International Food Research Journal 23(4): 1453-1458 (2016)

Journal homepage: *http://www.ifrj.upm.edu.my*

Pre-treatment conditions affect quality and sensory acceptability of dried osmotic dehydrated coconut

[1*]Chantaro, P., [1]Sribuathong, S., [2]Charoen, R. and [3]Chalermchaiwat, P.

[1]*Food Science and Technology Program, Faculty of Science and Technology, Suratthani Rajabhat University, Suratthani, 84100, Thailand*

[2]*Department of Innovation and Product Development Technology, Faculty of Agro-industry, King Mongkut's University of Technology North Bangkok, Prachinburi, 25230, Thailand*

[3]*Food and Nutrition Program, Department of Home Economics, Faculty of Agriculture, Kasetsart University, Bangkok, 10900, Thailand*

Article history

Received: 1 June 2015
Received in revised form: 16 October 2015
Accepted: 23 October 2015

Keywords

Blanching
Dried osmotic dehydrated coconut
Pre-treatment

Abstract

One problem of dried osmotic dehydrated coconut is product discoloration. To improve quality of product, this research was to study the effect of pre-treatment conditions on the quality of dried osmotic dehydrated coconut. Raw coconut was soaked in $K_2S_2O_5$ (0 and 0.1%) + $CaCl_2$ (0 and 2%) for 1 h and blanching (0 and 5 min) before soaking in sucrose solution (65 °B) for 24 h, then drying at 58±1°C for 20 h. Physical (color and shear force), chemical (total soluble solid (TSS), water activity (a_w), reducing sugar, total sugar and titratable acidity) and sensory (on a 9-points hedonic scale; n = 140) quality were investigated. The result revealed that pre-treatment method did not affect on TSS and reducing sugar. Blanching caused a decrease in redness *(a^*)*, yellowness *(b^*)*, shear force, and titratable acidity, but an increase in moisture content (MC), water activity (a_w), lightness *(L^*)* and total sugar of dried osmotic dehydrated coconut. Sensory evaluation indicated that liking scores of all sensory attributes from blanched coconut samples were higher than those of unbalanced coconut samples. The study suggested that pre-treatment method with blanching of the raw coconut for 5 min was sufficient to produce dried osmotic dehydrated coconut, which can be improve color of product and acceptable to consumer.

Introduction

Coconut (*Cocos nucifera* L.) palms are grown in more than 80 countries, Thailand is the world sixth largest producer of coconuts, producing about 1,056,658 tons in 2012 (Office of Agricultural Economics, 2014). Some of the coconut-based products are dried coconut, coconut milk, concentrated coconut milk, coconut milk powder and coconut oil. It's suggested that these products are the materials for preparing end products. For example, dried coconut is one of the coconut-derived products for using in the preparation of ice cream and donuts (Niamnuy and Devahastin, 2005). It's an alternative choice for producing coconut to be a ready-to-eat product as a snack food, e.g., dried coconut and coconut chips.

However, enzymatic browning can be a significant problem, limiting the shelf life of many dried products especially the raw materials are applied heat during processing. Several methods can be applied to avoid enzymatic browning, based on inactivating the enzyme or by removing essential components from the product. For example, Potato cubes were dipped in a 1% sodium metabisulphite solution for 1-2 min (Eren and Kaymak-Ertekin, 2007) and acerolas were blanched at 80 ºC for 3 min (Gomes Alves *et al*., 2005) to prevent from enzymatic browning reaction. Blanching of dates in water at 96 ºC for 5 min and subsequent drying in hot air dryer yielded dehydrated dates with glossy appearance and soft texture (Kulkarni *et al*., 2008). Giovanelli *et al.* (2012) also reported that the blanching pre-treatment of osmotic dehydrated blueberries could improve the overall quality of processed end products, e.g. prevented the loss of phenolic components and the color of blanched sample was deeper.

Osmotic dehydration is a process for partial removal of water from food by immersion in a concentrated hypertonic solution (Mercali *et al*., 2011). It has been reported the advantages of osmotic dehydration with the traditional air-drying method, which are less energy cost, less heat impaired changes in the food components, retention of a natural quality and desirable nutrients can also be added during the osmotic dehydration process (Shi *et al.*, 1997: Corrêa *et al*., 2010). However, osmotic dehydration is not a perfectly removal water from food, it's applied to obtain intermediate moisture food, therefore osmotic

*Corresponding author.
Email: *prawta.cha@gmail.com*
Tel: +66-7791-3397; Fax: +66-7791-3397

dehydration combined with air-drying was found to be advantageous for quality of dried products (Lewicki *et al.*, 2002). For the pre-treatment methods, sulfite agents have been used in the food industry to prevent browning by releasing sulfite ions, which prevent melanin formation. Calcium chloride could improve the fruit texture and heating also prevents browning by inactivating the polyphenol oxadase. Therefore, the objective of this research was to study the effect of pre-treatment conditions (Soaking in $K_2S_2O_5$ + $CaCl_2$ solution and blanching) on the quality and sensory acceptability of dried osmotic dehydrated coconut.

Materials and Methods

Dried osmotic dehydrated coconut preparation

Coconut was procured from a farm in Suratthani province, Thailand. Maturation of fruit was 8 months old. The shell was removed from the coconut kernel, washing and cutting coconut kernel into 10 mm cubes. The coconut cubes were subjected in the $K_2S_2O_5$ (0 and 0.1%) and $CaCl_2$ (0 and 2%) solution for 1 h (ratio of coconut and solution = 1:3). Then, coconut cubes was blanched at 95ºC (0 and 5 min, ratio of coconut and water = 1:5), cooling and the excess water was removed. The pre-treatment coconut was subjected into sucrose solution in the presence of 2% citric acid (65 °B, ratio of coconut and osmotic solution = 1:2) for 24 h. The osmotic dehydrated coconut was then dried in hot air oven at 58±1°C for 20 h. Physical, chemical and sensory qualities were evaluated.

Chemical quality measurement

Moisture content: Dried osmotic dehydrated coconut was blended 2 min with a food blended (model Assistent, Electrolux, Thailand) for reducing of sample size. Moisture content (%, wb.) was determined by using a vacuum oven (model iov-11, Jeio, Korea) with drying to constant weight at 70ºC under reduced pressure of 10 kPa (method 934.06, AOAC, 2000). Water activity (a_w): Homoginated sample was determined water activity (a_w) by using water activity meter (model CH-8303, Rotronic, Switzerland). Total soluble solid (TSS): Five grams of sample were homogenised with ten grams of distilled water for 2 min. The mixture was filtered though a filter paper (Whatman No. 4). The filtrate was determined total soluble solid (TSS, ºBrix) by using a refractometer (Now, Tokyo, Japan). TSS of sample was calculated with multiply TSS of the filtrate by 3. Reducing sugar and total sugar: The Lane-Eynon method (method 923.09 of AOAC, 2000) was adapted to determine reducing sugar and total sugar in dried osmotic dehydrated coconut with different pre-treatment conditions. Titratable acidity: The total acidity was determined by the method of AOAC (2000). Sample preparation was same as the method of TSS. The filtrate was titrated with 0.1 N NaOH using phenolphthalein as an indicator. The total acidity was calculated as citric acid and expressed as grams of citric acid per 100 grams of dried coconut.

Physical quality measurement

Color measurement: The color of sample was measured in the L^*, a^* and b^* mode of CIE (angle 10°, illuminant D65) by using a Hunter Lab (Color Flex, Hunter Lab, VA, USA). L^*, a^* and b^* indicate lightness, redness/greenness and yellowness/blueness, respectively. Shear force measurement: Shear force was performed using a texture analyzer (TA.XT plus, YL, UK.) equipped with the TA.XT version 2.0.7.0 software program. A Warner-Bratzler blade under compression mode with a cross-head speed of 0.5 mm/sec was applied. The maximum force (kg) cut through the cross section of sample was recorded (Chockchaisawasdee *et al*., 2010). Ten samples were measured to obtain an average value for each treatment.

Sensory evaluation

Sensory evaluation (acceptability test) was carried out by an untrained 140 panels with balanced incomplete block design (BIB) using plan 11.10 (Cochran and Cox, 1992). The sensory test was conducted in Suratthani Rajabhat University. Each panelist was served 4 samples and asked to rate the liking of quality attribute according to appearance, color, odor, flavor, texture, sweetness and overall liking of each sample using a 9-point hedonic scale (1 = dislike extremely, 5 = neither dislike nor like, and 9 = like extremely).

Statistical analysis

The experiments were conducted in three replications. The results were reported as the mean value with standard deviation. Analysis of variance (ANOVA) and Duncan's New Multiple's Range Test (DMRT) were used to determine statistically significant differences of treatment parameters ($p < 0.05$) using the SPSS V.21 statistical software package.

Results and Discussion

Chemical quality

The pre-treatment conditions with soaking coconut cubes in 0.1% $K_2S_2O_5$ + 2% $CaCl_2$ solution

Table 1. Moisture content (MC), total soluble solid (TSS) and water activity *(a_w)* of dried osmotic dehydrated coconut with different pre-treatment conditions

$K_2S_2O_5$ (%)	$CaCl_2$ (%)	Blanching time (min)	MC (%)	TSS ^{ns} (%)	a_w
0	0	0	4.83 ± 0.17^b	24.54 ± 2.57	0.65 ± 0.04^{bc}
0	0	5	6.92 ± 0.94^a	24.69 ± 2.82	0.72 ± 0.04^a
0	2	0	4.50 ± 0.22^b	24.67 ± 2.70	0.63 ± 0.04^{bc}
0	2	5	6.56 ± 0.12^a	24.48 ± 2.72	0.69 ± 0.03^a
0.1	0	0	4.48 ± 0.43^b	21.91 ± 0.00	0.61 ± 0.03^c
0.1	0	5	6.56 ± 0.19^a	21.80 ± 0.00	0.70 ± 0.02^a
0.1	2	0	5.24 ± 0.27^b	22.01 ± 0.00	0.66 ± 0.03^{abc}
0.1	2	5	6.80 ± 0.59^a	24.63 ± 2.63	0.67 ± 0.05^{abc}

Mean ± standard deviation values followed by different lower case letters within the same column are significantly different ($p < 0.05$) by Duncan's multiple range test.

and blanching at 95ºC did not affect on the total soluble solid (TSS) of dried osmotic dehydrated coconut ($p \geq 0.05$) as shows in table 1. Moisture content (MC) and water activity (a_w) of dried coconut increased significantly with blanching pre-treatment ($p<0.05$, table 1). Blanching resulted in increasing of moisture content and water activity of dried coconut due to the migration of water into coconut cubes during blanching. The total soluble solid, moisture content and water activity values of products after drying at 58ºC for 20 h are in the ranges of 21.91 - 24.69%, 4.48 - 6.92% and 0.61 - 0.72, respectively, which is corresponding to the specification of Thai Community Product Standard 136/2007. The standard defines that the moisture content and water activity value of dried osmotic dehydrated fruit is no more than 18% and 0.75, respectively. Megías-Pérez *et al.* (2014) have been reported water activity of commercial dehydrated fruits in Spain which was ranged from 0.292-0.526 such as coconut (0.561), strawberry (0.292 - 0.514), blueberry (0.458), cranberry (0.523 - 0.526), apple (0.513), grapefruit (0.414), mango (0.360), pineapple (0.532), banana (0.508) and papaya (0.560). In addition, moisture content and water activity relate to the shelf life stability of product. Water activity of food below 0.60 is not sufficient moisture to support the growth of bacteria, yeasts and mold (Anthony and Fontana, 2008).

Reducing sugar and total sugar of the dried osmotic dehydrated coconut was determined by the Lane-Eynon method (Method 923.09, AOAC 2000) which is based on a reduction of Cu(II) ions in alkaline solution to Cu(I) ions that precipitate as the brick-red oxide Cu_2O. Tartrate ions are added to keep the Cu(II) in solution under the alkaline conditions. The precipitate of cuprous oxide can be determined by titration in the presence of methylene blue (Nielsen, 1998). The pre-treatment conditions of dried osmotic dehydrated coconut with soaking coconut cubes in 0.1% $K_2S_2O_5$ + 2% $CaCl_2$ solution and blanching at 95ºC did not affect on the reducing sugar ($p \geq 0.05$) but influenced significantly on the total sugar ($p<0.05$) as shows in table 2. The reducing sugar of dried coconut is 0.87 – 1.01 g/100 g dried coconut. The pre-treatment conditions, especially blanching method, affected on the total sugar. The total sugar content of dried coconut increased (from 8.43 – 10.02 to 11.97 – 12.83 g/100 g dried coconut) with blanching due to the softness of coconut cell leading to the higher migration of sucrose molecules during soaking coconut cubes in 65 ºB sucrose solution. Megías-Pérez *et al.* (2014) also reported a percentage of total sugar content in commercial dehydrated fruits in Spain such as coconut (12.8 - 52.0%), strawberry (62.7 - 91.2), blueberry (80.1), cranberry (80.9 - 83.6), apple (88.3), grapefruit (81.4), mango (86.1), pineapple (76.8), banana (19.0) and papaya (86.3).

However, pre-treatment method with soaking coconut cubes in 0.1% $K_2S_2O_5$ + 2% $CaCl_2$ solution before blanching decreased the total sugar in dried coconut. It may be explained that $CaCl_2$ improved the firmness of coconut leading to the lower migration of sucrose molecules. Generally, $CaCl_2$ was considered as a chemical agent for textural improvement (Jaswal, 1970; Tsantili *et al.*, 2008; Palma-Zavala *et al.*, 2009).

Titratable acidity is related to the concentration of organic acids present in a food (Martinez *et al.*, 2013). Dried osmotic dehydrated coconut was determined the titratable acidity by titration with 0.1 N NaOH and expressed in grams of citric acid per 100 grams of dried coconut. The pre-treatment conditions with

Table 2. Reducing sugar, total sugar and titratable acidity of dried osmotic dehydrated coconut with different pre-treatment conditions

$K_2S_2O_5$ (%)	$CaCl_2$ (%)	Blanching time (min)	Reducing sugar [ns] (g/100 g sample)	Total sugar (g/100 g sample)	Titratable acidity (g/100 g sample)
0	0	0	0.92 ± 0.10	10.02 ± 0.92[b]	0.23 ±0.06[b]
0	0	5	1.01 ± 0.05	12.83 ± 0.26[a]	0.18 ± 0.04[c]
0	2	0	0.97 ± 0.16	9.89 ± 0.20[b]	0.28 ± 0.05[a]
0	2	5	0.99 ± 0.03	12.80 ± 0.25[a]	0.20 ± 0.03[bc]
0.1	0	0	0.91 ± 0.02	9.25 ± 1.17[b]	0.31 ± 0.06[a]
0.1	0	5	0.96 ± 0.16	12.52 ± 1.29[a]	0.20 ± 0.02[bc]
0.1	2	0	0.92 ± 0.02	8.43 ± 0.13[b]	0.29 ± 0.04[a]
0.1	2	5	0.87 ± 0.05	11.97 ± 0.53[b]	0.20 ± 0.01[bc]

Mean ± standard deviation values followed by different lower case letters within the same column are significantly different ($p < 0.05$) by Duncan's multiple range test.

Table 3. Color (L^*, a^* and b^*) parameter and shear force of dried osmotic dehydrated coconut with different pre-treatment conditions

$K_2S_2O_5$ (%)	$CaCl_2$ (%)	Blanching time (min)	L*	a*	b*	Shear force (kg)
0	0	0	78.60 ± 0.89[b]	2.71 ± 0.40[a]	15.74 ± 0.58[a]	10.93 ± 1.26[b]
0	0	5	83.11 ± 1.17[a]	-0.89 ± 0.15[b]	8.99 ± 0.66[b]	6.93 ± 0.45[c]
0	2	0	78.97 ± 0.62[b]	2.00 ± 0.47[a]	14.89 ± 0.70[a]	11.99 ± 1.00[ab]
0	2	5	82.29 ± 0.29[a]	-0.62 ± 0.08[b]	10.64 ± 0.61[b]	12.16 ± 1.48[ab]
0.1	0	0	78.59 ± 1.85[b]	2.29 ± 1.12[a]	15.46 ± 1.92[a]	13.34 ± 1.83[a]
0.1	0	5	83.47 ± 0.92[a]	-0.93 ± 0.05[b]	9.35 ± 0.75[b]	11.52 ± 1.50[b]
0.1	2	0	79.07 ± 0.60[b]	1.64 ± 0.18[a]	15.77 ± 1.18[a]	11.21 ± 1.54[b]
0.1	2	5	82.59 ± 0.56[a]	-1.03 ± 0.13[b]	9.86 ± 0.25[b]	10.83 ± 1.10[b]

Mean ± standard deviation values followed by different lower case letters within the same column are significantly different ($p < 0.05$) by Duncan's multiple range test.

soaking coconut cubes in 0.1% $K_2S_2O_5$ + 2% $CaCl_2$ solution did not influence on the titratable acidity of dried coconut ($p≥0.05$) (Table 2). Blanching at 95ºC for 5 min decreased significantly titratable acidity from 0.23 – 0.31 to 0.18 – 0.20 g/100 g dried coconut ($p<0.05$) because some organic acids loss in coconut. Wang *et al*. (2008) found that titratable acidity content of tomato was slightly increased after blanching at 60ºC and declined after blanching at the higher temperature.

Physical quality

Color is a significant attribute of food which influences consumer decision. The pre-treatment conditions with soaking coconut cubes in 0.1% $K_2S_2O_5$ + 2% $CaCl_2$ solution did not affect on color parameter (L^*, a^* and b^*) of dried osmotic dehydrated coconut ($p≥0.05$, Table 3). Color of dried coconut was influenced significantly with blanching at 95 ºC for 5 min ($p<0.05$, Table 3). Blanching caused in an increasing the lightness *(L^*)* of dried coconut from 78.59 - 79.07 to 82.29 - 83.47 whereas decreasing the redness *(a^*)* and yellowness *(b^*)* from 1.64 - 2.71 to -1.03 - -0.62 and 14.89 - 15.77 to 8.99 - 10.64, respectively. The key factor for darkness of coconut during osmotic dehydration and drying process is an enzymatic browning reaction. It involves two enzymes: polyphenoloxidase (PPO) and peroxydase (POD). PPO catalyzes two reactions, the first, a hydroxylation of monophenols to diphenols, which

Table 4. Sensory score of dried osmotic dehydrated coconut with different pre-treatment conditions

$K_2S_2O_5$ (%)	$CaCl_2$ (%)	Blanching time (min)	Appearance Color	Odor	Flavor	Texture	Sweetness	Overall liking
0	0	0	6.6±1.1[abc]	6.3±1.6[ab]	6.4±1.4[b]	6.5±1.4[a]	6.3±1.4[b]	6.8±1.0[a]
0	0	5	6.9±1.2[a]	6.8±1.2[a]	6.8±1.3[ab]	6.8±1.3[a]	6.9±1.3[a]	7.3±1.1[a]
0	2	0	6.7±1.3[abc]	6.5±1.3[ab]	6.7±1.4[ab]	6.4±1.6[a]	6.6±1.5[ab]	6.9±1.2[a]
0	2	5	6.9±1.4[a]	6.8±1.4[a]	7.0±1.1[a]	6.7±1.3[a]	7.0±1.3[a]	7.1±1.1[a]
0.1	0	0	6.3±1.6[c]	6.1±1.6[b]	6.3±1.6[b]	6.4±1.6[a]	6.4±1.6[b]	6.7±1.6[a]
0.1	0	5	7.0±1.2[a]	6.7±1.2[a]	6.5±1.3[b]	6.5±1.4[a]	6.6±1.3[ab]	7.0±1.2[a]
0.1	2	0	6.5±1.2[bc]	6.4±1.5[ab]	6.6±1.3[ab]	6.4±1.3[a]	6.6±1.4[ab]	6.8±1.5[a]
0.1	2	5	6.8±1.2[ab]	6.8±1.7[a]	6.7±1.3[ab]	6.7±1.2[a]	6.8±1.3[ab]	6.9±1.5[a]

Mean ± standard deviation values followed by different lower case letters within the same column are significantly different ($p < 0.05$) by Duncan's multiple range test.
Liking scores are based on a 9-point hedonic scale (1 = dislike extremely, neither dislike nor like and 9 = like extremely)

is relatively slow and results in colorless products. The second, the oxidation of diphenols to quinines, is rapid and gives colored products (Queiroz *et al.*, 2008; Ioannou and Ghoul, 2013). Blanching is a heat treatment to destroy or inactivate these enzymes before osmotic dehydrated and drying of product resulting to the brightness of color. Sulfites are considered as reducing agents to inhibit enzymatic browning reaction by removal of oxygen, however, it seems that soaking coconut cubes in 0.1% $K_2S_2O_5$ solution did not influence on the L^*, a^* and b^* values of dried coconut in this experiment. Other important change may be the Maillard reaction which can also occur during drying and storage of dried product. This reaction is influenced by several factors such as water activity, temperature, pH and chemical composition of products (Megías-Pérez *et al.*, 2014). However, Maillard reaction is not obvious in dried osmotic dehydrated coconut in this experiment.

The shear forces of dried osmotic dehydrated coconut were determined using the Warner-Bratzer blade under compression and shearing completely through the samples. The hardness of samples was recorded as the maximum force. The shear force exhibited lower values with blanching at 95ºC for 5 min (Table 3, $p<0.05$) due to the softness of coconut. However, blanching did not affect on textural of dried coconut which is soaked in 0.1% $K_2S_2O_5$ + 2% $CaCl_2$ solution ($p\geq0.05$). This indicated that $K_2S_2O_5$ and $CaCl_2$ prevented the damage of coconut cell from blanching (Jaswal, 1970; Tsantili *et al.*, 2008; Palma-Zavala *et al.*, 2009). Calcium ions interact with biopolymers, mainly pectins, increase mechanical resistance of the material undergoing blanching and drying process (Lewicki *et al.*, 2002).

Sensory evaluation

The acceptance test was conducted by untrained panelists using the 9-point hedonic scale. The liking scores of the sensory attributes (appearance/color, odor, flavor, texture, sweetness and overall liking) for dried osmotic dehydrated coconut with different pre-treatment methods are shown in Table 4. The scores of appearance/color, odor, flavor, texture and sweetness for blanched coconut samples were significantly higher than those of unblanched coconut sample ($p<0.05$). The liking score of all attributes for blanched coconut samples and unblanched coconut samples were about 6.5 - 7.0 and 6.1 - 6.7, respectively. The overall liking scores of dried osmotic dehydrated coconut with different pre-treatment methods were about 6.7 – 7.3 (like slightly - like moderately) and exhibited no significant difference ($p\geq0.05$). However, the overall liking score of dried coconut which was blanched at 95ºC for 5 min without soaking in $K_2S_2O_5$ and 2% $CaCl_2$ solution exhibited the highest value (7.3, like moderately). The result of sensory evaluation revealed that liking scores of dried coconut with blanched were higher than dried coconut without blanched. This would be caused by (1) blanching destroys polyphenoloxidase enzyme (PPO) leading to the lightness of dried coconut, (2) blanching results in softness of coconut tissue and (3) blanching also destroys an lipase enzyme which is related to the rancidity of dried coconut.

Conclusion

The strong influence of pre-treatment conditions, especially blanching at 95ºC for 5 min, was observed by increasing the total sugar and lightness *(L^*)* of dried osmotic dehydrated coconut, whereas the shear force, indicating of softness, decreased with blanching. Preference score of dried osmotic dehydrated coconut from blanched sample were higher than those of unblanched samples. All result indicated that pre-treatment method with blanching of the raw coconut for 5 min was sufficient to produce dried osmotic dehydrated coconut, which can be improve color of product and acceptable to consumer.

Acknowledgement

The authors are grateful to the Suratthani Rajabhat University (SRU) for providing the research fund.

References

Anthony, J. and Fontana, Jr. 2008. Water Activity in Foods: Fundamentals and Applications. Wiley Online Library, p. 405.

A.O.A.C. 2000. Official Methods of Analysis. 17th ed. Vol. 2. Washington, D. C.: Association of official Analytical Chemist.

BeMiller, J. N. 2003. Carbohydrate Analysis. In Nielsen, S. S. (Eds). Food Analysis. P. 143-174. New York: Kluwer Academic.

Chockchaisawasdee, S., Mounsey, J.S. and Costas, E. 2010. Textural and rheological characteristics of sun-dried banana traditionally prepared in the North-East of Thailand. Food Science and Technology Research 16: 1-4.

Cochran, W. G. and Cox, G. M. 1992. Experimental Designs. 2nd ed. New York: John Wiley and Sons, Inc.

Corrêa, J. L. G., Pereira, L. M., Vieira, G. S. and hubinger, M. D. 2010. Mass transfer kinetics of pulsed vacuum osmotic dehydration of guavas. Journal of Food Engineering 96: 498-504.

Eren, I. and Kaymak-Ertekin, F. 2007. Optimization of osmotic dehydration of potato using reponse surface methodology. Journal of Food Engineering 79: 344-352.

Giovanelli, G., Brambilla, A., Rizzolo, A. and Sinelli, N. 2012. Effects of blanching pre-treatment and sugar composition of the osmotic solution on physic-chemical, morphological and antioxidant characteristics of osmodehydrated blueberries (*Vaccinium corymbosum* L.). Food Research International 49: 263-271.

Gomes Alves, D., Barbosa Jr., J. L., Antonio, G. C. and Murr, F. E. X. 2005. Osmotic dehydration of acerola fruit (*Malpighia punicifolia* L.). Journal of Food Engineering 68: 99-103.

Ioannou, I. and Ghoul, M. 2013. Prevention of enzymatic browning in fruit and vegetables. European Scientific Journal 9: 310-341.

Jaswal, A. S. 1970. Effects of various chemical blanching on the texture of French fries. American Potato Journal 47: 13-18.

Kulkarni, S. G., Vijayanand, P., Aksha, M., Reena, P. and Ramana, K. V. R. 2008. Effect of dehydration on the quality and storage stability of immature dates *(Pheonix dactylifera)*. LWT – Food Science and Technology 41: 278-283.

Lewicki, P. P., Vu Le, H. and Pomaranska-Laznka, W. 2002. Effect of pretreatment on the convective drying of tomatoes. Journal of Food Engineering 54: 141-146.

Mercali, G. D., Marczak, L. D. F., Tessaro, I. C. and Norena, C. P. Z. 2011. Evaluation of water, sucrose and NaCl effective diffusivities during osmotic dehydration of banana (*Musa sapientum*, shum.). LWT – Food Science and Technology 44: 82-91.

Megías-Pérez, R., Gamboa-Santos, J., Soria, A.C., Villamiel, M. and Montilla, A. 2014. Survey of quality indicators in commercial dehydrated fruits. Food Chemistry 150: 41-48.

Niamnuy, C. and Devahastin, S. 2005. Drying kinetics quality of coconut dried in fluidized bed dryer. Journal of Food Engineering 66: 267-271.

Office of Agricultural Economics (OAE). 2014. Fruits data. Downloaded from *http://www.oae.go.th/fruits/index.php/coconut-data* on 13/01/2014.

Palma-Zavala, D. J., Quinter-Ramos, A., Jiménez-Castro, J., Talamás-Abbud, R., Barnard, J., Balandrán-Quintana, R. R. and Solis-Matinez, F. 2009. Effect of stepwise blanching and calcium chloride solution on texture and structural properties of Jalapeňo peppers inbrine. Food Technology and Biotechnology 47(4): 464-470.

Queiroz, C., Lopes, M. L. M., Fialho, E. and Valente-Mesquita, V. L. 2008. Polyphenol Oxidase: Characteristics and Mechanisms of browning control. Food Reviews international 24: 361-375.

Shi, J. X., Maguer, M. L., Wang, S. L. and Liptay, L. 1997. Application of osmotic treatment in tomato processing – effect of skin treatments on mass transfer in osmotic dehydration of tomatoes. Food Research International 30(9): 669-674.

Tsantili, E., Christopoulos, M. V., Pontikis, C. A. and Kaltsikes, P. 2008. Texture and other quality attributes in olives and leaf charecteristics after preharvest calcium chloride sprays. Hort Science 43: 1852-1856.

Wang, M., Sun, J., Feng, W., Cao, J. and Jiang, W. 2008. Identification of a ripening-related lipoxygenase in tomato fruit as blanching indicator enzyme. Process Biochemistry 43: 932-936.