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Effect of temperature and salt concentration during osmotic dehydration of garlic cloves

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Abstract

Osmotic dehydration of garlic cloves was done by dipping the cloves in 20, 25 and 30°Bx salt solutions at 30, 40 and 50°C temperatures for 1.5 h. The effect of process parameters during osmotic dehydration such as duration of osmosis, concentration and temperature of salt solution on mass reduction, water loss and salt gain were studied. It was found that the mass reduction, water loss and salt gain increased with increase of temperature and salt concentration. The mass reduction, water loss and salt gain after osmotic dehydration was found to be in the range of 2.83 to 8.36 %, 8.26 to 15.11 % and 5.43 and 6.47 %, respectively, corresponding to experiments at low level (20°Bx, 30 ºC after 1.5 h) and high level (30°Bx, 50ºC after 1.5 h).

Key words : Garlic cloves, osmotic dehydration, salt concentration, salt gain, water loss.

Introduction

Garlic (*Allium sativum L.*) has been cultivated since ancient times all over the world especially in Asia. Garlic has medicinal properties and it is an important ingredient in the leading cuisines around the world. Garlic as a spice is utilized in both fresh and dehydrated state in the food industry. It is dehydrated into different products such as flakes, slices, and powders. India is one of the second largest producers of garlic with share of 13.2 % of worlds production. Garlic is semi-perishable spices the moisture content of products and surrounding relative humidity play an important role in maintaining its quality. Immediately after harvesting, these perishable raw materials have to be preserved against deterioration and spoilage. Garlic at harvest contains 60-65 % of moisture, and these moisture levels need to be lowered to less than 10 % for their preservation and production of different dehydrated garlic products. The selection of the drying method is dependent on the condition of the product, economy and social condition. A number of drying techniques have been used over years such as solar drying. Besides the solar drying being slow and uncontrolled process, the product obtained have unappealing colour, poor texture, taste and changed flavour, which significantly affect their acceptability. Also, another simplest and most economic method for dehydration of foods is hot air-drying in convectional tray, cabinet or vacuum dryers. But these dehydrated products have same problems associated with products qualities such as the undesirable changes in colour, texture, flavour and loss in nutritive value. There should be use of a drying technique for fruits and vegetables which can consume less reliance fossil fuels and it can reduce the moisture content of the product to a level where microbiological growth will not occur and simultaneously keep the nutritive value high in final dried product. Hence, a new method osmotic dehydration is used to water removal, at low temperature with low energy consumption. Since this process cannot remove moisture to a level that will avoid microbial growth, it is method suitable only for pretreatment. Bechaa *et al*., 2019 studied the osmotic dehydration facilitates subsequent drying of sliced garlic and found that the 15% sodium chloride at 35°C was optimal in terms of water loss, solids gain and product color. This pre dehydration allows a decrease in drying time and final moisture content. Masud *et al*., 2017 studied the osmotic development of value added garlic products through dehydration and mechanical drying and results revealed that the rate of extent of weight loss, moisture content, solid gained and normalised solid content were strongly influenced by strength of osmotic solution, immersion time and were rapid during the first 6 hrs of osmotic dehydration. It is seen that as the solution temperature increases, the moisture content at any given time decreases. In other words, the rate of mass transfer increases with the increase in temperature. Thus water loss, solid gain and normalised solid content increased with increasing temperature. The osmotic dehydration process has been studied by various researchers for many fruits and vegetables, such as carrot (Maguer, 1988),

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cauliflower (Vijayanand, *et al*., 1995), apple (Sablani, *et al*., 2002), mango (Tedjo*et al*., 2002), strawberry (Viberg, *et al*., 1998), pineapple (Silveira, *et al*., 1996), grapes (Grabowski *et al*., 1994), papaya (Ahmed and Choudhari, 1995, Chaudhari, *et al*., 2000), ginger (Patil *et al*., 2015), mushroom (Kaur *et al*., 2014), litchi (Bera and Roy, 2015) and pineapple (Dhingra *et al*., 2013). Good preservation technique for vegetables, as cell damage is minimum; high retention of flavour and nutrients resulting in product with superior organoleptic characteristics; process is quite simple, economical and does not require any sophistication; the energy requirement is 2-3 times less compared to the conventional drying are some merits of the osmotic process as indicated by above mentioned researchers. Acid removal and salt uptake by vegetables modifies the composition and improves the taste and acceptability, which is called candying effect. Therefore, a study was proposed to investigate osmotic behavior characteristic of garlic cloves.

Materials and methods

Garlic bulbs procured from local market (Udaipur market) was selected for the investigation. The good quality of garlic cloves was peeled and unwanted material like dust, dirt surface adheringwas removed.Salt solution (Sodium chloride) of desired (20, 25 and 30°Bx) concentration was prepared by dissolving required amount of salt in tap water. The total soluble solid of prepared salt solution was measured by using digital refractometer (ranges0-45, 28-62 and 45-90°Bx).The moisture content of the fresh as well as osmotically dehydrated garlic samples was determined by method as suggested by Ranganna (Ranganna, 2002). The average initial moisture content of garlic was found as 60.58% (wb).

Experimental Set up for Osmotic Dehydration

A small capacity water bath was used as osmotic dehydration unit which consist of a water bath of size 35 cm × 30 cm × 25cm (approximate capacity, 5 litres) and temperature controller probe was used to regulate the required temperature for the investigation. Fig. 1 shows the schematic diagram of osmotic dehydration unit. Experiments were conducted with a sample size of approximately 30ggarlic cloves at three concentrations (20, 25 and 30°Bx) and three temperatures (30, 40 and 50°C). The sample to solution ratio of 1:5 were kept constant for all combinations. The samples (garlic cloves) were weighed for every experiment and immersed in the salt solution (20, 25 and 30°Bx) contained in a 250 ml glass beaker. The beakers were placed inside the constant temperature water bath.

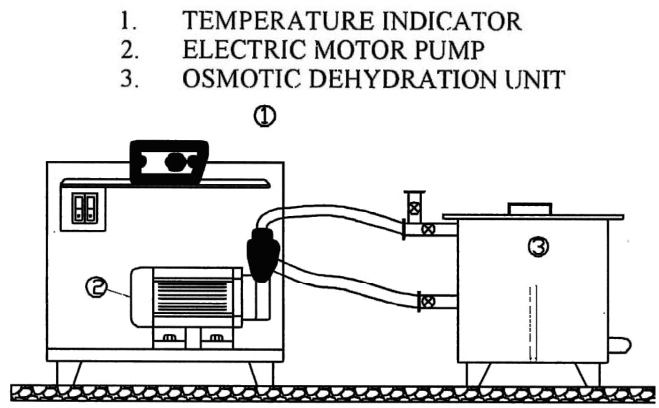

Fig. 1. Schematic diagram of osmotic dehydration unit

The solution in the beakers was manually stirred at regular intervals to maintain uniform temperature. One beaker was removed from the water bath at designated time (after every 30 min intervals), samples were taken out and placed on absorbent paper for 5 min and immediately rinsed in flowing water and placed on tissue paper to remove surface moisture to eliminate excess solution from the surface before weighing.The samples were weighed and their moisture contents were determined. All experiments replicated thrice.

The water loss (WL), salt gain (SG) was calculated on wet basis by equations 1 and 2, respectively (Silveira *et al*., 1996; Lenartand Flink, 1984; Kaleemullah*et al*., 2002). The water loss was the net weight loss of the vegetables on initial weight basis and will be estimated as

$$WL = \frac{W_i.X_i - W_\theta.X_\theta}{W_i} \quad \ldots (1)$$

The salt gain is the net uptake of salt by the cloves on initial weight basis. It was computed using following expression

$$SG = \frac{W_\theta(1-X_\theta) - W_i(1-X_i)}{W_i} x100 \quad \ldots (2)$$

The overall exchange in the salt and liquid of the sample do affect the final weight of the sample. The mass reduction (WR) can be defined as the net weight loss of the vegetables on initial weight basis.

$$WR = \frac{W_i - W_\theta}{W_i} \quad \ldots (3)$$

Where,

WL is the water loss (g $100g^{-1}$ mass of sample); WR is the mass reduction; SG is the salt gain (g $100g^{-1}$ mass of sample); W_θ is the mass of cloves after time θ, g; W_i is the initial mass of cloves, g; X_θ is the water content as a fraction of mass of cloves at time θ; and X_i is the water content as a fraction of initial mass of cloves.

Results and discussion

Effect of Different Concentrations on Water Loss

The kinetics of osmotic dehydration has been depicting the variation in water loss at various salt concentration and temperature of solution. The water loss after osmotic dehydration was found to be in the range of 8.26 to 15.11 %, corresponding to experiments at low level (20°Bx, 30°C after 1.5 h) and high level (30°Bx, 50°C after 1.5 h). The water loss increased from 0 to 8.26, 0 to 9.91, and 0 to 12.70 % when duration of osmotic dehydration increased from 0 to 1.5 h for 20°Bx at 30, 40 and 50°C temperatures, respectively. Similarly, for 25 and 30°Bx, the water loss was found to vary from 10.45, 10.97, 14.10 % and 12.8, 13.9, 15.11 at 30, 40 and 50°C temperatures, respectively (Fig.2, 3 and 4).

It can be observed that when solution temperature increased from 30 to 50°C for 30°Bx, water loss increased from 12.81 to 14.66 % after 1.5 h of osmotic dehydration causing approximately 1.85 % increment. Similarly, for 25°Bx, the water loss increased from 10.45 to 12.56 % when solution temperature increased from 30 to 50ºC resulting into 2.11 % increment. Similarly, for 20°Bx the water loss increased from 8.26 to 12.70 % when solution temperature increased from 30 to 50°C resulting into 4.44 % increment.

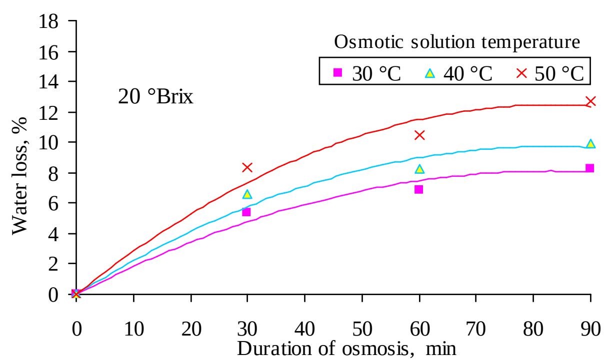

Fig. 2. Water loss with duration of osmosis at 20°Bx concentration

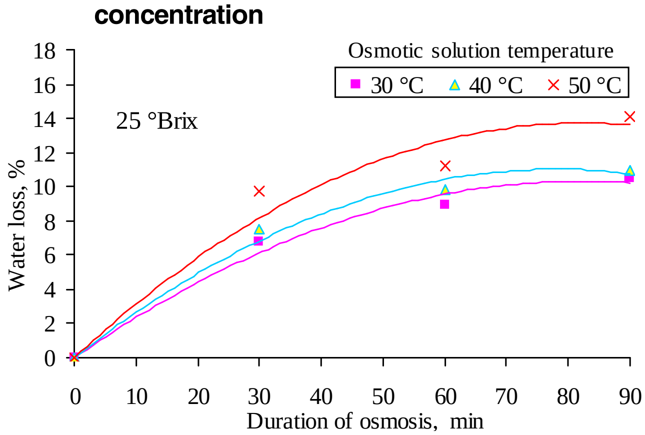

Fig. 3. Water loss with duration of osmosis at 25°Bx concentration

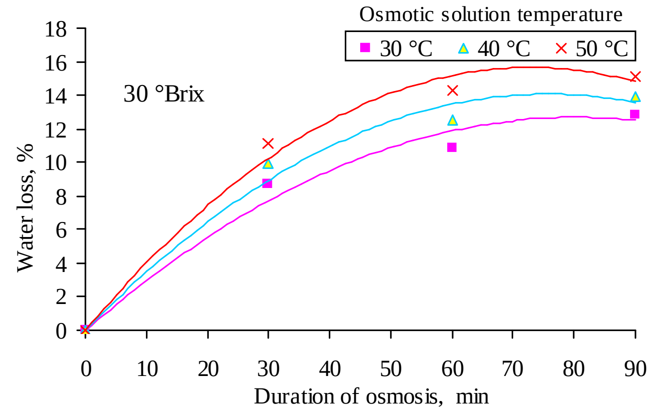

Fig. 4. Water loss with duration of osmosis at 30°Bx concentration

Effect of Different Concentrations on Salt Gain

The variation in salt gain at various salt concentrations and temperatures of solution has been illustrated in Fig. 5, 6 and 7. Similar to mass reduction and water loss, salt gain also indicates relatively smooth progression of various curves. The salt gain increased from 0 to 5.43, 0 to 5.63 and 0 to 5.80 % when duration of osmotic dehydration increased from 0 to 1.5h for 20°Bx at 30, 40 and 50ºC temperature, respectively. Similarly, for 25 and 30°Bx, the salt gain was found to vary from 0 to 5.88, 0 to 6.17, 0 to 6.34 and 0 to 6.18, 0 to 6.35, 0 to and 0 to 6.74 % at 30, 40 and 50ºC solution temperatures, respectively.

It can be observed that when solution temperature increased from 30 to 50ºC for 30ºBx, salt gain increased from 6.18 to 6.74 % after 1.5 h of osmotic dehydration showing approximately 0.56 % increment. Similarly, for 25°Bx, the salt gain increased from 5.88 to 6.34 % when solution temp increased from 30 to 50ºC resulting into 0.46 % increase. Similarly, for 20ºBx, the salt gain increased from 5.43 to 5.80 % when solution temp increased from 30 to 50ºC resulting into increase of only 0.37 %.

Effect of Different Concentrations on Mass Reduction

The kinetics of osmotic dehydration has been illustrated in Fig. 8, 9 and 10 depicting the variation in mass reduction at various salt concentration and temperature of solution. The mass reduction after osmotic dehydration was found to be in the range of 2.88 to 8.36 %, corresponding to experiments at low level (20ºBx, 30ºC after 1.5 h) and high level (30ºBx, 50ºC after 1.5h).The mass reduction increased from 0 to 2.88, 0 to 4.28, 0 to 6.9 % when duration of osmotic dehydration increased from 0 to 1.5 h for 20°Bx at 30, 40, 50ºC temperatures, respectively. Similarly, for 25 and 30ºBx, the mass reduction was found to vary from 0 to 4.56, 0 to 4.8 and 0 to 7.76 % and 6.63, 7.53, 8.36 % at 30, 40 and 50ºC temperatures, respectively.

Fig 8, 9 and 10 revealed that a low temperature-low concentration combination (30°C-20°Bx) resulted in a low mass reduction (2.88 % after 1.5 h of osmosis) and a high temp-high concentration combination (50ºC and 30°Bx) resulted in a higher mass reduction (8.36 % after 1.5 h of osmosis). This indicates that mass reduction can be increased by either increasing the solution temperature or concentration of solution. Similar results have been reported for osmotic dehydration of onions (Sagar, 2001).

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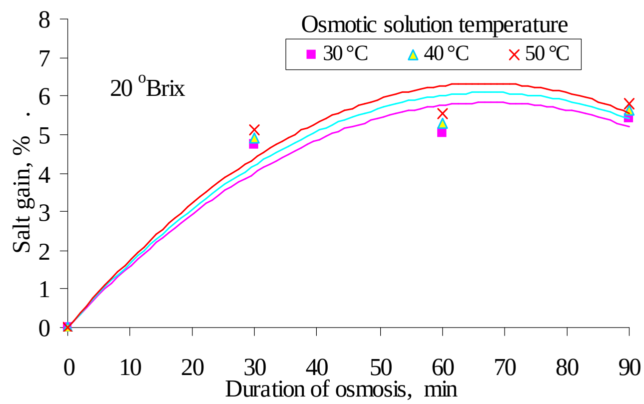

Fig. 5. Salt gain with duration of osmosis at 20°Bx concentration

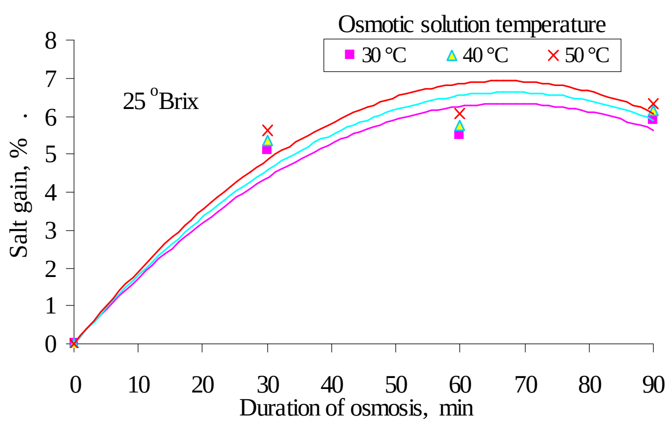

Fig. 6. Salt gain with duration of osmosis at 25°Bx concentration

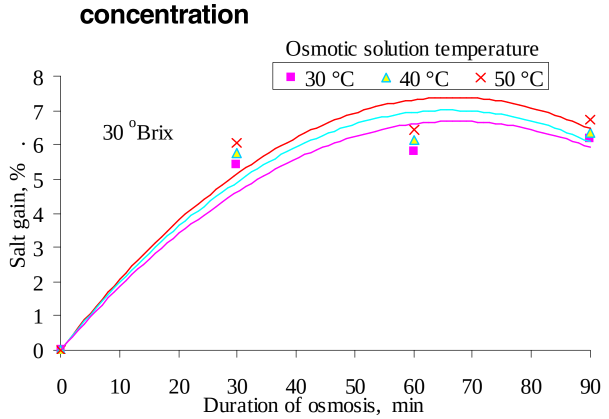

Fig. 7. Salt gain with duration of osmosis at 30°Bx concentration

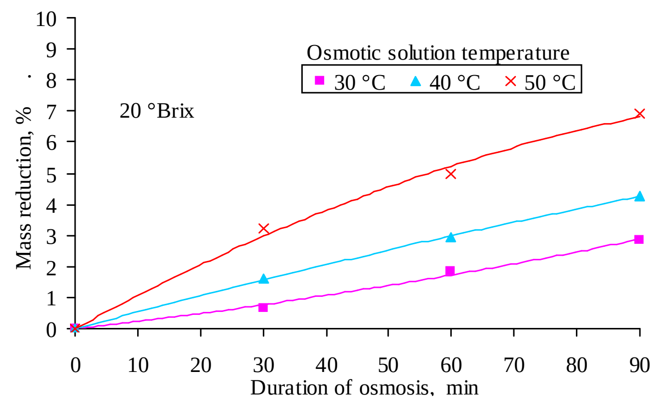

Fig. 8. Mass reduction with duration of osmosis at 20°Bx concentration

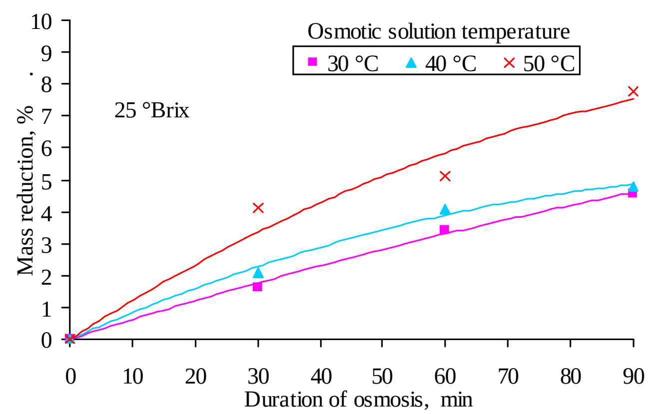

Fig. 9. Mass reduction with duration of osmosis at 25°Bx concentration

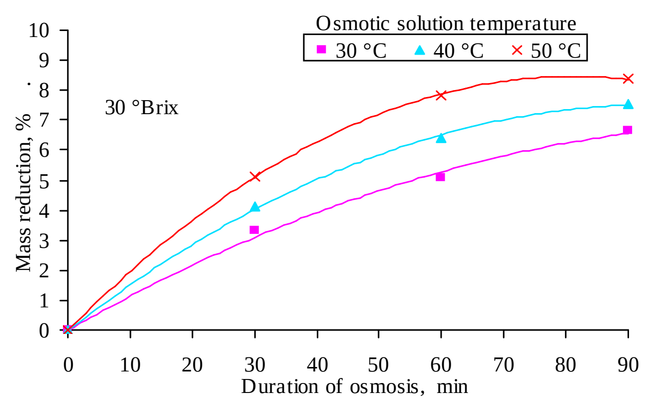

Fig. 10. Mass reduction with duration of osmosis at 30°Bx concentration

1.5 h of osmosis). This indicates that mass reduction can be increased by either increasing the solution temperature or concentration of solution. Similar results have been reported for osmotic dehydration of onions (Sagar, 2001).Evaluations of mass exchange between solution and sample during osmotic dehydration were made by using the parameters such as water loss (WL), solid gain (SG) and weight reduction (WR) were calculated by Hamledari *et al.,*2012.

Statistical analysis

The standard statistical technique ‘Analysis of Variance’ (ANOVA) was applied for the water loss, salt gain and mass reduction data from three replicates of 1.5 h osmotically dehydrated garlic samples to study the effect of process variables *viz.*, osmotic concentration and temperature on water loss characteristics. Critical difference and co-efficient of variances (CV) were evaluated for water loss and presented in Table 1, 2 and 3.

It is the revealed that combine effect of temperature and salt concentration on water loss, salt gain and mass reduction were significant with critical difference of 0.77, 0.02 and 0.38. The co-efficient of variances (CV) were 3.74, 5.44 and 2.74 for water loss, salt gain and mass reduction respectively. The combine effect of both concentrations and temperatures of osmotic solution had significant effect (at 1%) on mass reduction, water loss and salt gain.

Table 1. ANOVA for the effect of process variables on the water loss

S.No	Source	df	SS	MS	F (Calculated)	SE(m)	CD (1%)
1.	A	2	56.52	28.26	139.566**	0.15	0.61
2.	B	2	60.17	30.08	148.582**	0.15	0.61
3.	A x B	4	5.03	1.25	6.215*	0.25	0.77
4.	Error	18	3.64	0.20			

A: Osmotic concentration, B: Temperature, CV = 3.7434, **, * Significant at 1 %, 5 %

Table 2. ANOVA for the effect of process variables on the salt gain

S. No.	Source	df	SS	MS	F (Calculated)	SE(m)	CD (1%)
1.	A	2	0.96	0.48	4.439*	0.11	0.00
2.	B	2	2.97	1.48	13.657**	0.11	0.44
3.	A x B	4	0.06	0.01	0.133*	0.19	0.02
4.	Error	18	1.96	0.10			

A: Osmotic concentration, B: Temperature,CV = 5.4475, **, * Significant at 1 %, 5 %

Table 3. ANOVA for the effect of process variables on the mass reduction

S.No.	Source	df	SS	MS	F (Calculated)	SE(m)	CD (1%)
1.	A	2	43.66	21.83	823.951**	0.054	0.22
2.	B	2	37.54	18.77	708.412**	0.054	0.22
3.	A x B	4	7.02	1.75	66.316**	0.093	0.38
4.	Error	18	0.47	0.026			

A: Osmotic concentration, B: Temperature,CV = 2.7446, ** Significant at 1 %

Conclusions

Water loss from the garlic samples was observed rapid for the first half hour of osmosis and reduced subsequently with the increase of duration of osmosis. An increase in salt concentration and temperature increased the water loss and salt gain during osmotic dehydration. The highest mass reduction (8.37%) was observed for 30°Bx concentration and at 50°C temperature of salt solution.

The water loss and salt gain was within range of 15.12 and 6.75% respectively.

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