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Research Article

APPLICATION OF OSMOTIC DEHYDRATION METHOD TO PRODUCE PHOSPHORUS ENRICHED BANANA

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ABSTRACT
Phosphorus has an important role in the bones and teeth. Deficiency of phosphorus causes loss of appetite, fatigue and impaired the bones and teeth. Dehydration of food products through osmosis that is the emerging of the food materials in concentrated solution is an old treatment. In this study the osmosis solution was made by sucrose dissolved in water and the concentration of 55% (w/w) by adding phosphorus in specified concentrations in the range of 0- 5% the solution making was completed. Based on central composite design and response surface method dehydration process took 0- 120 minutes while the fruit to solution ratio was 1:5. The moisture content, weight reduction, solid gain and water loss of samples through the process was determined. According to the results it can be stated the amount of absorption of sugar and dehydration of banana in the presence of phosphorus ions is considerable and maximum weight reduction was 6.44% while using phosphorus as osmosis agent. When the concentration of phosphorus in the solution is the 5% the solid gain and water loss would be minimal. Factors influencing the rate of weight reduction during the process of osmosis of banana were ion concentration and time.

Keywords: *Dehydration, Enrichment, Banana, Phosphorus*

INTRODUCTION
Minerals form the hard and soft tissues of the human body these substances should be available to the cells at the adequate levels. Our body obtains minerals through the consumed food then the minerals are released by the digestion of food in the form of ions and are absorbed by the intestinal tract. The minerals are delivered to the liver and other organs through the blood. Some of them used at the time and the remain is stored for use in future. Providing of the body necessity for the minerals via other resources such as food and supplements is vital Due to loss of minerals with age.
Due to the lack of minerals in the diet the body is subjected of serious damage in terms of health and also economic and social consequences lies there. Among the elements that have frequently been deficiencies are elements such as iron, calcium, phosphorus and potassium. All the minerals needed by the human body must be supplied by the food sources since the body cannot make them and only can keep the level of minerals in balance for a short time. If the body's absorption of nutrients from food reduced then body compensate for this deficiency by removing the minerals from the muscles, liver and bone that adverse effects will follow. The frequency of phosphorus in the body is at the second place after calcium. Phosphorus and calcium have an important role in the bones and teeth. Protein-rich foods are also rich in phosphorus. Deficiency of phosphorus causes loss of appetite, fatigue and impaired the bones and teeth (Agheli, 2006). The recommended amount of daily intake of phosphorus is 800 mg/day for men and 1200 mg/day for women (www.brianmac.co.uk) in some references the recommended daily intake of this nutrient is mentioned as 700 mg/day for adults and 500-1250 mg/day for children (healthalternatives2000.com).
Dehydration of food products through osmosis that is the emerging of the food materials in concentrated solution is an old treatment which is regarded as a pretreatment in recent years for subsequent processing of food products (Raoult, 1994). The osmosis is based on placing the food at hypertonic solution (concentrate) of sugar or salt in order to achieve some change in concentration, drying and spontaneous food formulation due to the immersion of the food in solution and interacts with components of their

solution. During osmotic dehydration water of food flows into the solution while the soluble components used in the solution flows at the opposite direction. The main phenomenon of osmosis is diluting of osmosis solution with weight gain and reduction in dehydration ability of osmosis agent (Torreggiani, 1995).

Fruit texture modification agents can be added to the solution promotes mass transfer characteristics and affect nutritional and stability of aromatic substances during processing (Ferrando, 1998). In recent decades osmotic drying processes has been regarded as a pretreatment in complex processes. During this process by using different and sequential technologies, controlled changes in the food properties can be achieved. While some processes such as freezing has their main role in the preservation of foods other processes such as osmosis dehydration can modify structural characteristics, nutritional, sensory and functional properties of the used raw materials (Maguer, 1998).

This study was carried out to determine the osmotic properties of banana in concentrated sucrose solutions in the presence of different concentrations of phosphorus ion over period of time also to investigate the amount of phosphorus which can be uptake by the banana and suggest this method as a pretreatment for enrichment processes of fruits.

MATERIALS AND METHODS

In this study osmosis solution was prepared by sucrose solving in deionized water at the concentration of 55% (w/w) by addition of the phosphorus in specified concentrations (0- 5%) to the solution the osmosis solution preparation was completed. In this experiment, the banana was cut in circular pieces after washing and was immersed in a solution containing sucrose and mineral for the period of 0-120 minutes. The fruit to solution ratio was 1:5. After the specified emerging time is passed fruits were taking away of the syrup and the extra water was eliminated of the surface of fruit samples. Osmosis process took place at a constant temperature (25 ˚C) and without stirring and without subsequent drying process. Fruits were weighed before and after the process and their dry matter was measured before and after the process.

The results were used to characterize of the osmotic dehydration process such solid gain, water loss and weight reduction. In the next step the amount of mineral in the fruit measured before and after the process. And the net absorbed amount and the percentage of increase was calculated and was compared by the amount of mineral in the fruit before process.

To determine the moisture content of osmosis treated and non treated fruit AOAC method was used. In this method, a certain amount of sample were placed in oven at 100 °C until the sample reaches the constant weight after that the sample weights again and moisture content and dry matter of the sample was calculated.

$Dry\ matter = (W_f / W_0) \times 100$ equation (1)

$Moisture\ content = 100 - dry\ matter$ equation (2)

Where, W_f: final weight and W_0: initial weight

Solid gain, water loss and weight reduction of the samples was determined using the following equations (Mavroudis, 1998):

$WR = (W_0 - W)/W_0$ equation (3)

$SG = (S - S_0)/W_0$ equation (4)

$WL = WR + SG$ equation (5)

Where, *WR*: weight reduction, *SG*: solid gain, *WL*: water loss, W_0: initial weight, *W*: final weight, S_0: initial dry matter and *S*: final dry matter.

Research based on central composite design according to response surface method. Duncan test was performed to compare means and analysis of variance.

RESULTS AND DISCUSSION

The results for osmosis treatment of banana indicates that regardable amount of water content of banana is removed during osmotic dehydration process on the other hand the amount of sold gain during osmotic dehydration is high, then the amount of weight reduction will be decreased. The highest amounts which

were obtained for water loss and solid gain were 44.24% and 39.46% respectively during osmosis treatment of banana in different solutions of phosphorus.

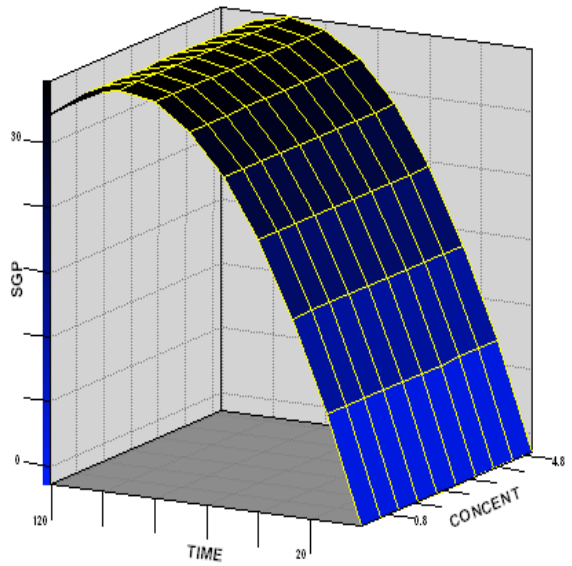

Figure 1: Surface plot of solid gain (SG) for banana

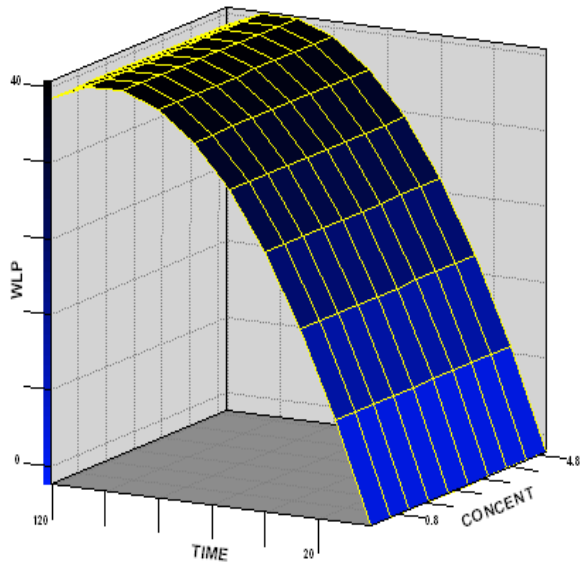

Figure 2: Surface plot of water lose (WL) for banana

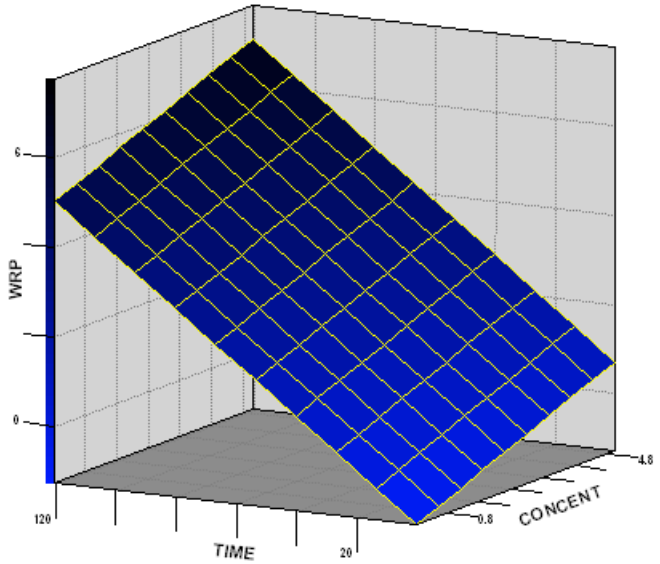

Figure 3: Surface plot of weight reduction (WR) for banana

This process will not be fruitful benefits if weight reduction be the purpose of osmosis treatment. The highest amounts which was obtained for weight reduction was 6.44%. While osmotic dehydration could be a powerful treatment for enriching the banana with minerals or other kinds of ingredients as like done in this project. Also when the reducing of water content of the product is the aim of process this method can be applied. For example in drying process osmotic dehydration could be used as a pretreatment to decrease the water content of the banana.

When the phosphorus ion is used as osmotic agents the osmotic dehydration properties (solid gain, water loss and weight reduction) have been increased as the process time increased. Also the osmotic

dehydration properties have increased by the increasing of ion concentration However; the concentration had not impact effects on osmotic properties in the short process time. The lower effects of ion concentration at the higher concentrations can be attributed to high density of ions in the solution and reduced freedom of movement of the ions. Figures 1 - 3 are shown the results of osmotic dehydration parameters (Solid gain, water loss and weight reduction) of banana. Sugar solution containing different concentrations of phosphorus and the treatment is performed during different process times.

According to the ANOVA table (Table 1) affecting factors of treatment on weight reduction during the process of osmosis of banana in concentrated solution of sucrose containing phosphorus are ion concentration and time at the level of 95% and 99%, respectively. The factors influencing the solid gain of banana during osmosis process in concentrated solution of sucrose containing phosphorus are time and square of time at level of 99%.

Factors affecting the level of water loss during the process of osmosis of banana in concentrated solution of sucrose containing phosphorus are time and square of time at the level of 99%. The below equations are related the independent variables of the experiment with the osmotic dehydration parameters of banana in concentrated solution at the presence of phosphorus ion at different concentration over period of time.

Table 1: ANOVA table for treatment factors and their effects on weight reduction

Source	DF	SS	MS	F	Pr > F
CONCENT	1	4.736873	4.736873	13.13795	0.011
TIME	1	47.53532	47.53532	131.8415	<.0001
CONCENT*CONCENT	1	0.204173	0.204173	0.566285	0.4802
CONCENT*TIME	1	0.002174	0.002174	0.006031	0.9406
TIME*TIME	1	0.005579	0.005579	0.015474	0.9051

$$WR = -1.32916 + 0.438454*concentration + 0.057355*time \quad \text{equation (6)}$$
$$SG = -2.11397 + 0.880345*time - 0.005107*time*time \quad \text{equation (7)}$$
$$WL = -2.32761 + 0.937285*time - 0.005103*time*time \quad \text{equation (8)}$$

The equation 6 obtained to represent the relation between independent variables of treatment and weight reduction with a correlation coefficient of 96.04%. On the other hand equations 7 and 8 were obtained to correlate the amount of solid gain and water loss during osmotic dehydration treatment of banana with independent variables of treatment. Correlation coefficients were as 86.35% and 90.02% for solid gain and water loss respectively.

Conclusion

It can be concluded that one serving of high phosphorus content treatment of treated fruits can supply all men body need to phosphorus and half need of women body to the phosphorus if the recommended daily intake assumed as 800 mg/day for men and 1200 mg/day for women. On the other hand Since the amount of recommended daily intake of phosphorus is different one serving of high phosphorus content treatment of treated fruits can supply all adult body need to phosphorus and half need of children body to the phosphorus if the recommended daily intake assumed as 700 mg/day for adults and 500-1250 mg/day for children.

The treatments which have low content of phosphorus after osmotic dehydration treatment they can also provide half of body need to the phosphorus.

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