International Food Research Journal 20(1): 189-196 (2013)
Journal homepage: *http://www.ifrj.upm.edu.my*

Effect of osmotic dehydration process on the physical, chemical and sensory properties of osmo-dried cantaloupe

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Article history

Received: 2 February 2012
Received in revised form: 6 May 2012
Accepted:7 May 2012

Keywords

Cantaloupe
osmotic dehydration
fast osmotic dehydration
slow osmotic dehydration

Abstract

The objective of this research was to study the effect of osmotic dehydration process (fast osmotic dehydration; FOD and slow osmotic dehydration; SOD) on the physical, chemical and sensory properties of osmo-dried cantaloupe. First, the effect of calcium salts (calcium chloride and calcium lactate) on the firmness of fresh cantaloupe was investigated to obtain the suitable immersion time, types of calcium salt and their concentrations for the pretreatment step prior to osmotic dehydration process. It was found that the proper condition for pretreatment step was 2% calcium lactate for 3 h as considered from the firmness and sensory evaluation. After pretreatment, cantaloupe slices were subjected to two osmotic dehydration processes and then dried in hot air oven to obtain osmo-dried cantaloupe. The physical, chemical and sensory properties of osmo-dried cantaloupe obtained from FOD and SOD were comparatively determined. The result showed that no difference in colour (L*, a*, b* values) and browning index was found between sample produced by FOD and SOD. SOD could maintain the shape and present softer texture, resulting in higher mean score of appearance as evaluated by consumers. However, lower vitamin C, phenolic compound and DPPH radical scavenging activity were found in sample produced by SOD compared to FOD. The sensory evaluation was found to be better in sample produced by SOD as considered from appearance and texture scores. However, no difference in mean score of overall acceptability was observed between sample produced by FOD and SOD process.

Introduction

Cantaloupe (*Cucumis melo*) is one of the most consumed fruits worldwide because of its flavor and health benefits. Health benefits have been attributed to the consumption of cantaloupe since it contains naturally occurring vitamins, minerals, and pigments, which provide high antioxidant and anti-inflammatory properties. Cantaloupe is an excellent source of vitamin C and a good source of vitamin A, notably through its β-carotene content. Cantaloupe is available year around in the Thailand; however, its shelf life is limited to approximately 15 days. This results in large losses of the crop and value (Ismail *et al*., 2010; Solval *et al*., 2012). Thus, preservation techniques should be applied to extend the shelf life of cantaloupe.

Osmotic dehydration is a traditional water removal process that decreases the water activity in high water content foods such as fruits. Placing foods in a hypertonic solution, two major processes take place simultaneously: water flow from the food into the solution and solute transfer from the solution into the food matrix. The natural cell surface acts as a semi-permeable membrane. Since the membrane responsible for osmotic transport is not perfectly selective, other natural solutes present in the cells such as sugars, organic acids, minerals, salts, etc. can also be leached into the osmotic solution (Naknean, 2012).

However, structural changes noticed in the product texture, are frequently observed as a result of the osmotic process (Sormani *et al*., 1999; Mastrangelo *et al*., 2000; Pereira *et al*., 2007). Loss of cell turgidity, deformation and/or cell wall rupture, splitting and degradation of the middle lamella, lysis of membrane, cellular collapse, plasmolysis and tissue shrinkage are indicated as the main effects of osmotic dehydration on the cellular structure of plant tissues (Lewicki and Porzecka-Pawlak, 2005).

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Thus, the pretreatment step by using calcium salt was studied to preserve the structure of fruit prior to osmotic dehydration.

The influence of various process variables such as the concentration of osmotic agents, process temperature, osmotic dehydration time, the ratio of food to osmotic solution, geometry of food and agitation speed on the mass transfer during osmotic dehydration and properties of the final products have been extensively studied (El-Aouar *et al*., 2006; Ispir and Togrul, 2009; Mundada *et al*., 2011; Naknean, 2012). Moreover, osmotic dehydration methods also affected the properties of the final product. Two osmotic dehydration methods including fast osmotic dehydration (FOD) and slow osmotic dehydration (SOD) commonly use to produce osmo-dried fruit. However, scientific data has rarely been reported on the physical, chemical and sensory of osmo-dried cantaloupe affected by osmotic dehydration methods. Therefore, the objective of this work was to investigate the effect of osmotic dehydration process on the physical, chemical and sensory properties of osmo-dried cantaloupe.

Materials and Methods

Material

Cantaloupe (*Cucumis melo* L. cv. Sun Lady), at commercial maturity, with 10–11% total soluble solid as measured by refractive index, was purchased from a local wholesale market. Sucrose was purchased from Mitr Phol Sugar Corp., Supanburi Thailand.

Sample preparation and Pretreatment process

The fruits were washed, hand-peeled and cut into slices with approximately 3×3.5×1.5 cm. The slices were immersed in two calcium sources (calcium chloride and calcium lactate) at two concentrations (2% and 3%) for 5 h. During immersion, the slices were collected at 1 h interval until the end of process to measure the firmness by Texture analyser. Moreover, sensory evaluation was done in each treatment presented the highest firmness.

Osmotic dehydration process

The slices obtained from the pretreatment process were used to study the effect of osmotic dehydration process. Two osmotic dehydration methods (under temperature approximately 30°C) including FOD and SOD were performed. The ratio between fruits and osmotic solution was 1:3 (fruits : osmotic solution). In FOD, the cantaloupe slices were immersed continuously in 50oBrix sucrose solution for 24 h and then washed in water (50°C). On the other hand, in SOD, the cantaloupe slices were first immersed in 30°Brix sucrose solution for 24 h. The slices were then transferred to a 40°Brix sucrose solution for 24 h. After that, the slices were transferred to a 50°Brix sucrose solution for another 24 h and then washed in water (50°C). Thereafter, the slices from each process were dried by using hot air oven at 60°C until the moisture content was below 18%. Then, the physical, chemical and sensory properties of the final product were measured.

Physical Properties measurement

Colour measurement

The surface colour on two sides of an individual piece was measured by using a Hunter Lab colourimeter. A colourimeter was adjusted for reflectance, illuminant D 65, and angle of 10°. Instrumental colour data was provided in accord with the CIE system in terms of L* (lightness), a* (redness and greenness) and b* (yellowness and blueness).

Browning measurement

Browning measurement was carried out using the method described by Koca *et al*. (2007) with some modifications. The sample (20 g) was rehydrated for 10 min in 50 mL acetic acid (1% v/v) and homogenised for 5 min, then diluted to 200 mL with acetic acid solution (1% v/v). After that, the mixture was filtrated through filter paper. After filtration, the clarified sample solution was measured browning intensity by spectrophotometer at 420 nm.

Texture measurement

Texture measurement was carried out with a TAXT2i Texture Analyzer (Stable Micro Systems Ltd, Godalming, UK). The firmness (gf) of calcium salt-treated samples was evaluated using a puncture probe. The hardness (N) of osmo-dried cantaloupe was evaluated using a knife blade probe. Ten measurements were performed on each sample to obtain the mean measurement for that sample.

Chemical properties analysis

Determination of pH

The pH value was measured at ambient temperature with a pH meter (Satorious, USA) which calibrated at pH 4.0 and 7.0.

Determination of total acidity

Total acidity was measured according to the procedure of Rangana (1986) with a slight modification. Ten gram of sample was homogenized in 30 ml of distilled water and then made up to 50 ml. The homogenate was filtered and centrifuged at 5000 rpm for 10 min. The supernatant was titrated with 0.01 N NaOH using a few drops of 1% phenolphthalein

solution as an indicator. The result was calculated as a percentage of citric acid.

Determination of moisture content

The moisture content of sample was measured using a hot air oven. About 2-5 g of the sample was placed in a pre-dried aluminum dish and dried in an oven at 110°C for 6 h. The dried sample was placed in a desiccator and cooled for 0.5 h to room temperature. The weight was recorded, and the percentage moisture based on the initial wet weight was calculated.

Determination of water activity

Water activity was measured at room temperature using a water activity meter (Novasina, Thermostanter). The sample was cut into tiny pieces and inserted into a sample cup and another water activity measurement was made immediately to restrict moisture transfer from the air to the samples.

Determination of total sugar and reducing sugar

The total sugar and reducing sugar content were quantified by the Lane and Eynon Volumetric method using titration with Fehling's reagents. The results were expressed as grams of glucose per 100 g of sample (Rangana, 1986).

Determination of vitamin C (ascorbic acid)

Vitamin C was determined according to the method of Guimaraes *et al*. (2010). The sample (450 mg) was extracted with metaphosphoric acid (1%, 30 ml) for 45 min at room temperature and filtered through Whatman No. 4 filter paper. The filtrate (1 ml) was mixed with 2,6-dichloroindophenol (9 ml) and the absorbance was measured within 30 min at 515 nm against a blank. A calibration curve of L-ascorbic acid, (Sigma-Aldrich) was utilised to quantify vitamin C content and the results were expressed as mg of vitamin C per g of sample.

Determination of HMF content

The sample (10 g) was homogenised in 30 ml of distilled water and then made up to 50 ml. The homogenate was filtered and centrifuged at 5000 rpm for 10 min. The supernatant was used to measure 5-hydroxymethylfurfural (HMF) content. First, 2 ml of supernatant was injected into the tube. Two ml of 12% trichloroacetic acid and 2 ml of 0.025 M thiobabituric acid were subsequently added and mixed thoroughly. The tube with the sample was then incubated in a water bath (40°C) for 50 min. After that, the tube was cooled immediately, using water, and the absorbance was measured at 443 nm. Content of HMF was calculated on the basis of the calibration curve of HMF (Sigma-Aldrich) and the results were expressed as mg of HMF per kg dry sample (Rattanathanalerk *et al*., 2005).

Determination of phenolic compounds

Quantification of phenolic compounds in each sample was carried out according to the method of Balange and Benjakul (2009). The sample (10 g) was homogenised in 30 ml of distilled water and then made up to 50 ml. The homogenate was filtered and centrifuged at 5000 rpm for 10 min. The supernatant was used to measure phenolic content. The sample (0.5 ml) was mixed with 0.5 ml of distilled water. Thereafter, 0.5 ml of Folin-Ciocalteu reagent (1:1 with water) and 2.5 ml of 2% sodium carbonate solution were added. The mixture was mixed thoroughly and placed in dark (40 min) and the absorbance was recorded at 725 nm. The total phenolic content was calculated from the standard curve of gallic acid and expressed as µg gallic acid per gram dry sample after blank substraction.

Determination of DPPH radical scavenging activity

DPPH radical-scavenging activity was determined by DPPH assay, as described by Binsan *et al*. (2008) with a slight modification. The sample (10 g) was homogenised in 30 ml of distilled water and then made up to 50 ml. The homogenate was filtered and centrifuged at 5000 rpm for 10 min. The supernatant was used to measure DPPH radical-scavenging activity. Sample (1.5 ml) was added to 1.5 ml of 0.15 mM 2,2-diphenyl-1-picrylhydrazyl (DPPH) in methanol. The mixture was mixed vigorously and allowed to stand at room temperature in the dark for 60 min. The absorbance of the resulting solution was measured at 517 nm using a UV-1601 spectrophotometer (Shimadzu, Kyoto, Japan). The blank was prepared in the same manner, except that distilled water was used instead of the sample. A standard curve was prepared using ascorbic acid. The activity was expressed as µg ascorbic acid equivalents per gram dry sample.

Sensory evaluation

Sensory evaluation was performed in calcium-treated samples, based on their texture and taste. In addition, the acceptance test was used for determining the quality and consumer acceptability of osmo-dried cantaloupe samples, based on their colour, appearance, flavour, texture and overall acceptability. Colour was evaluated by visual observation. Texture was evaluated by eating. Flavour was evaluated by smell and taste. The samples were presented to a test panel on a white plate labeled with three-digit

number codes. Sixty untrained panelists were asked to rate each sensory attribute on a 9-point hedonic scale from 1 (dislike extremely) to 9 (like extremely) (1: extremely poor; 3: poor; 5: acceptable; 7: good; 9: excellent). The experiment was conducted under a controlled environment in an air-conditioned room (25°C), with cool white fluorescence office lighting.

Statistical analysis

All analysis and measurements were performed in triplicates. The experimental designs for physical and chemical properties were a completely randomized design (CRD). The experimental design for sensory evaluation was a randomized complete block design (RCBD). The means were subjected to Student's t-test to verify significant differences between the quality attributes investigated.

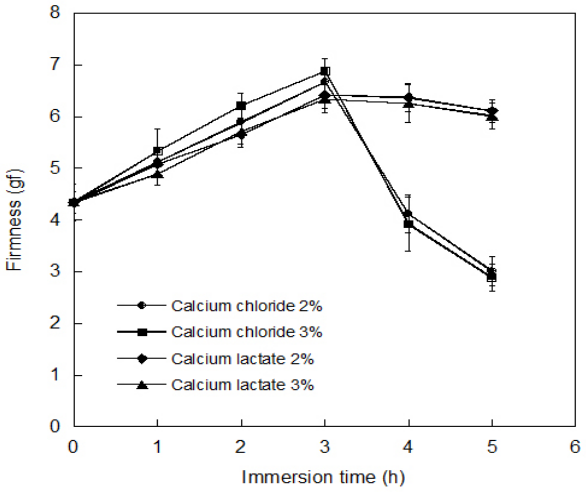

Figure 1. Changes in the firmness of cantaloupe slices immersed in various calcium salts

Results and Discussion

Effect of calcium salts on the firmness of fresh cantaloupe

Different calcium salts have been studied for improvement the texture of fruit before processing. Before osmotic dehydration process, the pretreatment by using calcium salts was studied as shown in Figure 1. Three factors including types of calcium salt, concentrations of calcium salt and immersion times were studied. Only types of calcium salt and immersion times had a significant effect on the firmness ($P \leq 0.05$). An increase in the concentration of each calcium salt from 2% to 3% was not significantly affected the firmness, thus only 2% calcium salts were considered. Regarding to the immersion time, it was found that the firmness of all treatments increased as the immersion time increased up to 3 h ($P \leq 0.05$). Thereafter, a sharp decrease in firmness of sample immersed in either 2% or 3% of calcium chloride was observed until the end of immersion process ($P \leq 0.05$) while the firmness of sample immersed in either 2% or 3% of calcium lactate slowly declined ($P \leq 0.05$). The firming effect provided by calcium salts was observed by several researches (Luna-Guzman and Barrett, 2000; Managanaris *et al*., 2007; Pereira *et al*., 2007) and explained by: (1) the complexing of calcium ions with cell wall and middle lamella pectin; (2) stabilisation of the cell membrane by the calcium ions; and/or (3) effect of calcium on cell turgor pressure. The decrease in firmness resulted in a flesh softening. This symptom was due to excessive salt concentration. The penetration of calcium into the fruit cell took place during immersion process. Prolonging immersion time could promote the increase in calcium content in the fruit, resulting in the increase in the risk for salt-related fruit injury, which appears to be a result of osmotic effects (Saftner *et al*., 1998; Manganaris *et al*., 2007). Manganaris *et al*. (2007) also observed the reduction in the firmness of peach caused by immersion in high calcium concentration salts. Thus, the suitable immersion time for pretreatment cantaloupe slices was 3 h.

Regarding to type of calcium salt, calcium chloride had higher firmness than calcium lactate. This result could be explained by higher amount of free calcium ions available for pectin linkage using calcium chloride solutions. In calcium chloride solutions, all calcium ions are dissociated, but in calcium lactate solutions only some of these ions are available (Pereira *et al*., 2007). From the result, calcium chloride should be selected for pretreatment process of cantaloupe as considered from high firmness. However, lower mean score of taste was found in sample immersed in either 2% or 3% of calcium chloride compared to calcium lactate. High concentration of calcium chloride may result in the bitter taste of the product (Luna-Guzman and Barrett, 2000). The use of calcium chloride was improper for pretreatment cantaloupe, hence calcium lactate proposed as an alternative source of calcium to use for improvement the texture of cantaloupe. Luna-Guzman and Barrett (2000) reported that calcium chloride and calcium lactate maintained melon firmness throughout cold storage. Calcium chloride, but not calcium lactate, imparted undesirable bitterness to the fruit pieces. As mentioned previously, there was no significant difference in firmness between 2% and 3% of calcium lactate ($P > 0.05$). Therefore, the soaking of cantaloupe slices in 2% of calcium lactate for 3 h was used for pretreatment prior to osmotic dehydration process.

Table 1. Sensory evaluation of cantaloupe slices immersed in various calcium salts

Calcium salts/Sensory attributes	Texture	Taste
Calcium chloride 2% (3 h)	6.72[a]	3.72[b]
Calcium chloride 3% (3 h)	6.78[a]	2.77[c]
Calcium lactate 2% (3 h)	6.62[a]	6.84[a]
Calcium lactate 3% (3 h)	6.74[a]	6.56[a]

Means within the same column with different letters are significantly different (P≤0.05)

Table 2. Physical properties of osmo-dried cantaloupe

Properties/Process		FOD	SOD
Colour	L*	56.79 ± 0.37[a]	57.74 ± 0.37[a]
	a*	14.63 ± 0.59[a]	14.03 ± 0.40[a]
	b*	22.08 ± 1.11[a]	21.08 ± 0.39[a]
Hardness		21.35 ± 0.41[a]	18.05 ± 0.63[b]
Browning index		0.29 ± 0.05[a]	0.27 ± 0.07[a]

Means within the same row with different letters are significantly different (P≤0.05)

Table 3. Chemical properties of osmo-dried cantaloupe

Properties/Process	FOD	SOD
Moisture content (%)	14.78 ± 0.23[a]	14.08 ± 0.53[a]
Water activity (a_w)	0.72 ± 0.00[a]	0.69 ± 0.01[b]
pH	5.44 ± 0.13[a]	5.72 ± 0.13[a]
Total acidity (% as citric acid)	0.12 ± 0.03[a]	0.07 ± 0.00[b]
Reducing sugar (%)	14.03 ± 0.52[b]	14.11 ± 0.53[a]
Total sugar (%)	39.25 ± 0.56[b]	44.57 ± 0.68[a]
Vitamin C (mg/100 g)	30.01 ± 0.58[a]	18.15 ± 0.63[b]
HMF content (mg/kg)	9.06 ± 0.45[a]	8.42 ± 0.40[a]
Phenolic content (μg/g)	681.52 ± 1.49[a]	632.08 ± 0.39[b]
DPPH radical scavenging activity (μg/g)	23.54 ± 1.45[a]	19.21 ± 0.61[b]

Means within the same row with different letters are significantly different (P≤0.05)

Effect of osmotic dehydration process on the physical properties of osmo-dried cantaloupe

The colour of osmo-dried cantaloupe was measured as depicted in Table 2. The colour characteristics of fresh cantaloupe using L*, a* and b* values were 63.55, 9.64 and 19.89, respectively. After drying process, the decrease in L* value and increase in a* value were observed in all treatments (P≤0.05). This result may due to an increased concentration of carotenoids that caused from water loss. Similarly, Heredia *et al*. (2009) reported that water loss could increase β-carotene and lycopene in cherry tomato. Falade *et al*. (2007) observed darker colour in osmo-dried watermelon since the increment of pigment content during osmotic dehydration and the drying process. In addition, a decrease in L* value and an increase in a* values could be a result of browning reactions occurring during hot-air drying. The Maillard reaction is mainly responsible for browning development in osmo-dried cantaloupe during the drying process. The Maillard reaction starts with a condensation between a free amino group (of an amino acid or in protein, but also the α-amino groups of terminal amino acids) and an α-hydroxyl carbonyl moiety of a reducing sugar in foods. No difference in L*, a*, b* values and browning index was observed between FOD-treated sample and SOD-treated sample (P>0.05).

The effect of osmotic dehydration process on the hardness of osmo-dried cantaloupe was studied as presented in Table 1. It was found that hardness was significantly higher in sample produced by FOD than that produced by SOD (P≤0.05). Sample produced by FOD was more shrinkage at the surface than that produced by SOD, resulting in the requirement of higher force to cut the sample. The use of high concentration of osmotic agent increased the osmotic pressure gradient, which could favour plant cell plasmolysis. This phenomenon caused more shrinkage of fruit cell. On the other hand, stepwise increment in concentration of osmotic agent could maintain the shape and reduce tissue shrinkage of the finished product (Korsrilabut *et al*., 2010).

Effect of osmotic dehydration process on the chemical properties of osmo-dried cantaloupe

The chemical properties, including pH, total acidity, moisture content, water activity, reducing sugar, total sugar, vitamin C, phenolic compound, HMF content and DPPH radical scavenging activity, were shown in Table 3. The water activity (a_w) is an intrinsic product characteristic that influences the microbial ecology of a sugar-rich product. It defined as free moisture content in the product. Both of moisture content and a_w are highly important for the shelf life of osmo-dried cantaloupe during storage. No difference in moisture content was found between sample produced by FOD and SOD (P>0.05). On the other hand, SOD-treated sample had a lower aw than FOD-treated sample (P≤0.05). This result may be due to SOD-treated sample contained high sugar content, which promoted the interaction of water and sugar molecules via hydrogen bond (Branen, 1990).

The pH and total acidity of fresh cantaloupe were 6.11 and 0.13%, respectively. The reduction in total acidity was detected in all osmo-dried cantaloupes compared to fresh cantaloupe. This might be due to leaching of acids into the medium took place during osmotic dehydration process. After drying process, the amount of vitamin C in all treatments was lower than fresh cantaloupes (48.34 mg per 100 g for fresh sample). This could be explained by a combination of two factors: leaching with water diffusion due to the high degree of vitamin C solubility in water and chemical degradation (enhanced by drying temperature) (Devic *et al*., 2010). Phenolic compounds are one of the most important groups of compounds in plant. In addition, they can be found in cantaloupe (Ismail *et al*., 2010). The phenolic content of fresh cantaloupe was 1023 μg GAE/g sample. This result of phenolic content was lower than the work of Ismail *et al*. (2010) (1680 μg GAE/g sample). This might be due to the difference in extraction method. The osmo-dried cantaloupe had a lower phenolic

Table 4. Sensory evaluation of osmo-dried cantaloupe

Sensory attributes/Treatments	FOD	SOD
Colour	6.57[a]	6.91[a]
Appearance	6.17[b]	7.15[a]
Texture	6.11[b]	7.05[a]
Flavour	6.52[a]	6.59[a]
Overall	6.37[a]	6.83[a]

Means within the same row with different letters are significantly different ($P \leq 0.05$)

content than fresh cantaloupe.

Lower total acidity, vitamin C and phenolic compound in sample produced by SOD were observed compared to FOD. Leaching of natural solutes such as acids, vitamins and small molecules of phenolic compound into the osmotic solution could take place during osmotic dehydration process. This could be attributed to prolonging osmotic dehydration process might induce a higher loss of natural solutes (Devic *et al*., 2010; Vijayakumari *et al*., 2007). Vijayakumari *et al*. (2007) reported that increase in soaking time of *B.purpurea* seed caused a reduction in phenolic compounds, suggested that leaching of phenolic molecules into the soaking medium.

DPPH is a chromogen-radical-containing compound that can directly react with antioxidants. When the DPPH radical is scavenged by antioxidants through the donation of hydrogen to form stable DPPH-H molecule, the colour is changed from purple to yellow. Stable radical DPPH has been widely used for the determination of primary antioxidant, that is, the free radical scavenging activities of pure antioxidant compounds, plants, fruit extracts and food materials (Shi *et al*., 2006). Sample produced by FOD presented greater DPPH radical scavenging activity than that produced by SOD. Components such as phenolic compounds and vitamin C might be responsible for its powerful antioxidant capacity. High leaching of soluble antioxidant components during osmotic dehydration process could be responsible for low antioxidant activity.

Higher reducing sugar and total sugar content were found in sample produced by SOD compared to FOD. Normally, osmotic dehydration is a gradual diffusion process. During osmotic dehydration, osmotic agent normally penetrates into the fruit while water flows from the fruit to the solution. Stepwise increment in concentration of osmotic solution, likes SOD, would promote an increase in solid gain. In addition, an increase in concentration of osmotic solution during osmosis as stepwise increment is also the standard practice in osmo-dried fruit factories in Thailand, and thus this is directly relevant to existing commercial practices. In addition, stepwise process as well as SOD could maintain the shape in the final product as mentioned previously (Korsrilabut *et al*., 2010).

Moreover, sucrose inversion could take place during drying process, leading to the increase in reducing sugar content. High sucrose content presented in the product might promote this reaction, resulting in higher reducing sugar content presented in SOD-treated sample. Additionally, reducing sugar content is an important parameter that affects the properties of osmo-dried cantaloupe during storage since it can act as a substrate of Maillard reaction.

In fresh foods, the HMF level is close to zero, but it is naturally generated in sugar-containing food during heat-treatments like drying. During drying process, the dehydration of carbohydrates, especially hexose, causes the formation of HMF. Moreover, the formation of HMF was induced by the Maillard reaction. Therefore, the considerable variations of HMF found in samples may be used as an indication of overheating during thermal process of food. HMF is used as an indicator of heat stress for sugar based foods because of its toxicological status (Kus *et al*., 2005). No difference in HMF content was found between sample produced by FOD and SOD. This result was in accordance with browning index.

Effect of osmotic dehydration process on the sensory properties of osmo-dried cantaloupe

The sensory evaluation of osmo-dried cantaloupe was shown in Table 4. Higher mean score of appearance and texture was observed in sample produced by SOD compared to FOD. This may be attributed due to the use of SOD could maintain the shape and reduce shrinkage at the surface of osmo-dried cantaloupe. The result of sensory evaluation was in agreement with the result of hardness. However, no difference in mean score of overall acceptability was observed between sample produced by FOD and SOD.

Conclusion

Calcium lactate treatment is a potential alternative to calcium chloride for improvement the texture of cantaloupe since it provided tissue firming without providing undesirable bitterness. Sample produced by SOD could maintain the shape and reduce hardness of finished product. Stepwise increment in concentration of osmotic solution (slow osmotic dehydration process) would promote an increase in solid gain. Moreover, an increase in concentration of osmotic solution during osmosis as stepwise increment is also the standard practice in osmo-dried fruit factories in Thailand, and thus this is directly relevant to existing commercial practices. However, high loss of nutritional component such as vitamin C

and small phenolic molecules should be considered when using long osmotic dehydration time. Further work is needed to establish the possible method to reduce leaching of nutritional components such as coating the fruit by edible film prior to osmotic dehydration process when SOD was used to produce osmo-dried fruit.

Acknowledgements

The authors are grateful to the Faculty of Agricultural Product Innovation and Technology, Srinakharinwirot University for financial supports.

References

Balange, A. and Benjakul, S. 2009. Use of kiam wood extract as gel enhancer for mackerel (*Rastrelliger kanagurta*) surimi. International Journal of Food Science and Technology 44: 1661–1669.

Binsan, W., Benjakul, S., Visessanguan, W., Roytrakul, S., Tanaka, M. and Kishimura, H. 2008. Antioxidative activity of Mungoong, an extract paste, from the cephalothorax of white shrimp (*Litopenaeus vannamei*). Food Chemistry 106: 185-193.

Branen, A. L., Davidson, P. M. and Salminen, S. 1990. Food additive. 1st edn. New York: Marcel Dekker Inc.

Devic, E., Guyot, S., Daudin, J. and Bonazzi, C. 2010. Effect of temperature and cultivar on polyphenol retention and mass transfer during osmotic dehydration of apples. Journal of Agricultural and Food Chemistry 58: 606-616.

El-Aouar, A. A., Azoubel, M. P., Barbosa, L. J. and Murr, X. E. F. 2006. Influence of osmotic agent on the osmotic dehydration of papaya (*Carica papaya* L.). Journal of Food Engineering 75: 267-274.

Falade, K. O., Igbeka, J. C. and Ayanwuyi, F. A. 2007. Kinetics of mass transfer and colour changes during osmotic dehydration of watermelon. Journal of Food Engineering 80: 979-985.

Guimares, R., Barros, L., Barreira, C. M. J., Sousa, J. M., Carvalho, M. A. and Ferreira, C. F. R. J. 2010. Targeting excessive free radicals with peels and juices of citrus fruits: Grapefruit, lemon, lime and orange. Food Chemical and Toxicology 48: 99-106.

Heredia, A., Peinado, I., Barrera, C. and Ande, A. 2009. Influence of process variables on colour changes, carotenoids retention and cellular tissue alteration of cherry tomato during osmotic dehydration. Journal of Food Composition and Analysis 22: 285–294.

Ismail, H. I., Chan, K. W., Mariod, A. A. and Ismail, M. 2010. Phenolic content and antioxidant activity of cantaloupe (*Cucumis melo*) methanolic extracts. Food Chemistry 119: 643-647.

Ispir, A. and Togrul, T.I. 2009. Osmotic dehydration of apricot: Kinetics and the effect of process parameters. Chemical Engineering Research and Design 87: 166-180.

Koca, N., Burdurlu, S.H. and Karadeniz, F. 2007. Kinetics of colour change in dehydrated carrots. Journal of Food Engineering 78: 449-455.

Korsrilabut, J, Borompichaicharkul, C and Duangmal K. 2010. Effect of invert sugar on the drying kinetics and water mobility of osmosed-air dried cantaloupe. International Journal of Food Science and Technology 45: 1524-1531.

Kus, S., Gogus, F. and Eren, S. 2005. Hydroxymethylfurfural content of concentrated food products. International Journal of Food Properties 8: 367-375.

Lewicki, P. P. and Porzecka-Pawlak, R. 2005. Effect of osmotic dewatering on the apple tissue structure. Journal of Food Engineering 66: 43-50.

Luna-Guzman, I. and Barrett, M. D. 2000. Comparison of calcium chloride and calcium lactate effectiveness in maintaining shelf stability and quality of fresh-cut cantaloupes. Postharvest Biology and Technology 19: 61-72.

Manganaris, A. G., Vasilakakis, M., Diamantidis, G. and Mignani, I. 2007. The effect of postharvest calcium application concentration, quality attributes, incidence of flesh browning and cell wall physicochemical aspects of peach fruits. Food Chemistry 100: 1385-1392.

Mastrangelo, M. M., Rojas, A. M., Castro, M. A., Gerschenson, L. N. and Alzamora, S. M. 2000. Texture and structure of glucose-infused melon. Journal Science of Food and Agriculture 80: 769-776.

Mundada, M., Hathan, S.B. and Maske, S. 2011. Mass transfer kinetics during osmotic dehydration of pomegranate arils. Journal of Food Science 76: 31-39

Naknean P. 2012. Factors affecting mass transfer during osmotic dehydration of fruit. International Food Research Journal 19: 7-18.

Pereira, M. L., Carmello-Guerreiro, M. S., Bolini, MA. H., Cunha, L. R. and Hubinger, D. M. 2007. Effect of calcium salts on the texture, structure and sensory acceptance of osmotically dehydrated guavas. Journal Science of Food and Agriculture 87: 1149-1156.

Ranganna S. 1986. Handbook of analysis and quality control for fruit and vegetable products. 1st edn. New Delhi : McGraw-Hill.

Rattanathanalerk M., Chiewchan N. and Srichumpoung W. 2005. Effect of thermal processing on the quality loss of pineapple juice. Journal of Food Engineering 66: 259-265.

Saftner, R. A., Conway, W. S. and Sams, C. E. 1998. Effects of postharvest calcium and fruit coating treatments on the postharvest life, quality maintenance, and fruit-surface injury in Golden Delicious apples. Journal of American Society of Horticultural Science 123: 294-298.

Shih P. W., Pai P. L. and Jen, H. W. K. 2005. Antioxidant activity of aqueous extracted of selected plants. Food Chemistry 99: 775-783.

Solval M. K., Sundararajan S., Alfaro L. and Sathivel S. 2012. Development of cantaloupe juice powder using spray drying technique. LWT-Food Science and Technology 46: 287-293.

Sormani, A., Maff, D., Bertolo, G. and Torreggiani, D. 1999. Texture and structural changes of dehydrofreeze-thawed strawberry slices: effect of different dehydration pretreatments. Food Science and Technology International 5: 479-485.

Vijayakumari, K., Pugalenthi, M. and Vadivel , V. 2007. Effect of soaking and hydrothermal processing methods on the levels of antinutrients and in vitro protein digestibility of *Bauhinia purpurea* L. seeds. Food Chemistry 103: 968-975.