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Effect of osmotic dehydration on physicochemical characteristics of dried Manis Terengganu melon

Muhamad, N[1]*and Basri, M. S. N[2],

[1]Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin, Besut Campus, 22200, Besut, Terengganu, **Malaysia**

[2]Faculty of Food Science & Technology, Universiti Putra Malaysia, 43400, Serdang, Selangor, **Malaysia**

***Correspondence:** norliamd@unisza.edu.my **Revised: 06 Oct. 2019, Accepted: 08 Oct. 2019 e-Published: 11 Nov. 2019**
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The aim of this study was to determine the physicochemical characteristics of dried immature Manis Terengganu melon pretreated with osmotic dehydration. The pretreatment was performed using osmotic solutions with different concentration and immersion time. Drying process was conducted at 60 °C. Samples were subjected to determinations of water loss, solid gain, weight reduction, water activity and texture analysis. Osmotic dehydration of melon in sucrose solutions with added calcium lactate significantly increased water loss, weight reduction and subsequently, reduced the incorporation of sugar in the fruit. Meanwhile, water activity and firmness were not dependent on type of treatments. Combination of osmotic dehydration and air-drying contributed a pronounce effect to drying time, final moisture content and water activity. The present obtained result would be useful in food industries for developing a product from waste of Manis Terengganu melon plantation.

Keywords: *Cucumis melo*, Osmotic dehydration, Cucurbitaceae, Air drying

INTRODUCTION

Rock melon is a member of the Cucurbitaceae family that includes some of the world's most vegetable crops, such as melon (*Cucumis melo* L.), cucumber (*C.sativus* L.*),* water melon and (*Citrullus Lanatus*), squash and pumpkin (*Cucirbita* L.). Rock melon is one of the most consumed fruits worldwide due to its nutritional value and pleasant flavour.

Ismail et al., (2010) reported that extract of rock melon pulp have high antioxidant and anti-inflammatory properties. High antioxidant capacity were observed in leaf and stem extract. Rock melon has high amount of pro-vitamin A and vitamin C that beneficial to health (Laur and Tian, 2011). The fruit peel extracts also contributes to anti-diabetic action due to the rich content of polyphenol and ascorbic acid (Parmar and Kar, 2008).

Manis Terengganu melon is a variety of *Cucumis melo* L. and cultivated mainly in Terengganu, Malaysia. Its degree of °Brix at full maturity is 13 °Brix and higher. Immature Manis Terengganu melon is a waste from the plantation as it will be removed to reduce competition and provide adequate nutrients (fertilizer, minerals, water and sunlight) for selected fruits from the trees in order to produce excellent quality of fruits for harvesting. There are limited studies on immature *Cucumis melo* L. Thus, this study focused on the immature fruits that have been removed from the plants. This fruits are not fully utilized and become waste to agriculture crop.

Manis Terengganu melon is highly perishable; even if harvested, handled and held under optimum conditions, it will keep its good quality for about two weeks after the harvest. Therefore, shelf life and by products of the fruits become major concern since the shelf life is short.

Shelf life of the fruit can be extended by introducing osmotic dehydration and air drying. Osmotic dehydration is the phenomenon of removal of water from food by immersion in a concentrated hypertonic solution. Thus, the drying times of the food will be shorter making this process more economical (Fasogbon et al., 2013). Nevertheless, in drying process, the major challenge is to remove water from material in most efficient way while retain the product quality, with lowest cost and minimal impact on the environment (Sabarez, 2016). Thus, this study aimed to identify the best osmotic condition prior to drying process and determine the physicochemical characteristics of dried Manis Terengganu melon.

MATERIALS AND METHODS

Materials

Manis Terengganu melon (*Cucumis melo*) was obtained from Ladang Tanaman Manis Terengganu, Besut, Terengganu. The immature fruits were selected with medium size; average length of 8.40 cm and average diameter of 6.77 cm. The samples were selected with similar °Brix or total soluble solid. The fruits were chilled at 4 °C to maintain its physical and chemical properties. Food grade sucrose and calcium lactate were obtained from local supplier and Merck (Darmstadt, Germany), respectively.

Preparation of samples

The fruits were initially cleaned, peeled and sliced using slicer (Sirman, Italy) with approximately 0.5 cm thickness. The concentration of initial soluble solids (SS) was analyzed using refractometer (ATAGO Master 53-T, Japan) and initial moisture content was analysed using oven drying method. The samples were analyzed to determine the initial °Brix, moisture content, water activity and firmness.

Osmotic dehydration

The osmotic dehydration (OD) was carried out by immersion of Manis Terengganu melon slice (0.5 mm) in the osmotic solution at room temperature (~25 °C). The concentration of osmotic solution was monitored using refractometer. The fruits solution ratio was fixed at 1:4 (w/w) throughout the experiment to prevent significant dilution by water removal during the process. The samples were immersed in sucrose concentration at specific time. Design of the experiment is presented in Table 1.

The study consists of 12 set of experiments. Analysis involved were water loss, solid gain and weight reduction in order to evaluate the performance of osmotic dehydration.

Table 1; Design of experiment with different treatments and immersion time.

Treatment (Sucrose concentration)	Immersion Time (hr)		
40 °Brix + 0% CL	1	2	3
40 °Brix + 2% CL	1	2	3
50 °Brix + 0% CL	1	2	3
50 °Brix + 2% CL	1	2	3

The experiments set also were analyzed for water activity (HygroLab, Rotronic, USA) and texture using texture analyzer (Stable Micro System, USA) to compare the firmness between osmotic dehydration with and without the addition of calcium lactate (CL). After all the analysis were performed, optimized processing condition was selected based on higher water loss, lower solid gain, lower weight loss, water activity and texture. Best osmotic condition was selected from the 12 set of experiment to be proceed with hot air drying.

Drying process

The drying experiment was conducted using cabinet dryer (Pro-tech Model FDD 720, Malaysia) at temperature 60 °C until constant weight was achieved. Optimized condition of osmotic dehydration sample and fresh sample without osmotic dehydration were selected to be proceed to drying. Moisture content was recorded every 30 minutes until constant weight was reached. The moisture content was calculated by using Equation (1):

$$\text{Moisture content, X (\%)} = \frac{\text{mass of water (g)}}{\text{mass of dry solid (g)}} \text{ x } 100\% \quad (\mathbf{1})$$

Analysis

Determination of weight reduction, solid gain, water loss

The weight and moisture content of each initial sample and the final sample was used to calculate the weight reduction (WR). (Eq. 2), water loss (WL) (Eq. 3) and solid gain (SG) (Eq. 4). The total mass change (weight reduction, solid gain and water loss) in relation to initial weight of sample during osmotic dehydration was calculated from the experimental data by using the Equation, (2)-(4) :

$$\mathbf{WR} = \frac{\mathbf{M} - \mathbf{M}^{\circ}}{\mathbf{M}^{\circ}} \qquad (2)$$

$$\mathrm{WL} = \frac{[(w_w M)\text{-}(w_w^{\circ} M^{\circ})]}{M^{\circ}} \qquad (3)$$

$$\mathrm{SG} = \frac{[(w_s M)\text{-}(w_s^{\circ} M^{\circ})]}{M^{\circ}} \qquad (4)$$

Where:

M° = initial sample weight (g)
M = final sample weight (g)
w_w° = mass fraction of initial water (g/g)
w_w = final fraction of water (g/g)
w_s° = mass fraction of initial soluble solids (g/g)
w_s = mass fraction of final soluble solid (g/g)

Determination of moisture content

The moisture content of sample was measured using oven drying method (Memmert, Germany). The weight of empty crucible was recorded after drying at 105 °C in an oven (W1). Then, 5 g of sample was added into the crucible and the weight was recorded before placing them in oven for 24 hrs at temperature of 105 °C (W2). The final weight of crucible was recorded after taking out from oven (W3). The moisture content was calculated by using Equation (5):

$$\mathrm{Moisture} = \frac{(W2 - W3)}{W2 - W1} \times 100 \qquad (5)$$

Where:

W1 = Weight of crucible (g)
W2 = Weight of crucible + weight of wet sample (g)
W3 = Weight of crucible + weight of dried sample (g)

Determination of water activity

Water activity was measured at room temperature using pre-calibrated water activity meter (HygroLab, Rotronic, USA). The sample was cut into tiny pieces and inserted into a sample cup and the measurement was made immediately to restrict moisture absorption from the air to the samples.

Texture analysis

Texture analysis was carried out with a texture analyzer (Stable Micro System, USA). The analysis was conducted for samples after osmotic dehydration and the osmo-dried samples (after drying process) in order to compare firmness of the fruits. The compression test for osmotic dehydration sample set with pre-test speed = 5.00 mm/sec, test speed = 1.00 mm/sec, post-test speed = 5.00 mm/sec and distance at 20 mm. Osmo-dried sample was measured with the setting of pre-test speed = 5.00 mm/sec, test speed = 5.00 mm/sec, post-test speed = 5.00 mm/sec and distance at 20 mm.

Statistical analysis

The data were collected and analyzed using two way analysis of Variance (ANOVA) to study the analysis of osmotic dehydration on factors of treatment and immersion time. One way analysis of Variance (ANOVA) was used for drying analysis. Both analysis were used Statistical Package Social Science (SPSS).

RESULTS AND DISCUSSION

Osmotic dehydration

Weight reduction, solid gain and water loss

Figures 1 to 3 show the experimental data for weight reduction (WR), solid gain (SG) and water loss (WL) obtained from all treatments, respectively. By referring to Figure 1, statistically significant differences (p value ≤ 0.05) of weight reduction were observed from all treatments which were explained by the fact that the rates of water loss were greater than the rates of solutes gain.

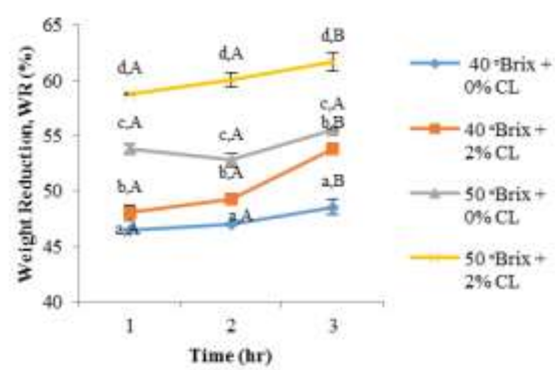

Figure 1: Weight reduction (WR)
Means with the same lower case letter for same immersion time do not differ significantly at $p \leq 0.05$ and means with the same capital letter

for same concentration do not differ significantly at $p \leq 0.05$ according to Tukey's test.

No significant changes of WR found when immersion time was increased from 1 hr to 2 hrs. However, WR greatly affected when immersion time was prolonged to 3 hrs. From the data obtained, WR was influenced by type of treatments and different immersion time; approximately 46% to 61% from initial weight.

According to Silva et al. (2014), preserved tissues have selectively permeable cell membrane that allow the transport of small molecules such as water, but restrict the transport of larger molecules such as sucrose. WR shows significant increase trend for different sucrose concentration (40 °Brix and 50 °Brix) and addition of calcium (0% and 2%). Treatments with calcium also showed higher WR compared to treatment without calcium; approximately 6% to 11% increase compared to osmotic solution without calcium salt. Guiamba et al., (2016) also reported that weight reduction of osmotically dehydrated mango was higher with the presence of 1% calcium in the osmotic solution. Notably, WR greatly increase by different treatment and immersion time.

Figure 2 shows the increase trend of solid gain with time during the osmotic dehydration process. According to Fernandes et al., (2008) solid gain was higher when osmotic solution was employed because of higher osmotic pressure and formation of micro channels in early stages of the pre-treatments facilitated the mass transfer of sugar through the tissue. Greater solid incorporation can be observed from treatments without calcium. Greatest solid gain was found in samples dehydrated for 3 hr in osmotic solution containing 50 °Brix sucrose concentration with the absence of calcium (50 °Brix + 0% CL).

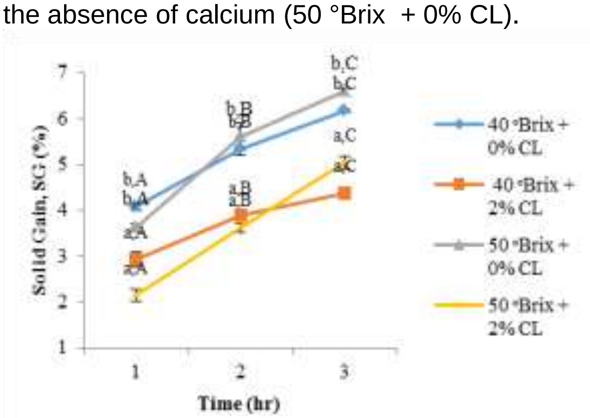

Figure 2: Solid Gain (SG)
Means with the same lower case letter for same immersion time do not differ significantly at $p \leq 0.05$ and means with the same capital letter for same concentration do not differ significantly at $p \leq 0.05$ according to Tukey's test.

Treatments with addition of calcium showed significant inhibition of solid gain compared to treatments without calcium but there were no differences observed in increasing sucrose concentration from 40 °Brix to 50 °Brix. The presence of calcium tends to restrict the sucrose gain in pineapple pre-treated with 2% calcium lactate Silva et al., (2014). They found that addition of calcium lactate at 2% in 50% sucrose solution reduced solid incorporation. A study by Barrera et al., (2009) reported that osmotic solution with addition of calcium lactate resulted in reduction of solid gain in apples.

The restricted transfer of sucrose into Manis Terengganu melon sample could be attributed by the pectin and enzyme present in the fruits. A research by Mavroudis et al., (2012) showed that solid gain in apple decreased with addition of 0.6% calcium lactate to osmotic solution and pointed that the result was affected by reduction of cell wall porosity. Fruit have pectin-methyl esterase enzyme (PME) that generates carboxyl groups that can interact with calcium and form pectin polymers cross linking that can reinforce cell wall Silva et al., (2014).

Enzymes were released when fruits are cut and injuries occur to the tissue, thus, initiating calcium pectate to be formed around the cut surface and act as partial barrier to the diffusion of larger molecules such as sucrose to the tissue (Barrera et al., 2009; Silva et al., 2013). In general, solid uptake was favored by immersion time and it was greatly restricted by the presence of calcium.

Figure 3 shows that water loss was favored by various treatments with different concentration and immersion time, reaching a reduction of half of the initial weight of sample from 51% to 60%. The highest water loss reported from treatment (50 °Brix + 2% CL) for 3 hr. As the sucrose concentration increases, the water loss also ascends. Tortoe (2010) stated that higher concentration of osmotic solution leads to greater rate of water loss. Increasing immersion time also greatly affect water loss of Manis Terengganu melon. Mundada et al., (2011) proved that the increase in immersion time leads to higher loss of moisture during osmotic dehydration.

Treatments with addition of calcium promoted greater water loss compared to treatments without calcium. Calcium lactate in osmotic solution enhanced process efficiency because of its ability to promote higher water loss and restricts sucrose impregnation; was observed by Mauro et al., (2015).

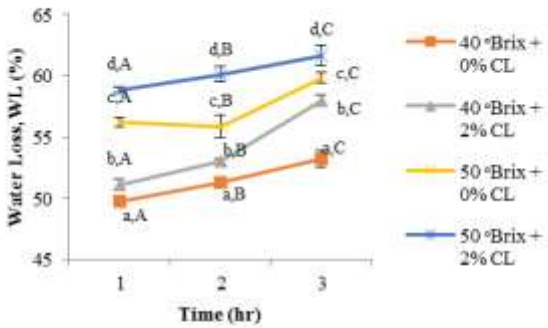

Figure 3: Water Loss (WL)

Means with the same lower case letter for same immersion time do not differ significantly at p ≤ 0.05 and means with the same capital letter for same concentration do not differ significantly at p ≤ 0.05 according to Tukey's test.

The author studies the effect of calcium lactate and ascorbic acid application on water loss and solid gain of apple soaked in sucrose solution. Rodrigues and Fernandes (2007) stated higher the water loss in osmotic dehydration, the better the dehydration process. In short, different treatment, immersion time and application of calcium contributed prominent effect to water loss.

Water activity

Figure 4 shows the water activity at each treatment during osmotic dehydration. Osmotic dehydration reduced the water activity of Manis Terengganu melon as compared to fresh melon and treated samples although there were no statistically differences between treatments.

Water activity was significantly reduced from fresh sample to 1 hr immersion time. Elongation of duration of osmotic process from 2 to 3 hrs did not show significant change of water activity. The addition of calcium and increasing osmotic concentration did not favor change of water activity.

The result shows same trend with a study conducted by Udomkun et al. (2014) who reported that water activity was reduced significantly for fresh and control papaya sample whereas no differences shown in varied percentage of calcium (0.5%, 1.5% and 2.5%).

The author also reported that the lowest water activity was from treatment with calcium lactate; alternatively with result that water activity were not reduced significantly in majority of the treatments.

In brief, water activity reduction of osmotically dehydrated melon was not influenced by treatments, however showed significant reduction when duration time was increased from 0 hr (fresh sample) to 1 hr.

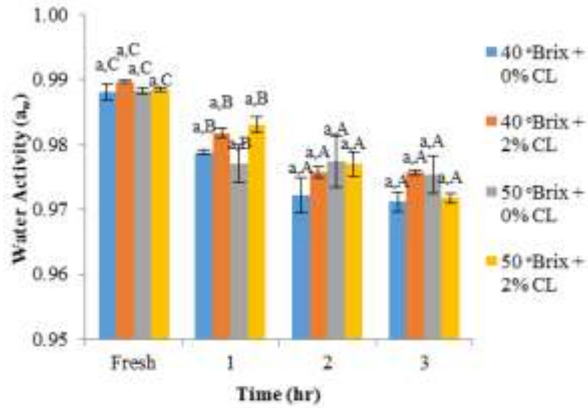

Figure 4: Water activity for fresh and treated samples.

Means with the same lower case letter for same immersion time do not differ significantly at p ≤ 0.05 and means with the same capital letter for same concentration do not differ significantly at p ≤ 0.05 according to Tukey's test.

Firmness

In order to study the influence of the treatments and immersion time on textural behavior of Manis Terengganu melon, compression test was performed to obtain firmness values. Figure 5 shows the decline trend of firmness measured in gram (g) for various treatments throughout immersion time. Duration of osmotic dehydration greatly reduced the sample firmness.

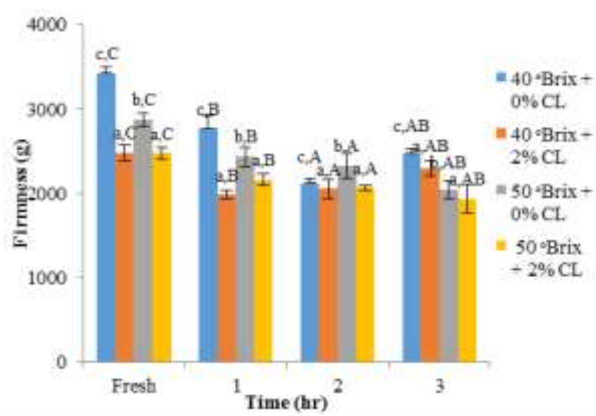

Figure 5: Firmness of fresh and treated samples.

Means with the same lower case letter for same immersion time do not differ significantly at $p \leq 0.05$ and means with the same capital letter for same concentration do not differ significantly at $p \leq 0.05$ according to Tukey's test.

Firmness of treated melon was reduced significantly with the increase of sucrose concentration from 40 °Brix to 50 °Brix sucrose concentration. The decline trend was continued by treatments with addition of calcium with no significant different observed between different sucrose concentrations. The result was similar with a study by Moraga et al., (2009) that evaluated the firmness of grapefruit do not affected by the presence of calcium lactate at 0% and 2% in osmotic solution.

The result showed an adverse effect of calcium application from many studies indicated that calcium salt could improve texture characteristics, especially fruit firmness by calcium ion cross linking with middle lamella pectin cell wall (Ferrari et al., 2013).

A study by Karunarathna and Rathnayaka (2012) showed that pineapple slice treated 1% calcium lactate and 2% calcium lactate incorporated in osmotic solution have a better firmness compared to those with no calcium treatment. In this case, the adverse result was probably due to the ability of the calcium to act in two opposite forms, one which maintains the cell walls through cross-linkage of pectin polymers, and the other causing severe internal disruption of the cell membranes and reduction in firmness of tissues (Anino et al., 2006).

Despite the fact that calcium impregnation can favour textural properties of sample tissue by forming calcium pectate linkage, concentration above 1.5% can also provide cell plasmolysis and increase the dissolution of pectin, reducing firmness of the sample (Ferrari et al., 2010). In sum, firmness of melon was reduced noticeably by treatments and addition of calcium was ineffective to increase firmness.

Optimized condition of osmotic dehydration

After performing various treatments and immersion time on Manis Terengganu melon, optimized condition of osmotic dehydration was chosen to proceed with hot air drying. The selection was based on statistical analysis from Two Way Analysis of Variance (ANOVA) performed on osmotic dehydration analysis. The criteria for selection were based on treatment and immersion time that achieved low weight reduction (WR), high water loss (WL), and low solid gain (SG). The selection also was influenced by the reduction of water activity and firmness of osmo-dehydrated melon. The optimized condition was studied on its efficiency during drying analysis.

Firstly, weight reduction take place because of water loss. From the data, the lowest WR were recorded from treatment (40 °Brix + 0% CL) and (40 °Brix + 2% CL). According to Lee and Lim (2011) the concentration difference between the sucrose solution and melon created two simultaneous flow in counter-current though the cell walls, one of water which moves to the solution and other of sucrose from solution to the melon. As a result, water loss was always closely associated with solid gain in osmotic dehydration treatment. Sucrose concentration 40 °Brix with calcium and without calcium contributed considerable WL and SG.

The highest WL recorded from 50 °Brix sucrose concentration, however, increasing sucrose concentration leading to increase in SG. When solid incorporation increased, this might affect the original or natural taste of melon (Yadav & Singh, 2012). By weighing this factor, treatment (40 °Brix + 0% CL) and (40 °Brix + 2% CL) provided desirable SG and WL. The result also shows addition of calcium restricted solid uptakes and promoted greater WL that were interesting to be observed during drying analysis. Higher WL obtained from osmotic dehydration stage was expected to reduce the total drying time.

In addition, water activity was found to be not dependent on type of treatment. Water activity was reduced significantly by time; however, 2 hrs and 3 hrs did not statistically influence the decrease of water activity. Therefore, 2 hrs duration time was selected because of its ability to reduce water activity to the lowest in the experiment. Equally important firmness that measured by texture analyzer showed a descend trend on different sucrose concentration with no statistically significant on treatments with the presence of calcium. Treatments (40 °Brix + 0% CL) and (40 °Brix + 2% CL) were selected because it showed less firmness loss during osmotic dehydration as compared to other treatments.

Immersion time also one of major factors considered in selecting the optimized condition of osmotic dehydration. Duration time of 2 hrs was selected because of its contribution on optimum WR, SG and WL. According to Mayor et al. (2006), the most significant changes occur during the first 3 hrs of the osmotic dehydration; after that the drying force decreases due to water loss and solid gain until equilibrium between the liquid phase in the fruit material and the osmotic solution was reached. WR, SG and WL were desirable with 2 hrs immersion time. On the other hand, increasing immersion time leads to higher WR, SG and WL and this adversely with optimized condition; which were measured by low WR, high WL, and low SG.

Water activity and firmness shows significant reduction when duration time was increased. Nevertheless, no significant reduction between 2 hrs and 3 hrs on both analysis. Therefore, 2 hrs was selected due to its ability to decrease water activity and firmness to significant level. In summary, two treatments; (40 °Brix + 0% CL) and (40 °Brix + 2% CL) and 2 hrs osmotic time were selected with the proof that these conditions provided optimum WR, SG, WL, water activity and firmness of osmo-dehydrated melon. The optimized conditions of osmotic dehydration are interesting to be analysed on the next drying.

Drying

After osmotic dehydration, treatment (40B + 0% CL) and treatment (40B + 2% CL) at 2 hrs were selected under optimum processing condition. The treated samples were further dried at temperature 60 °C and compared to fresh sample that did not undergo pre-treatment. Drying time was obtained when constant weight was reached. According to Guiamba et al., (2016) the drying temperature was selected by considering thermo labile products such as fruits, high temperature degrade the nutritional quality and sensorial, while lower temperature requires longer drying times which may affect the factors mentioned. Moisture content of dried sample for different treatments and drying time is presented in Figure 6.

Osmotic pre-treatments shortened the drying time at 60°C compared to untreated sample, as a considerable amount of water was removed during the osmotic process. For treatment (40 °Brix + 0% CL) and treatment (40 °Brix + 2% CL) water was removed 51% to 53% by the previous osmotic dehydration stage. The lowest drying time was 2.0 hrs (40 °Brix + 2% CL); followed by 2.5 hrs (40 °Brix + 0% CL) and 3.5 hrs (untreated sample).

The result obtained indicated that osmotic dehydration as pre-treatment greatly reduced drying time, approximately 43% faster as compared to untreated sample. Costa Ribeiro et al., (2016) also observed similar pattern on drying of osmotically dehydrated pear; drying time was reduced 42% in comparison with pear dried without pre-treatment. Another author also presented that osmotic dehydration speed up drying period by 6.3 hrs; approximately 56% as compared to using only air-drying process to dry melon (Fernandes & Rodrigues, 2007). The moisture content rapidly decreased and then gradually decreased with the increase in drying time.

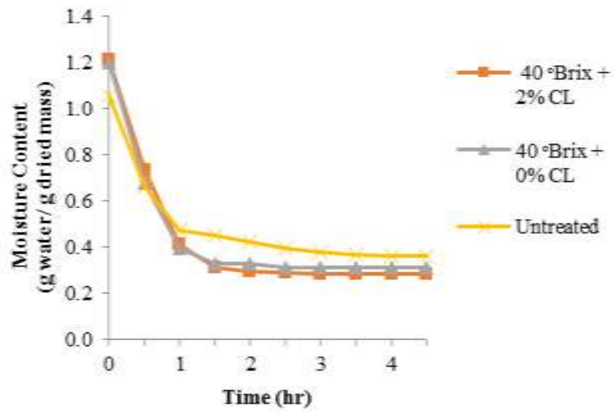

Figure 6: Drying curves of melon samples.

The result also reported that there were significant differences of final moisture content in all samples. Untreated sample persisted higher moisture content, 0.36 (g water/ g dried mass) than treated sample; treatment with addition calcium was found to have significant lower moisture content at 0.29 (g water/ g dried mass) compared to treatment without calcium and untreated sample. Similar result obtained by Udomkun et al., (2014) which lower moisture content noted in calcium-treated papayas compared to control sample. Combined effect of calcium salts and sugar in osmotic solution promoted a greater dehydration effect which related to increased osmotic pressure gradient (Pereira et al., 2007).

Water activity

Water activity (a_w) is an intrinsic product characteristic that influences the stability of food product on storage. Both of a_w and moisture content are essential for the shelf life of osmo-dried melon during storage.

Water activity of osmo-dried melon is presented in Figure 7. Untreated sample have higher water activity (0.5484) compared to treated sample but there was no significant difference among treatment with and without calcium. The reduction of water activity in treated melon proved that osmotic dehydration has profound effect in lowering water activity in dried melon.

Similar result was reported by Lee and Lim (2011) who found that water activity of dried pumpkin that undergone osmotic dehydration was lower compared to untreated pumpkin. The author also reported that significant reduction of water activity provided better preservation effect as water has a decisive influence of the quality and durability of food products through its effect on many physicochemical and biological changes. Although water activity was different among the treatments, they were under minimum level of aw = 0.62 which considered safe for storage and prohibited from microbial growth (Jangam and Mujumdar, 2010).

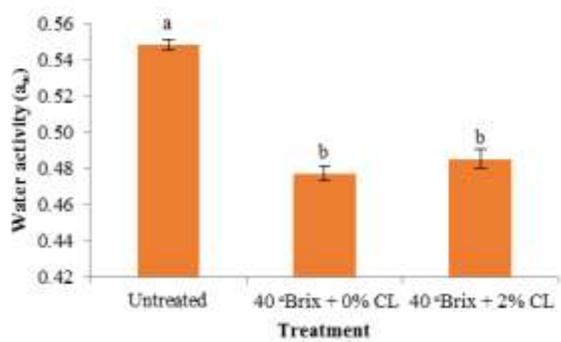

Figure 7: Water activity for untreated and treated dried melon.

Means with same lower case letter do not differ significantly at $p \leq 0.05$ according to Tukey's test.

Firmness

Firmness was defined as resistance of food to the applied compressive forces. The textural behavior especially firmness of osmo-dried melon is presented in Figure 8.

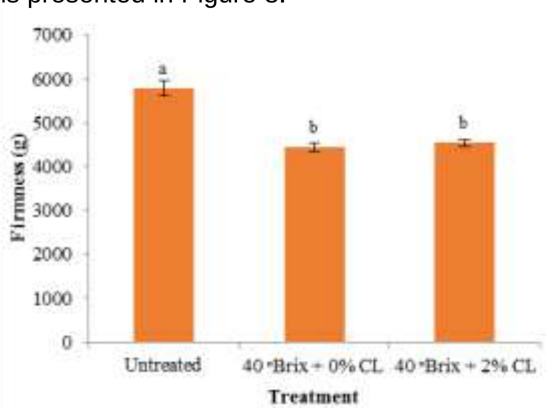

Figure 8: Firmness for different treatments of dried melon.

Means with same lower case letter do not differ significantly at $p \leq 0.05$ according to Tukey's test.

The significant firmness loss observed in pretreated fruits after drying process could be due to changes produced at the structural level during osmotic dehydration stage (Ciurzyńska et al., 2016). During osmotic dehydration, sample treated with osmotic solution containing calcium was found to have lower firmness value that may be due to internal disruption of the cell membranes caused by the calcium (Anino et al., 2006). This reduction of firmness in osmotic dehydration stage may affect the firmness after drying. Nevertheless, there was no significant difference among reduction of firmness observed in any pre-treatment samples. According to Alzamora et al., (2000) during the osmosis step, degradation of polysaccharides can occur and promote leaching of pectin and other wall-soluble components.

Other authors such as Mandala et al., (2005) obtained different behavior with dried apples depending on the solute used as humectant during osmosis; with glucose they observed an increase in firmness but with sucrose the firmness decrease detected during drying. Di Scala et al., (2011) observed firmness loses of dried pepino fruit and reported that softening of pepino fruit was associated with breakdown of structural cell wall and reduction of cohesive forces binding cells together. The significant firmness losses observed in pretreated fruits in comparison with untreated melon evidences that; the characteristic of the final product will be significantly different depending on dehydration process selected.

CONCLUSION

Osmotic dehydration of melon in sucrose solutions with added calcium lactate significantly increased the weight reduction, water loss and subsequently, reduced the incorporation of sugar in the fruit. Meanwhile, water activity and firmness were not dependent on type of treatments. In addition, treatment (40 °Brix + 0% CL) and treatment (40 °Brix + 2% CL) with 2 hrs duration time were selected as optimized condition of osmotic dehydration based on desirable weight reduction, water loss and solid gain.

Combination of osmotic dehydration and air-drying were reported to contribute pronounce effect to drying time, final moisture content and water activity. Osmotically dehydrated sample with the presence of calcium exhibited shorter drying time, 43% reduction and had the lowest final moisture content as compared to untreated sample. The result also shows that water activity was reduced with no significant difference observed on both pre-treatments and calcium application does not enhance dried melon firmness.

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AUTHOR CONTRIBUTIONS

Muhamad, N and Mohamad Basri, S. designed this work. Mohamad Basri, S. performed the experiments with all its analysis. Both authors participated in manuscript writing, reviewed and approved the final version.

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