Food Research 8 (6) : 361 - 369 (December 2024)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

RESEARCH PAPER

Effect of osmotic dehydration on some physicochemical parameters of dried pineapple slices

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Article history:
Received: 10 November 2022
Received in revised form: 22 December 2022
Accepted: 9 March 2024
Available Online: 24 December 2024

Keywords:
Osmotic dehydration,
Pineapple,
Moisture,
Reducing sugar

DOI:
https://doi.org/10.26656/fr.2017.8(6).562

Abstract

Osmotic dehydration is one of the processes that contribute to the increase in sensory value and shelf life of the product. This study aimed to investigate the influence of osmotic dehydration on the physicochemical parameters of pineapple fruit, which was harvested in Can Tho City, Vietnam. The parameter range of sugar content in the osmotic dehydration solution from 400 to 600 g/L and the temperature factor from 18 to 38°C (±1°C) during osmotic dehydration were investigated. Osmotic dehydration time was investigated until osmotic equilibrium appeared. The effects of the stir condition during osmotic dehydration were monitored and compared with conventional osmotic dehydration. The indicators of moisture content and sugar content in raw materials were evaluated after each hour of osmotic dehydration. The color difference (rE) was also investigated for some osmotic dehydration samples. The results showed that osmotic dehydration at 38°C and sugar content was 600 g/L under the support of continuous stirring for the best osmotic dehydration effect. Study results have provided an overview of the whole process of osmotic dehydration at different concentrations of osmotic solutions. These results were the basis for flexibly choosing conditions for osmotic pineapple in accordance with the purpose of each product (e.g. jelly) and consumer demand (e.g. sweetness level).

1. Introduction

Osmotic dehydration is one of the processes used to treat raw materials before drying. The drying process under the aid of the osmotic dehydration process increases the product quality significantly. Currently, a number of countries are in the development stage, which have ignored a large number of agricultural products due to the few processing and storage facilities. At the same time, the limited knowledge of food processing is one of the reasons hindering the increase in the number of processing enterprises (Lombard *et al*., 2008). The loss of moisture in vegetables and fruits occurs during the immersion of the material in a solution of large total soluble solids. However, this loss only results in a partial loss of moisture content and cannot bring the moisture content of the material to a low moisture content (<15%). In order to increase the storage time and minimize the damage of microorganisms to the product, it is necessary to further treat it by drying or freezing processes (Biswal *et al*., 1991; Bolin and Huxsoll, 1993). The process of osmotic dehydration combined with hot air water separation has been proposed by many previous studies (Şahin and Öztürk, 2016; Prosapio and Norton, 2017; Bozkir *et al*., 2019; Dao *et al*., 2021). Fresh fruit if penetrated will contribute to minimising the influence on the taste and color of the product. At the same time, this process indirectly protects and maintains nutrition in the performance of hot air drying. The osmotic dehydration process caused many changes in the chemical composition of the raw materials. This directly affected the drying rate and water absorption capacity (Rahman and Lamb, 1991). In addition, osmosis dehydration with a solution with a high total soluble solids concentration will directly affect the recovery efficiency of the product (Jayaraman *et al*., 1990). The degree of damage to the cells and the rate of drying are difficult to control. Therefore, it is necessary to reduce a part of the water content in the raw materials in order to minimize the influence on color, sensory and nutritional properties, and to improve the drying efficiency. Pineapple is one of the agricultural products containing many nutrients with high content such as vitamin C in pineapple reaching 84.2 mg/100 mL, which is 5 times higher than that in orange (16.75 mg/100 mL) (El-Ishaq and Obirinakem,

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2015; Khalid *et al*., 2016). In addition, some minerals such as Calcium (13 mg/100 g), Potassium (109 mg/100 g), Magnesium (12 mg/100 g), Phosphorus (8 mg/100 g) are also present. The energy value of 100 g of pineapple is estimated at 209 KJ (Azarpazhooh and Ramaswamy, 2009).

Some previous studies are mentioned as reported by author Lerici *et al.* (1985) investigating the osmotic dehydration of apples supplemented with NaCl and without NaCl. The results showed a decrease in water activity and an increase in the total soluble solids concentration in the material. At the same time, the drying process is efficient when the material is subjected to osmosis (Lerici *et al*., 1985). Dao *et al*. (2022) showed the influence of osmotic dehydration of apple slices with sugar syrup solution (60°Bx) on the quality of the product and a decrease in the total content of polyphenols, vitamin C, and tannins was shown in the study. Bozkir *et al.* (2019) investigated pretreatment by osmosis method before drying persimmons by convection drying method. The results showed that the water loss in the material and the sugar content increased when the osmotic dehydration process was performed. On the other hand, the drying rate significantly increased when the osmotic dehydration process was performed with the help of ultrasonic waves. However, ultrasonic-assisted osmotic dehydration had a significant effect on color and total polyphenol content (Bozkir *et al*., 2019). Another report mentioned the process of water separation by osmosis. The negative effect of the osmotic dehydration process on the taste, texture, and organoleptic properties of the product has also been studied (Konopacka *et al*., 2009). The negative influence of osmosis conditions on product quality parallels the benefits that this process brings. Many reports and assertions on this matter have been published. However, the report of low-temperature osmosis and the effects of aids such as continuous stirring and no stirring during osmosis is currently rare information, with fruits in general and pineapples in particular. This study investigated the effects of sugar content, temperature, and time of osmosis on the quality of dried pineapple products. At the same time, the evaluation of the influence of stirring and no stirring operations on product quality was also carried out. These results are the basis for flexibly choosing conditions for osmotic pineapple in accordance with the purpose of each product and consumer demand as well as cost savings in the production of pineapple-based products, which are produced by osmosis dehydration.

2. Materials and methods

2.1 Samples

About 72 kg pineapple (Queen) was provided by Can Tho city (coordinate 10°01’57”N longitude 105° 47’03”E). The degree of ripeness was about 80-90% (based on the ratio of yellow color of the peel to the whole fruit). The average weight of each pineapple ranges from 1.2 to 1.5 kg. Raw materials were peeled and sliced into circles with a thickness of 1 cm with a common knife. The initial moisture content of raw materials was about 80-86% (Hossain *et al*., 2015).

2.2 Processing

Pineapple after being preliminarily processed and undergoing osmotic dehydration in sugar syrup (Matusek *et al*., 2008; İspir and Toğrul, 2009) with a content of 400-600 g/L (35-45°Bx) (Phisut, 2012; Akbarian *et al*., 2014). The ratio of solution and pineapple was 6:1 (w/w) (Tortoe, 2010). The osmotic solution was investigated at a temperature range of 18-38°C (Rahman and Lamb, 1990; Raoult-Wack, 1994; Phisut, 2012). Intervals were continuously monitored for 21 hrs, and the indicators (total sugar content, moisture content) were evaluated every hour of the first 8 hrs. The osmosis process was evaluated and compared between the two methods of support in the osmotic dehydration process (stir and no stir). Samples after performing the osmotic dehydration process at the largest time were dried at 55°C until the moisture content was about 20% (Dao *et al*., 2022).

2.3 Determination of moisture content

Moisture content was conducted based on the principle of mass difference before and after drying the sample at 105°C to constant weight. Approximately 5 g of each sample was dried in a convection oven to constant weight (Olalusi and Erinle, 2019).

2.4 Determination of reducing sugar content

The method is based on the principle that reducing sugars (glucose, fructose, maltose) can easily reduce copper (II) oxide to copper (I) oxide ($Cu^{2+} \rightarrow Cu^{+}$), copper(I) oxide precipitates brick red in alkaline media. The test process was performed as described by Wildman and Hansen (1940) as follows: Fehling A-69.28 g $CuSO_4.5H_2O$ was titrated to 1000 mL with warm water; Fehling B-346 g $KNaC_4H_4O_6.4H_2O$ and 130 g NaOH titrated to 1000 mL with warm water; Ferric ammonium sulphate solution was prepared from 240.9 g $Fe(NH_4)(SO_4)_2.12H_2O$ and 200 mL concentrated H_2SO_4. The mixture was cooled and made up to 1000 mL. The solution of potassium dichromate was prepared from 4.9037 g $K_2Cr_2O_7$ with 1000 mL of distilled water. Sodium diphenylamine sulphonate was prepared from

https://doi.org/10.26656/fr.2017.8(6).562

0.32 g of barium diphenylamine sulphonate, 100 mL of distilled water and 1 g of sodium sulphate. The mixture was reacted for 1 hr of incubation. The solid sample was extracted into a solution, and a mixture of 20 mL of sample, 10 mL of Fehling A, and 10 mL of Fehling B were added to the centrifuge tube, respectively. The temperature of 80°C was kept constant for 20 mins. The tubes were cooled rapidly immediately after incubation and centrifuged at > 1000 rpm for 4 mins. The solution was transferred to a beaker and 6-9 drops of sodium diphenylamine indicator were added. The solution was titrated with 0.1N $K_2Cr_2O_7$ solution until the solution turned dark purple from the original emerald green.

2.6 Statistical analysis

Microsoft Excel software (Redmond, WA, USA) and Statgraphics Centurion XV version 15.1.02 were used in this study with a statistical significance of $p < 0.05$ (Vu *et al*., 2022).

3. Results and discussion

3.1 The effect of osmosis time at osmotic solution concentrations on moisture content was lost and reducing sugar content was gained

The difference in total soluble solids between the osmotic solution and the raw material was responsible for the variation in the osmotic dehydration rate. The higher the difference, the greater the rate of displacement of total soluble solids between the two media (Azoubel and Murr, 2004). When investigating the effect of osmotic solution concentration on the osmotic dehydration rate of pineapple, the results were evaluated based on the moisture content (MC) was lost and reducing sugar content (RSC) was gained in pineapple over time of osmotic dehydration. The MC was lost and RSC was gained, according to the change of osmotic solution concentration shown in Table 1.

The regression equations showed that the MC was lost and RSC was gained, which increased during the osmotic dehydration of three different osmotic solutions (Figure 1). The rate of osmosis was proportional to the osmotic solution concentration which has been shown by the decrease in MC and the increase in RSC in pineapple slices. The osmosis dehydration was continuous for 20 hrs. For each time level investigated, the greater the MC was lost for the osmotic solution with a higher concentration. The results are similar to several previously reported of an increase in MC lost by soaking cherry tomatoes and apples (Azoubel and Murr, 2004; Phisut, 2012). At all concentrations of osmotic solution investigated, it was found that during the first 1-2 hrs, dehydration was very rapid, similar to the observation of Lazarides (1994). Pineapple soaked in a solution of low concentration (400 g/L) after the first 7 hrs of osmosis, almost reached equilibrium. This was reflected in the degree of moisture loss and the slow movement of sugar into the material. In the case of pineapples soaked in a solution of high concentration (500 g/L and 600 g/L), a rapid increase in sugar content was observed in the first 7 hrs, followed by a slower increase until 20 hrs of osmosis. This may be due to the difference in the solute concentration of the material and the osmotic solution, which causes the sugar to move into the material and attract the moisture out faster. After over 20 hrs of osmotic dehydration, a statistically significant difference in RSC was gained and MC was lost, which was not found (Lenart and Flink, 1984). The results are explained by the low difference in total soluble solids between the inside and outside of the ingredients and the high sugar concentration on the outside that will hinder the absorption of sugar into the pineapple slice. However,

Table 1. The correlation between time and concentration of osmotic solution to MC was lost and RSC was gained during osmosis dehydration.

Time	MC was lost (%)			RSC was gained (%)		
(Hrs)	400 g/L	500 g/L	600 g/L	400 g/L	500 g/L	600 g/L
1	$0.088±0.007^{a}$	$0.082±0.002^{a}$	$0.097±0.010^{a}$	$0.051±0.005^{a}$	$0.044±0.006^{a}$	$0.062±0.008^{a}$
2	$0.112±0.010^{ab}$	$0.119±0.010^{b}$	$0.130±0.002^{b}$	$0.062±0.008^{ab}$	$0.061±0.010^{ab}$	$0.088±0.003^{b}$
3	$0.120±0.006^{ab}$	$0.154±0.020^{bc}$	$0.162±0.003^{c}$	$0.069±0.005^{b}$	$0.081±0.010^{b}$	$0.106±0.004^{c}$
4	$0.140±0.020^{b}$	$0.167±0.005^{c}$	$0.175±0.002^{c}$	$0.075±0.010^{bc}$	$0.083±0.004^{b}$	$0.112±0.004^{c}$
5	$0.158±0.002^{bc}$	$0.192±0.005^{cd}$	$0.199±0.004^{d}$	$0.088±0.002^{c}$	$0.096±0.000^{bc}$	$0.113±0.006^{c}$
6	$0.185±0.003^{c}$	$0.215±0.002^{de}$	$0.235±0.001^{e}$	$0.102±0.000^{cd}$	$0.107±0.003^{bc}$	$0.129±0.003^{d}$
7	$0.191±0.010^{cd}$	$0.234±0.020^{e}$	$0.258±0.002^{f}$	$0.109±0.010^{d}$	$0.115±0.010^{c}$	$0.136±0.005^{d}$
8	$0.224±0.004^{d}$	$0.243±0.010^{e}$	$0.259±0.002^{f}$	$0.126±0.003^{e}$	$0.121±0.002^{c}$	$0.136±0.006^{d}$
20	$0.316±0.020^{e}$	$0.384±0.002^{f}$	$0.413±0.020^{g}$	$0.147±0.002^{f}$	$0.194±0.009^{d}$	$0.216±0.009^{e}$
21	$0.320±0.020^{e}$	$0.405±0.030^{f}$	$0.414±0.010^{g}$	$0.151±0.004^{f}$	$0.214±0.030^{d}$	$0.222±0.000^{e}$

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different at 95% confidence level.

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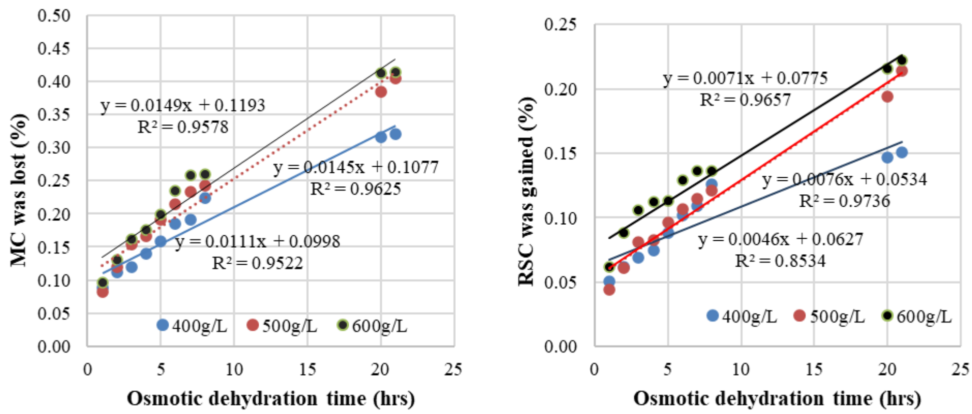

Figure 1. The regression equation shows the MC was lost and RSC was gained during osmotic dehydration at different concentrations of osmotic solutions.

some previous reports have suggested that osmosis at high concentrations of syrup helps to increase the permeability of the cell membrane, leading to easier permeation of soluble solids into the material (Akbarian *et al*., 2014). Another report also mentioned the investigation of osmotic solution concentrations from 30 to 45°Bx and found that the water transport rate increased with increasing osmotic solution concentration to 45°Bx (Giraldo *et al*., 2003). Watermelons permeated in a solution with a syrup concentration of 40-60°Bx showed the greatest water loss at 60°Bx and higher than those performed with osmotic dehydration at 40°Bx and 50°Bx (Falade *et al*., 2007). Soaking of apricots (İspir and Toğrul, 2009) and pomegranates (Mundada *et al*., 2011) under similar conditions also indicated a similar osmotic dehydration mechanism. The process of osmotic dehydration of potato tubers reaching equilibrium was found after 20 hrs (Lenart and Flink, 1984).

The color of product samples soaked with sugar tends to differ greatly from the standard yellow color (Table 2). The rE value increased from 41.02 for fresh samples to 42.58 for samples soaked in sugar solution with 400 g/L ($p<0.05$). After the osmotic dehydration process, the samples were dried at 55°C, which can be the main cause of the obvious color change between soaked and unsoaked samples, the amount of sugar on the surface of the product is easy to change brown when exposed to high temperature. Therefore, the product samples soaked with sugar syrup solution had the most color difference (Topuz *et al*., 2009). However, the visual perception of the sample was still within the acceptable range. The process of investigating the sugar content in the syrup solution from 400 to 600 g/L did not show a statistically significant difference ($p>0.05$). The main reason may be that the amount of sugar syrup covered on the surface of each slice of pineapple is the same. The effect of temperature on the browning of sugar is the same for each slice of pineapple. In this study, the final product color assurance was most similar to the selected fresh pineapple color.

3.2 Effect of osmosis time at different temperatures on the moisture content was lost and reducing sugar content was gained

Temperature is an important factor that directly affects cells and causes many changes in the properties of materials and the movement of molecules. This is the cause leading to the results of variation in the rate of soluble solids infiltration into the material (Alakali *et al*., 2006; Tortoe, 2010). Investigation of the osmotic solution temperature from 18 to 28°C (±1°C) showed an increase in MC was lost and RSC was gained (Lazarides, 1994) (Table 3). As the increasing temperature changed the viscosity of the osmotic solution (Kobus *et al*., 2015), the movement of molecules in the solution became rapid, which led to the impetus for the osmotic rate to happen faster. On the other hand, an increase in temperature can break the bonds between cells. The mechanism of cell expansion that occurs at warm temperatures and contraction at cold temperatures will create a larger pore space between cells (Lazarides, 1994; Dao *et al*., 2022). Favorable conditions for the transfer of total soluble

Table 2. Effect of sugar content, temperature in osmotic solution and processing method on product color.

Sugar content (g/L)	△E	Temp (°C)	△E	Processing method	△E
Fresh	41.02^{a1}	Fresh	41.02^{a2}	Fresh	41.02^{a3}
400	42.58^{b1}	18	43.09^{b2}	Stir	43.51^{b3}
500	43.27^{b1}	28	43.51^{b2}	Do not stir	42.31^{a3}
600	43.78^{b1}	38	43.47^{b2}		

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different at 95% confidence level.
[1-3] distinguished between sugar content, temperature and processing method.

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Table 3. The correlation between time and temperature to MC was lost and RSC was gained during osmosis dehydration.

Time	MC was lost (%)			RSC was gained (%)		
(Hrs)	400 g/L	500 g/L	600 g/L	400 g/L	500 g/L	600 g/L
1	0.065±0.002^{a}	0.082±0.002^{a}	0.105±0.008^{a}	0.028±0.001^{a}	0.045±0.006^{a}	0.041±0.003^{a}
2	0.083±0.002^{ab}	0.119±0.010^{b}	0.129±0.010^{a}	0.049±0.001^{b}	0.061±0.010^{ab}	0.061±0.007^{ab}
3	0.095±0.010^{b}	0.154±0.020^{bc}	0.172±0.010^{b}	0.058±0.009^{bc}	0.081±0.010^{b}	0.081±0.010^{bc}
4	0.128±0.001^{c}	0.167±0.005^{c}	0.197±0.010^{b}	0.075±0.008^{c}	0.083±0.004^{b}	0.085±0.010^{bc}
5	0.148±0.005^{c}	0.192±0.005^{cd}	0.226±0.010^{c}	0.084±0.003^{cd}	0.096±0.000^{bc}	0.096±0.001^{bcd}
6	0.178±0.006^{d}	0.215±0.002^{d}	0.243±0.009^{cd}	0.087±0.001^{cd}	0.107±0.003^{bc}	0.101±0.010^{cd}
7	0.219±0.009^{e}	0.234±0.020^{de}	0.265±0.010^{d}	0.101±0.010^{d}	0.115±0.010^{c}	0.113±0.020^{cd}
8	0.233±0.008^{e}	0.243±0.010^{de}	0.293±0.010^{e}	0.110±0.001^{de}	0.121±0.002^{c}	0.132±0.020^{d}
20	0.344±0.010^{f}	0.384±0.002^{f}	0.434±0.001^{f}	0.172±0.005^{f}	0.195±0.009^{d}	0.225±0.010^{e}
21	0.355±0.007^{f}	0.405±0.030^{f}	0.449±0.005^{f}	0.173±0.000^{f}	0.214±0.030^{d}	0.241±0.010^{e}

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different at 95% confidence level.

solids into the material and the conduction of moisture from the material to the environment are created by this mechanism. The temperature factor is the main cause of the change in viscosity of the osmotic solution. With high-temperature osmotic dehydration, total soluble solids pass more easily through the semi-permeable membrane of the cell. This is because the low viscosity increases the degree of flow resulting in limited inhibition of intracellular translocation (Phisut, 2012). Rastogi *et al.* (2000) agreed that increasing the osmosis investigation temperature from 5 to 35°C increased the moisture diffusion rate. Besides, after 20 hrs of osmotic dehydration at each temperature level, a statistically significant difference was not found (p>0.05). This difference does not mean that there is an equilibrium in the concentration of total soluble solids between the inside and outside of the material. This is demonstrated in an increase in MC was lost and RSC was gained when further increasing the temperature to 38°C (Figure 2). A similar report for potato osmotic dehydration after 20 hrs reached equilibrium (Lenart and Flink, 1984).

The browning reactions occurred on the product surfaces with samples having the same sugar content, resulting in similar color difference between the product color and the standard yellow color. Increasing the osmotic solution temperature only changed the amount of solution moving inside the material center without any difference in browning reaction on the surface of pineapple slices (p>0.05) (Table 2). The drying process affected the tissue structure of the cells, the cells shrink, leading to the backflow of a part of the previously permeable sugar solution to the surface of the product. Browning of sugar molecules occurs continuously by this mechanism. The phenomenon of caramelization of rice bran was mentioned in a previous study (Phong *et al.*, 2017)

3.3 The change of osmotic rate of pineapple when the osmotic solution was stirred

The mechanical impact on osmotic dehydration also significantly affects permeability. It was shown in Table 4 that MC was lost at the no-stir condition was lower than that under the stir condition during osmotic dehydration.

The same is true for RSC was gained in the process of osmotic dehydration with mechanical stirring. The use

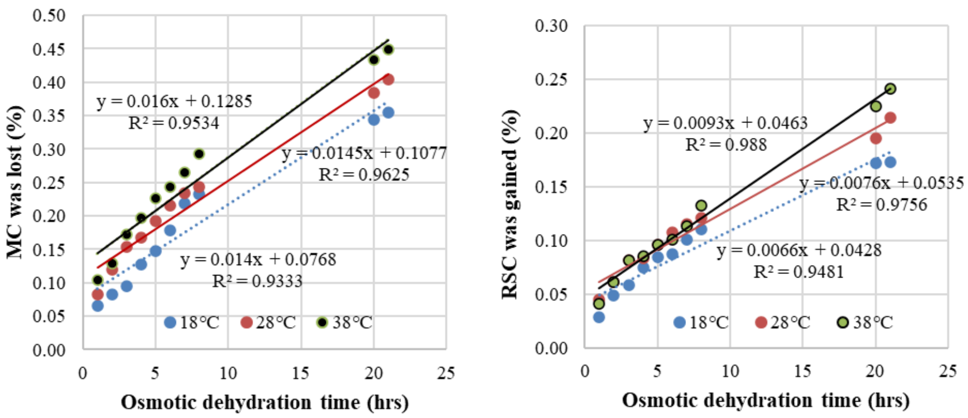

Figure 2. The regression equation shows the MC was lost and RSC was gained during osmotic dehydration at different osmotic solution temperatures.

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Table 4. Effect of stirring and no stirring support measures on MC was lost and RSC was gained during osmosis dehydration.

Time (Hrs)	MC was lost (%)		RSC was gained (%)	
	Stir	Do not stir	Stir	Do not stir
1	0.137±0.010^{a}	0.088±0.003^{a}	0.084±0.009^{a}	0.056±0.000^{a}
2	0.181±0.000^{b}	0.116±0.010^{b}	0.116±0.001^{b}	0.069±0.008^{b}
3	0.208±0.010^{c}	0.151±0.007^{c}	0.133±0.001^{c}	0.094±0.003^{c}
4	0.254±0.010^{d}	0.191±0.010^{d}	0.145±0.000^{d}	0.108±0.001^{d}
5	0.293±0.010^{e}	0.214±0.010^{e}	0.158±0.007^{e}	0.109±0.007^{d}
6	0.301±0.004^{e}	0.252±0.010^{f}	0.165±0.005^{e}	0.122±0.004^{e}
7	0.334±0.010^{f}	0.273±0.002^{fg}	0.180±0.005^{f}	0.134±0.002^{f}
8	0.369±0.007^{g}	0.290±0.010^{g}	0.195±0.003^{g}	0.144±0.006^{f}
20	0.478±0.006^{h}	0.311±0.010^{gh}	0.277±0.004^{h}	0.160±0.001^{g}
21	0.476±0.001^{h}	0.338±0.004^{i}	0.280±0.002^{h}	0.167±0.001^{h}

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different at 95% confidence level.

of mechanical stirring helps the sugar content in the ingredients to increase more per unit of time. The stirring process helps the pineapple slices to be in contact with the osmosis device locations. The pineapple slices at the bottom of the osmosis device are under pressure from the solution more than the surface. Stirring the pineapple slices helps the pineapple to be absorbed equally at all times. On the other hand, stirring helps the surface of the material to increase the friction with the low-permeability device and the osmotic solution, which has reduced the resistance of sugar molecules on the surface of the raw material leading to increased fluidization. Transfer the molecules of soluble solids in the syrup into the pineapple slices. In contrast, osmosis does not support stirring because it is hindered by sugar molecules in the cell pores (Saurel *et al.*, 1994) and pineapple slices are not subjected to the same osmotic pressure leading to a slow osmotic rate (Moreira *et al.*, 2007). However, MC was lost and RSC was gained of pineapple slices were continuously increased up to 16 hrs and no change in MC was lost and RSC was gained which was observed with a further increase in osmotic dehydration time greater than 16 hrs for the osmosis process with a stir (Figure 3). In contrast, osmosis without stirring support continued to increase with increasing stirring time. The action of mechanical stirring only assists the pineapple slices to quickly reach an equilibrium between the inside and the outside of the solution. Therefore, without the support of mechanical stirring, the osmosis process is prolonged. This is evidenced by the continued increase in MC was lost and RSC was gained with continued osmotic dehydration over a duration of more than 16 hrs. Some similar reports of osmotic water loss of chestnuts without the effect of stirring reduced the rate of water transport out of the material (Moreira *et al.*, 2007; Phisut, 2012). The comparison of the effects of stirring and no stirring was also investigated in the previous report, the results show that the stirring effect still gives better osmotic dehydration efficiency (Shi and Xue, 2008).

Although the stirring process increases the permeability of soluble solids from the osmotic solution into the material. However, stirring will increase the oxygen content of the solution due to the constant attraction of oxygen from the air. The stir was continuous throughout the long osmosis process. The oxygen content in the osmotic solution was high, which facilitated the contact of the pineapple slices with

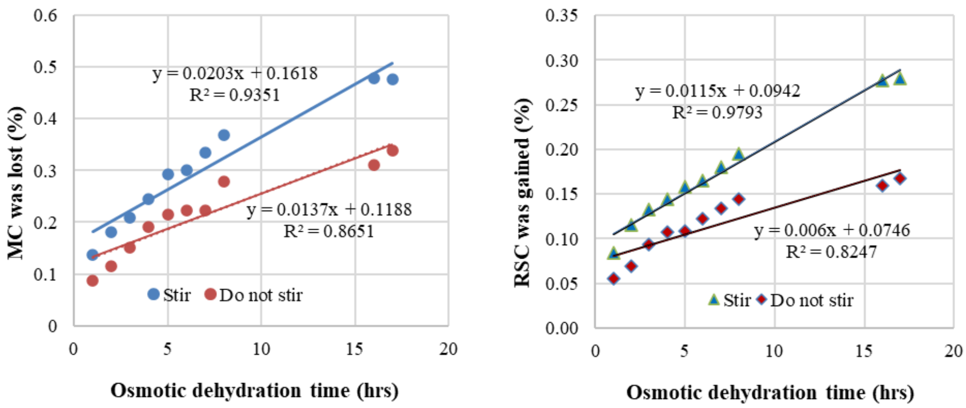

Figure 3. The regression equation shows the MC was lost and RSC was gained during osmotic dehydration with and without stirring the osmotic solution.

https://doi.org/10.26656/fr.2017.8(6).562

oxygen. Both enzymatic and non-enzymatic browning reactions occurred during osmosis (Vauzour *et al*., 2010). Hence, the color difference for stirring during osmosis was the highest (Table 2). A similar report of the Maillard reaction occurred in apples, mushrooms, and eggplants in the presence of oxygen (Billaud *et al*., 2005).

4. Conclusion

In this study, the variation of moisture content and sugar content in raw materials during the soaking process of pineapple slices was successfully investigated. The results showed that the increase of sugar content in the osmotic solution increased the rate of soluble solids moving into the material due to the difference in pressure inside the materials and the osmotic solution pressure. The temperature factor is a factor that affects the cells to help the penetration faster. At the beginning of the osmosis process, the difference in pressure inside the material and the pressure of the osmotic solution is large. At the same time, the osmosis process is assisted by mechanical stirring to help all materials penetrate evenly. Therefore, about the first 16 hrs of osmosis process, the sugar content of the material increased continuously for mechanical stir-assisted osmosis, and took about 21 hrs to reach soluble solids equilibrium during osmosis and do not stir. In the process of osmosis dehydration at a temperature range of 18-38°C and sugar syrup osmosis at concentrations from 400-600 g/L, MC was lost and RSC was gained had no statistically significant difference. However, a difference between MC was lost and RSC was gained, before and after osmosis dehydration was noticed. The large color difference for stirring-assisted osmosis dehydration was shown with rE = 43.51.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

This work was supported by Can Tho University and Nguyen Tat Thanh University provided the facilities required to perform this work. Simultaneously, the assistance of Nguyen Thi Tuyet Van – A student at Can Tho University, Viet Nam during the experiment is highly appreciated.

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