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Quality Characteristics of Tarts Made with Molecular Press Dehydrated Purple Sweet Potatoes during Storage

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Abstract

Purpose: Molecular press dehydration is one of the dehydration methods. The purpose of this study was to investigate the quality characteristics of tarts made with dehydrated purple sweet potatoes during the storage period. **Methods:** Quality characteristics of purple sweet potato tarts were evaluated by analyzing moisture content, water activity, total phenolics, anthocyanins, 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging activity, color, and sensory evaluation for 45 days of storage. **Results:** Moisture content of tart crust made with molecular press dehydration treated purple sweet potatoes with concentrations of 20%, 40%, 60%, and 80% maltodextrin as a dehydrating agent for 45 days was 8.47%, 7.95%, 6.96%, and 6.24% respectively; however, the moisture content of non-treated tart crust was 11.99% ($p<0.05$). Total phenolics, anthocyanins, and DPPH free radical scavenging activity of dehydrated purple sweet potato tarts were lowered than those of non-treated tart ($p<0.05$). **Conclusion:** These results indicated that tarts made with molecular press dehydrated purple sweet potatoes had effectively controlled moisture content and water activity during storage although total phenolics, anthocyanins, DPPH free radical scavenging activity, color, and sensory evaluation were decreased.

Key words: purple sweet potato, tart, maltodextrin, molecular press dehydration, anthocyanin

분자압축탈수된 자색고구마로 제조한 타르트의 저장 중 품질특성

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초 록

목적: 본 연구에서는 탈수방법 중 분자압축탈수법을 이용하여 탈수한 자색고구마로 제조한 타르트의 저장 중 품질특성을 조사하였다. **연구방법:** 자색고구마타르트의 수분함량, 수분활성도, 총페놀함량, 안토시아닌함량, DPPH 자유라디칼 소거능, 색도 및 관능평가를 45일 동안 실시하였다. **결과:** 탈수제인 말토덱스트린 20%, 40%, 60%, 80%로 분자압축탈수 후 제조한 자색고구마타르트 크러스트의 수분함량은 45일 저장 후 8.47%, 7.95%, 6.96%, 6.24%로 분자압축탈수하지 않은 자색고구마로 제조한 타르트 크러스트의 수분함량인 11.99%에 비하여 낮았다 ($p<0.05$). 하지만 총페놀함량, 안토시아닌 함량과 DPPH 자유라디칼 소거능이 분자압축탈수한 자색고구마타르트가 그렇지 않은 타르트에 비해 낮게 나타났다($p<0.05$). **결론:** 분자압축탈수 후 제조한 자색고구마타르트는 수분함량을 효율적으로 낮춰주어 저장 동안 타르트 크러스트의 바삭함을 유지할 수 있었으나 총페놀 및 안토시아닌 함량, DPPH 자유라디칼 소거능, 색도 및 관능평가 결과가 감소하였다.

주제어: 자색고구마, 타르트, 말토덱스트린, 분자압축탈수, 안토시아닌

Ⅰ. Introduction

Baking products are not suitable for main cooking but they are perfect for refreshments and have emerged as rapidly expanding market items over the past years (Sloan AE 1998, McWatters S et al. 2005, Mondal A & Datta AK 2008). In particular, tart, a baked product consisting of a filling over a pastry base with an open top, has been consumed by many people whilst enjoying their brunch and dessert (Boyle J & Kolbe AL 2002). Not only bakeries but also food manufacturers have produced tarts with the expansion of brunch and dessert markets (Worosz

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MR 2006, Thornsbury S & Martinez L 2012). As a filling material in tarts, purple sweet potatoes have been increasingly used because of their taste and health benefits imparted by the presence of phenolic compounds and anthocyanins (Konczak-Ilsam I et al. 2003, Kano M et al. 2005, Yang HS 2012). However, sometimes, the purple sweet potatoes as a filling in tarts caused the degradation of tart quality because of high moisture content (Sanguinetti AM et al. 2009). Because of the movement of moisture from the filling to a tart crust during storage, the crust loses its crunchy texture. Henceforth, it is necessary to control moisture contents of purple sweet potato tarts during storage.

Molecular press dehydration is one of the dehydration methods, which is based on the cytorrhysis phenomenon occurring outside of the plant cell walls using a dehydrating agent with large molecular size (Yoo MS & Seo HC 2003). Because solute molecule is greater than pore size of cell wall, solute molecule is pressed which leads to collapse of the cell wall (Choi DW & Shin HH 1999, Choi DW et al. 2006). This dehydration method has been continuously employed to dehydrate raw materials for food preparation. Kim MH et al. (2008) reported effective dehydration of green peppers employing maltodextrin as a dehydrating agent in high concentrations. Lee HS et al. (2010) reported that molecular press dehydrated ginger indicated great dehydration rate, high recovery rate, stable color, and sensory characteristics. To control moisture content of purple sweet potatoes prior to baking tarts, they were dehydrated by molecular press dehydration with a dehydrating agent, maltodextrin, and the effect of treatment on the quality characteristics of purple sweet potato tarts during storage was investigated.

Ⅱ. Materials and Methods

1. Materials

Purple sweet potatoes were provided by Jeju Purple Sweet Potato Farming Association (Jeju, Korea). The maltodextrin (Samyang Genex Co., Seoul, Korea) was used as dehydrating agent. Folin-Ciocalteu reagent and a,a-diphenyl-2-picryl-hydrazyl (DPPH) were purchased from Sigma-Aldrich (St. Louis, MO, USA) to measure total phenolic content and DPPH free radical scavenging activity.

2. Molecular press dehydration of purple sweet potatoes

Purple sweet potatoes were molecular press dehydrated as following. Washed purple sweet potatoes were peeled and ground using a blender (SMX-8000EMT, Hanil, Seoul, Korea). They were mixed with maltodextrin at concentrations of 0%, 20%, 40%, 60%, and 80% (w/w) and dehydrated at 25°C for 12 h in a shaking incubator (JSSI-100T, JS Research Co., Gongju, Korea). Dehydrated purple sweet potatoes were separated from the dehydrated solution by filtering and used for the preparation of tart filling.

3. Preparation of purple sweet potato tarts

Tart filling was prepared by mixing dehydrated purple sweet potato, butter, sugar, treha (Hayashibara Co., Okayama, Japan), eggs, and salt. Tart crust dough was made with 48% wheat flour (soft flour, Samyang Co., Seoul, Korea), 22% margarine (Ottogi Co., Ahnyang, Korea), 15% butter (Seoul Dairy Co., Seoul, Korea), 9.6% sugar (CJ Cheil-Jedang Co., Seoul, Korea), 5.4% eggs (Hanaro mart, Jeju, Korea), and salt (purified salt, Hanju Co., Ulsan, Korea). The entire mixture of purple sweet potato filling and dough were put into a tart molding machine (System one SO-2A, Masdac Co., Saitama, Japan) to form the shape of a tart. Molded tarts were then baked in a baking oven (FDO-7102, Daeyung Bakery Machinery Ind. Co., Seoul, Korea) for 30 min at 190-200°C. After cooling down the baked tarts, they were individually packaged in plastic bags. All experiments were performed for storage period of 0, 3, 7, 10, 15, 20, 30, and 45 days at room temperature.

4. Moisture content and water activity of tarts

Tarts were separated into purple sweet potato filling and tart crust. The moisture content of tart filling and crust was determined by the method of AOAC (2005).

Water activities of tart filling were measured by water activity meter (HP23-AW-A, Rotronic AG, Zurich, Switzerland). Water activity was measured 20 times and expressed as the average value.

5. Determination of total phenolic content

Total phenolic content of tart filling was measured following the modified method of Rumbaoa RGO et al. (2009) using Folin–Ciocalteau reagent. The absorbance was measured at 765 nm using a UV-Vis spectrophotometer (Optizen 2120UV, Mecasys Co., Daejeon, Korea). As a standard, gallic acid (Sigma-Aldrich Co.) solutions were prepared in varying concentrations (50-150 mg/L) in a similar manner to construct a calibration curve. Total phenolic acid content was expressed as milligram of gallic acid equivalents per 100 g of sample (mg GAE/100 g).

6. Determination of total anthocyanin content

Total anthocyanin content of purple sweet potato in the tart filling was measured according to the pH-differential method as described by Park HM et al. (2012). The absorbance was measured at pH 1.0 and pH 4.5 with a UV-Vis spectrophotometer (Mecasys Co.). Total anthocyanin concentration (TAC, mg/100 g) was then calculated using the following equation and expressed as cyanidin-3-glucoside equivalents:

$$TAC\ (\text{mg/100 g}) = \frac{A \times MW \times DF \times 20 \times 100}{\varepsilon \times 1}$$

Where,

A = (absorbance at 520 nm – absorbance at 700 nm) at pH 1.0 – (absorbance at 520 nm – absorbance at 700 nm) at pH 4.5

MW = cyanidin-3-glucoside molecular weight (449.2 g)

DF = dilution factor

20 = volume of the final concentrated sample (20 mL)

100 = divided value by 10 g of the sample weight of the extract solution for the change per 100 g of sample

ε = cyanidin-3-glucoside molar absorptivity (26,900 L/cm·mol)

1 = path length in cm.

7. DPPH free radical scavenging activity

To compare the antioxidant capacity of tart during storage, hydrogen electron donating abilities of tart filling were determined by DPPH method (Liu YN et al. 2013). Subsequently, the absorbance was measured at 517 nm using a UV-Vis spectrophotometer (Mecasys Co.). Ethanol (Daejung Chemicals & Metals Co., Shiheung, Korea) was used as a control in the same way. Butylated hydroxyanisole (BHA, Sigma-Aldrich Co.) and ascorbic acid (Sigma-Aldrich Co.) levels were measured for comparison. DPPH free radical scavenging activities (%) were calculated by the difference in absorbance between the control and the tart filling sample.

$$\textit{DPPH free radical scavenging activity}\ (\%) = 1 - \frac{A}{A_0} \times 100$$

Where, A_0: absorbance of the control and A: absorbance of the sample.

8. Color measurement

The color of tart filling was measured by a colorimeter (UltraScan VIS Spectrophotometer, Hunter Lab Inc., Reston, VA, USA) after correcting the color with a white and black standard plate. L (lightness), a (redness), and b (yellowness) values were measured and expressed as the average value. The total color difference (ΔE) was defined using the following equation:

$$\Delta E = [(L - L_0)^2 + (a - a_0)^2 + (b - b_0)^2]^{1/2}$$

Where, L, a, and b values were of tarts made with dehydrated purple sweet potatoes treated with maltodextrin and L_0, a_0, and b_0 values were of tarts made with purple sweet potatoes non-treated with maltodextrin.

9. Sensory evaluation

Sensory evaluation was conducted with 10 panelists at Department of Food Bioengineering in Jeju National University, who were explained about the objective of the study and valuation basis. When the sensory evaluation was performed, panelist rinsed their mouth with water after evaluating each sample. Samples given with random number were conducted to ensure the objectivity of the study and to increase the accuracy. Evaluation details included characteristic of appearance, color, flavor, texture, and overall acceptability. Nine points evaluation was conducted with a range from very poor (1 point) to excellent (9 points) and a high preference gave a high score.

10. Statistical analysis

All experiments were performed in triplicate except water activity. Data were determined by one-way ANOVA followed by Duncan's multiple range test using SPSS Statistics (ver. 18.0, SPSS Inc., Chicago, IL, USA). Significant differences were considered at $p<0.05$.

Ⅲ. Results and Discussion

1. Moisture content and water activity

Changes in moisture contents of tart filling and a tart crust made with purple sweet potato dehydrated with 0%, 20%, 40%, 60%, and 80% maltodextrin as a dehydrating agent are shown in Fig. 1. Purple sweet potatoes dehydrated using more than 20% maltodextrin controlled the moisture content of tart filling and tart crust low during storage of 45 days. No major changes in moisture content of purple sweet potato in the tart filling without maltodextrin was

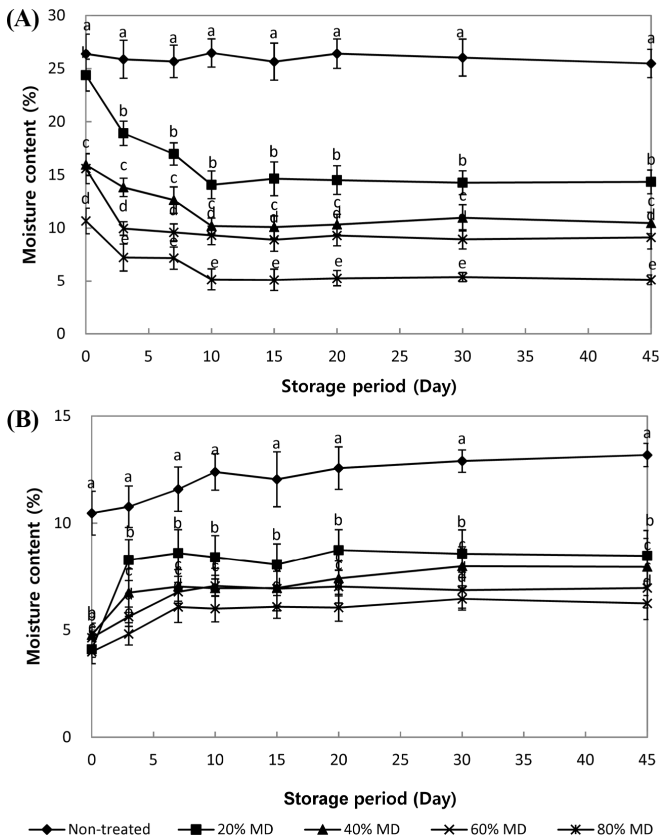

Fig. 1. Moisture content of tart filling (A) and tart crust (B) made with molecular press dehydrated purple sweet potatoes with different concentrations of maltodextrin as a dehydrating agent for 45 days. Mean±SD. Means with different small letters on the bar indicate significant difference within storage days at $p<0.05$.

observed from 0 days (26.39%) to 45 days (25.48%), which signifies maintenance of high moisture content. Furthermore, moisture content of tart crust non- treated by maltodextrin increased gradually from 0 days (10.47%) to 45 days (13.18%). As the concentration of maltodextrin used in the molecular press dehydration increased to 20%, 40%, 60%, and 80%, moisture content of purple sweet potato tart filling on 0 days exhibited a decreasing pattern as 24.39%, 15.96%, 15.59%, and 10.67%, respectively. Under similar conditions, moisture content of tart crust exhibited a decreasing trend as 4.10%, 4.77%, 4.64%, and 3.98%, respectively. Moisture content of tart filling made with molecular press dehydrated purple sweet potatoes in the presence of 20%, 40%, 60%, and 80% maltodextrin gradually decreased to 14.34%, 10.48%, 9.11%, and 5.12% after 45 days, respectively. Under similar condi- tions, moisture content of tart crust gradually increased to 8.47%, 7.95%, 6.96%, and 6.24% after 45 days, respectively. The higher concentration of maltodextrin used in molecular press dehydration led to lower moisture contents of tart filling and tart crust. Tarts made with molecular press dehydrated purple sweet potatoes helped keep moisture contents low during storage. Previously, the green peppers, gingers, and carrots were effectively dehydrated by malto- dextrin and the moisture contents were kept low (Kim MH et al. 2008, Kim MH et al. 2009, Kim MK et al. 2009). Therefore, these results suggested that merchandise made with molecular press dehydration efficiently maintained low moisture contents during storage.

Water activity of tart fillings made with purple sweet potato dehydrated with 0%, 20%, 40%, 60%, and 80% maltodextrin as a dehydrating agent was changed during storage for 45 days as shown in Table 1. Water activity

Table 1. Water activities of tart made with molecular press dehydrated purple sweet potatoes with different concentrations of maltodextrin (MD) as a dehydrating agent during storage

Tart	Storage (days)							
	0	3	7	10	15	20	30	45
Non-treated	$0.869±0.015^{1)b2)D3)}$	$0.881±0.013^{aC}$	$0.885±0.012^{aC}$	$0.886±0.012^{aBC}$	$0.890±0.013^{aBC}$	$0.895±0.013^{aB}$	$0.890±0.017^{aBC}$	$0.915±0.013^{aA}$
20% MD	$0.890±0.010^{aA}$	$0.855±0.019^{bB}$	$0.830±0.012^{bC}$	$0.793±0.015^{bD}$	$0.787±0.012^{bD}$	$0.772±0.020^{bE}$	$0.757±0.016^{bF}$	$0.753±0.013^{bF}$
40% MD	$0.847±0.014^{cA}$	$0.788±0.013^{cB}$	$0.759±0.014^{cC}$	$0.744±0.014^{cD}$	$0.741±0.016^{cD}$	$0.742±0.015^{cD}$	$0.740±0.014^{cD}$	$0.744±0.012^{cD}$
60% MD	$0.833±0.011^{dA}$	$0.737±0.013^{dB}$	$0.729±0.014^{dBC}$	$0.732±0.015^{dBC}$	$0.727±0.017^{dCD}$	$0.722±0.013^{dCD}$	$0.719±0.015^{dDE}$	$0.713±0.014^{dE}$
80% MD	$0.752±0.020^{eA}$	$0.686±0.013^{eC}$	$0.663±0.020^{eE}$	$0.673±0.013^{eD}$	$0.689±0.012^{eC}$	$0.686±0.012^{eC}$	$0.718±0.015^{dB}$	$0.715±0.015^{dB}$

[1)] Values are mean±SD.
[2)] Means with different small letters within a column indicate significant difference at $p<0.05$.
[3)] Means with different capital letters within a row indicate significant difference at $p<0.05$.

of tart fillings made with molecular press dehydrated purple sweet potato were lower as compared to the water activity of tart filling made without dehydration during storage for 45 days. As the concentration of maltodextrin used in the molecular press dehydration increased to 20%, 40%, 60%, and 80%, water activity of tart fillings of purple sweet potato for 0 days decreased to 0.890, 0.847, 0.833, and 0.752, respectively. After 45 days of storage, the water activity gradually decreased to 0.753, 0.744, 0.713, and 0.715, respectively. These results indicated that tart made with molecular dehydrated purple sweet potatoes was possibly stored for a long time with expected crusty texture.

2. Total phenolic and anthocyanin contents

Total phenolic content in tarts made with purple sweet potato dehydrated with 0%, 20%, 40%, 60%, and 80% maltodextrin as a dehydrating agent is shown in Fig. 2(A). Total phenolic content of tart made with non-treated purple sweet potato was 412.46 mg GAE/100 g on 0 days and no significant change in total phenolic content (408.74 mg GAE/100 g) for 45 days of storage was observed. However, total phenolic content of tarts made with molecular press dehydrated purple sweet potatoes exhibited a decreasing range of 183.22 to 194.43 mg GAE/100 g on 0 days. These results exhibited similar trends as reported by Wang SM et al. (2011), which stated the occurrence of total phenolic content in purple sweet potatoes during molecular press dehydration.

Total anthocyanin content in tarts made with purple sweet potato dehydrated with 0%, 20%, 40%, 60%, and 80% maltodextrin as a dehydrating agent is shown in Fig. 2(B). Purple sweet potato tart prepared without dehydration of purple sweet potato by maltodextrin contained 33.16 mg/100 g of anthocyanin on 0 days and the content decreased significantly to 29.20 mg/100 g after 45 days of storage. These results were in concordance with the reports of Brownmille C et al. (2008) and Hager A et al. (2008), which stated that over half of total anthocyanins in blue berry purees and black raspberry juice was lost after 6 months of storage.

Total anthocyanin contents of purple sweet potato tarts made with molecular press dehydration with 20%, 40%, 60%, and 80% maltodextrin were 6.68, 6.29, 6.20, and 5.31 mg/100 g on 0 days, respectively. In addition, these values decreased to 5.68, 5.61, 5.47, and 5.17 mg/100 g after 45 days of storage (p>0.05). Anthocyanins in purple sweet

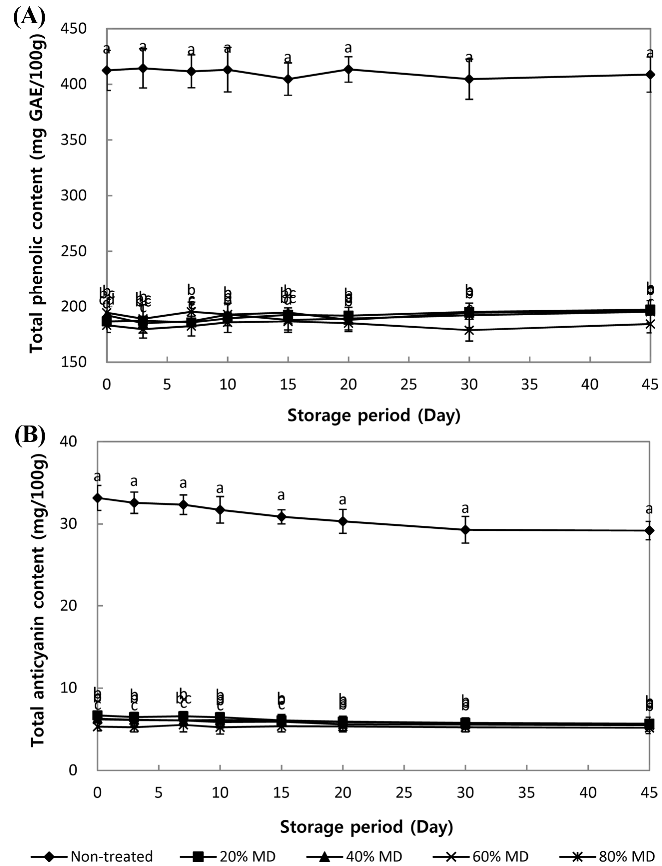

Fig. 2. Total phenolic content (A) and anthocyanin content (B) of tarts made with molecular press dehydrated purple sweet potatoes with different concentrations of maltodextrin as a dehydrating agent for 45 days. Mean±SD. Means with different small letters on the bar indicate significant difference within storage day at $p<0.05$.

potatoes were discharged into molecular press dehydrated solution during molecular press dehydration (Chun HH et al. 2012). Because of low stability of anthocyanins, marked loss was noted during the process of dehydration.

3. DPPH free radical scavenging activity

Changes in DPPH free radical scavenging activity of tarts made with purple sweet potato dehydrated with 0%, 20%, 40%, 60%, and 80% maltodextrin as a dehydrating agent are shown in Fig. 3. The DPPH free radical scavenging activity of tarts made with non-treated purple sweet potatoes was 88.45% on 0 days and 83.61% after 45 days of storage. The antioxidant capacities of BHA (10%) and ascorbic acid (10%) were in the range of 86.61-90.90% and 94.23-95.24% from 0 days to 45 days, respectively. The antioxidant capacity of non-treated purple sweet potato tart was similar to the activities of BHA. However, the

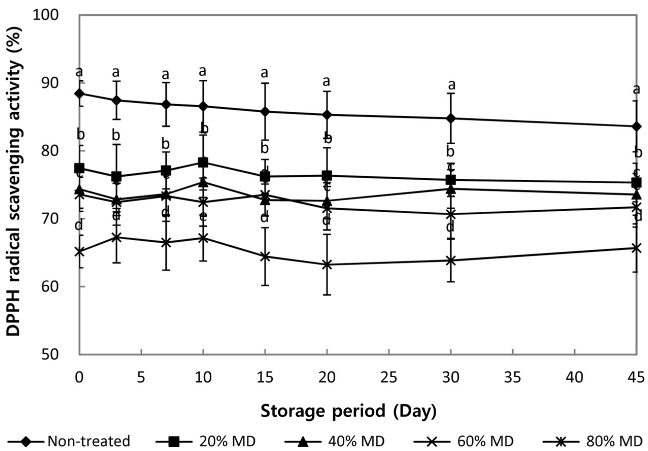

Fig. 3. DPPH radical scavenging activity of tarts made with molecular press dehydrated purple sweet potatoes with different concentration of maltodextrin as a dehydrating agent for 45 days. Mean±SD. Means with different small letters on the bar indicate a significant difference within storage day at $p<0.05$.

DPPH free radical scavenging activity of purple sweet potato tarts made with molecular press dehydration with 20%, 40%, and 60% maltodextrin was 77.44%, 74.36%, and, 73.58%, respectively, on 0 days and 75.33%, 73.58%, and 71.71%, respectively, after 45 days of storage. The tart made with the purple sweet potato dehydrated with 80% maltodextrin showed no change in the DPPH free radical scavenging activity during storage. There were no significant differences in the antioxidant activities of purple sweet potato tarts during storage. The DPPH free radical scavenging activity of tarts made with molecular press dehydrated purple sweet potatoes significantly decreased with increasing the concentration of maltodextrin from 20%, 40%, and 60% to 80%. Although the total phenolic and anthocyanin contents were significantly low in tarts made with maltodextrin dehydrated purple sweet potatoes, no major difference in the DPPH free radical scavenging

Table 2. Color of cross section of tarts made with molecular press dehydrated purple sweet potatoes with different concentrations of maltodextrin (MD) as a dehydrating agent during storage

Tart		Storage (days)							
		0	3	7	10	15	20	30	45
L	Non-treated	21.54±1.33$^{1)a2)A3)}$	22.15±1.05^{a}	21.62±1.47^{a}	22.28±1.08^{a}	21.77±1.26^{a}	21.93±1.85^{a}	22.11±1.08^{a}	22.32±1.11^{a}
	20% MD	17.69±1.90^{cA}	17.41±1.16^{b}	16.67±1.65^{d}	16.56±0.83^{d}	17.10±1.27^{c}	17.12±1.96^{c}	16.53±1.33^{d}	17.27±1.67^{d}
	40% MD	19.67±2.52^{bA}	18.29±1.75^{bB}	18.86±1.45^{cAB}	18.57±1.10^{cAB}	19.74±1.46^{bA}	19.64±1.41^{bA}	18.41±2.14^{cB}	18.98±1.02^{cAB}
	60% MD	21.24±1.14^{aAB}	21.68±1.56^{a}	20.27±2.73^{b}	21.16±1.24^{b}	21.24±1.13^{a}	21.42±1.05^{a}	20.37±2.45^{b}	20.85±1.16^{b}
	80% MD	21.33±2.25^{aA}	20.99±2.82^{a}	21.79±1.48^{a}	21.04±1.61^{b}	21.24±1.50^{a}	21.18±1.74^{a}	21.08±0.87^{ab}	21.46±1.12^{b}
a	Non-treated	8.18±0.81^{bC}	8.13±0.76^{bC}	8.27±1.19^{aC}	8.18±1.07^{bC}	8.44±0.85^{aBC}	8.97±0.81^{aAB}	9.21±1.00^{aA}	9.15±0.54^{aA}
	20% MD	4.60±0.78^{dAB}	4.62±0.41^{dAB}	4.83±0.91^{cA}	4.68±0.58^{dAB}	4.51±0.74^{cAB}	4.94±1.22^{cA}	4.64±0.57^{dAB}	4.16±0.55^{cB}
	40% MD	5.67±0.74^{cA}	5.82±0.46^{c}	5.82±1.58^{b}	5.72±0.47^{c}	5.53±0.53^{b}	5.67±0.39^{b}	5.52±0.75^{c}	5.91±0.50^{b}
	60% MD	8.93±0.70^{aA}	8.71±1.25^{aAB}	8.87±0.70^{aAB}	8.96±0.58^{aA}	8.54±0.67^{aAB}	9.03±0.83^{aA}	8.28±1.51^{bB}	8.93±0.45^{aA}
	80% MD	5.17±1.09^{cA}	5.10±1.07^{c}	5.85±0.91^{b}	5.68±0.84^{c}	5.74±0.89^{b}	5.75±0.41^{b}	5.84±1.48^{c}	5.88±1.64^{b}
b	Non-treated	-3.73±0.87^{dA}	-3.49±0.65^{a}	-3.46±0.97^{d}	-3.57±0.74^{d}	-3.27±0.77^{d}	-3.36±0.73^{d}	-3.47±0.62^{d}	-3.49±0.68^{d}
	20% MD	4.03±0.99^{bcAB}	4.07±0.75^{cAB}	3.80±1.70^{cAB}	3.59±0.30^{cAB}	3.49±0.84^{cB}	4.23±0.62^{bA}	4.12±0.42^{bAB}	4.05±0.75^{bcAB}
	40% MD	4.61±1.24^{bA}	4.57±0.75^{b}	4.86±1.72^{b}	4.54±0.69^{b}	4.42±0.69^{b}	4.45±0.62^{b}	4.49±0.60^{b}	4.81±0.53^{b}
	60% MD	5.67±1.55^{aAB}	5.69±1.08^{aAB}	5.93±1.22^{aA}	5.39±0.89^{aAB}	5.40±1.27^{aAB}	5.10±0.89^{aB}	5.77±1.10^{aAB}	5.38±0.80^{aAB}
	80% MD	3.57±0.42^{cAB}	3.80±0.48^{cAB}	3.68±0.62^{cAB}	3.37±0.80^{cB}	3.52±0.48^{cB}	3.63±0.50^{cAB}	3.97±0.84^{cA}	3.68±0.65^{cAB}
ΔE	Non-treated	1.79 ±1.01^{cB}	1.97±0.75^{c}	2.30±0.83^{c}	2.09±0.92^{c}	2.11±0.78^{c}	2.48±0.77^{d}	2.18±0.51^{d}	2.02±0.84^{d}
	20% MD	10.41±1.02^{aAB}	10.49±0.76^{aAB}	10.54±1.42^{aAB}	10.32±0.49^{aAB}	10.13±0.84^{aB}	10.70±0.90^{aAB}	10.82±0.65^{aA}	10.71±0.70^{aAB}
	40% MD	10.20±1.12^{aAB}	10.26±0.52^{aAB}	10.45±1.59^{aA}	10.09±0.58^{aAB}	9.83±0.64^{aAB}	9.83±0.53^{bB}	10.32±0.58^{bAB}	10.18±0.53^{bAB}
	60% MD	10.43±1.56^{aAB}	10.57±1.02^{aAB}	10.97±1.58^{aA}	10.16±0.91^{aAB}	10.16±1.27^{aAB}	9.88±0.87^{bB}	10.86±1.03^{aA}	10.14±0.80^{bAB}
	80% MD	9.23±0.87^{bAB}	9.60±0.97^{bA}	8.98±0.69^{bB}	8.75±0.59^{bB}	8.84±0.61^{bB}	8.95±0.42^{cB}	9.24±0.71^{cAB}	9.02±0.54^{cB}

1) Values are mean±SD.
2) Means with different small letters within a column indicate significant difference at $p<0.05$.
3) Means with different capital letters within a row indicate significant difference at $p<0.05$.

activity was observed in tart made with non-treated purple sweet potato. This result was similar to the results of Lee HS et al. (2009), which demonstrated loss of antioxidant capacities of green peppers treated with maltodextrin as a dehydrating agent.

4. Color

Change in the color of tarts made with purple sweet potatoes dehydrated with 0%, 20%, 40%, 60%, and 80% maltodextrin as a dehydrating agent is shown in Table 2. The lightness (L) of tart made with non-treated purple sweet potatoes changed from 21.54 to 22.32 after 45 days of storage. The L value of tarts made with molecular press dehydrated purple sweet potatoes increased from 17.69 to 19.67, 21.24, and 21.33 as maltodextrin concentration increased from 20% to 40%, 60%, and 80%, respectively. However, the ΔE value of tarts made with molecular press dehydrated purple sweet potatoes was significantly different with that of tart made with non-treated purple sweet potato. The redness (a) and yellowness (b) of purple sweet potatoes were greatly lost compared to the non-treated tart during molecular dehydration process, which led to an increase in the ΔE values.

Table 3. Sensory evaluation of tarts made with molecular press dehydrated purple sweet potato with different concentrations of maltodextrin (MD) as a dehydrating agent

Sensory evaluation	Tart	Storage (days)	
		0	45
Appearance	Non-treated	7.2±0.9[1)a2)]	6.7±1.1[a]
	20% MD	3.2±1.2[b]	3.9±1.6[b]
	40% MD	4.1±1.5[b]	4.5±0.8[b]
	60% MD	4.1±1.3[b]	3.8±1.1[b]
	80% MD	3.9±0.9[b]	3.2±1.2[b]
Color	Non-treated	7.2±0.9[a]	6.8±0.9[a]
	20% MD	2.9±1.0[c]	3.5±1.7[b]
	40% MD	4.2±1.5[b]	3.3±0.9[b]
	60% MD	4.3±1.5[b]	4.0±1.2[b]
	80% MD	4.2±1.5[b]	3.7±1.3[b]
Flavor	Non-treated	7.5±1.0[aA3)]	6.0±1.7[aB]
	20% MD	3.8±1.3[b]	4.0±1.2[b]
	40% MD	4.5±2.0[b]	4.8±1.0[ab]
	60% MD	4.7±1.8[b]	4.7±1.6[ab]
	80% MD	4.4±1.5[b]	4.5±1.6[bA]
Texture	Non-treated	7.0±0.9[a]	6.3±1.8[a]
	20% MD	4.1±1.6[b]	3.9±1.0[b]
	40% MD	4.1±1.5[b]	3.0±1.4[b]
	60% MD	4.3±1.5[b]	4.0±1.4[b]
	80% MD	3.3±1.5[b]	2.8±1.5[b]
Overall acceptability	Non-treated	7.2±1.1[a]	6.9±1.4[a]
	20% MD	3.4±1.4[b]	3.4±1.2[b]
	40% MD	3.4±1.3[b]	3.2±1.1[b]
	60% MD	4.0±0.9[b]	3.6±1.3[b]
	80% MD	3.2±1.4[b]	2.6±1.1[b]

1) Values are mean±SD.
2) Means with different small letters within a column indicate significant difference at $p<0.05$.
3) Means with different capital letters within a row indicate significant difference at $p<0.05$.

5. Sensory evaluation

Sensory evaluation of tarts made with purple sweet potatoes dehydrated with 0%, 20%, 40%, 60%, and 80% maltodextrin as a dehydrating agent is shown in Table 3. Sensory evaluation of tarts included appearance, color, flavor, texture, and overall acceptability and measured at 0 and 45 days. Appearance, color, flavor, texture, and overall acceptability of tart made with non-treated purple sweet potato had scores of 7.2, 7.2, 7.5, 7.0, and 7.2 and changed to 6.7, 6.8, 6.0, 6.3, and 6.9, respectively, after 45 days of storage. All the sensory values of tarts made with molecular press dehydrated purple sweet potatoes were significantly lower as compared to the tarts made without molecular press dehydration. The molecular press dehydration by maltodextrin led to reduction in the sensory quality of tarts although the moisture content and water activity were low, the resultant effect was seen as maintenance of crustiness of shell of tart.

Ⅳ. Summary and Conclusion

Tarts made with molecular press dehydrated purple sweet potatoes with 20%, 40%, 60%, and 80% maltodextrin resulted in maintenance of low moisture content, which prevented movement of moisture towards the shell of tart. However, loss in total phenolic and anthocyanin contents was noted during molecular press dehydration with malto-dextrin and these compounds directly affected the loss of DPPH free radical scavenging activity of purple sweet potatoes. The lightness of color in tarts made with 60% or 80% maltodextrin molecular press dehydrated sweet purple potatoes was not changed as compared to the tart made with non-treated purple sweet potatoes. The redness and yellowness of purple sweet potatoes were greatly lost as compared to the non-treated tart during molecular dehydration. Sensory evaluation of tarts with molecular press dehydrated purple sweet potato had lower scores with respect to appearance, color, flavor, texture, and overall acceptability. Molecular press dehydration was observed as an effective process to reduce moisture content of tarts and in maintaining consistent quality of tart crust and water activity of purple sweet potato; however, decrease in total content of phenolics and anthocyanins, and sensory quality was observed.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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