± 4.63^{xp}	73.39 ± 6.74^{xp}	18.38 ± 0.54^{zr}
4%PS+6%MD	1863.39 ± 36.26^{zr}	81.10 ± 3.68^{xp}	77.74 ± 1.54^{Xp}	17.69 ± 0.51^{yr}
4%PS+8%MD	1622.21 ± 16.59^{xr}	84.65 ± 0.13^{xp}	81.78 ± 2.41^{yp}	18.32 ± 0.52^{zr}
4%PS+10%MD	1745.24 ± 49.81^{yr}	82.86 ± 4.89^{xp}	81.18 ± 3.59^{yp}	16.13 ± 0.13^{xr}

x-t Different letters in the same column indicate a significant difference between the concentration of MD at $P < 0.05$.
p-r Different letters in the same column indicate a significant difference between the samples with MD or 4%PS+MD at $P < 0.5$.

The particle density of quince powders with MD and 4%PS+MD ranged between 746.63-1690.50 kg/m³ and 1622.21- 1977.09 kg/m³ and the particle density of the powders significantly decreased depending on the increasing MD concentration (P<0.05). The porosity values (%) of the quince powders significantly decreased depending on the increasing MD concentration (P<0.05). The higher porosity values were observed for quince powders with MD compared to the quince powders with 4%PS+MD, however, the differences between the samples generally were not found to be significantly important (P>0.05, except quince powder with 6%MD). No significant differences were observed between the dispersibility values of the quince powders on MD concentration (P>0.05) and the addition of the powdered sugar to the quince pure with MD did not affect the dispersibility values of the quince powder (P>0.05). The hygroscopicity values of quince powders with MD were not found to be statistically different (P>0.05). The higher hygroscopicity values were generally obtained from the samples, which have lower moisture (quince powder with 4%PS+MD) contents.

4. Conclusion

In this study, the physical and the powder properties of the quince powders with maltodextrin and powdered sugar were determined. In a result of the physical analysis, as the amount of added maltodextrin increased, a decrease in L value was observed while a* and b* is the highest value at 10% concentration. Furthermore, quince powder with 10% maltodextrin and powdered sugar has the lowest value of moisture content and water activity. Besides, the drying process time of the samples with only maltodextrin is shorter than another group. According to analysis of the powder properties, the addition of maltodextrin and powdered sugar did not affect the wettability and solubility times of the samples. The porosity values, CI and HR values decreased depending on the addition of the amount of MD. The hygroscopicity values and dispersibility of quince powders with MD were not found to be statistically different.

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