Optimization of processing conditions for osmotic dehydration of orange segments

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ABSTRACT
The orange is 5th most important tropical fruit in the world production. The juice or pulp is extracted from the oranges and preserved for further use. Whereas for fruits and vegetables, osmotic dehydration is considered as one of best method for preservation. Hence in the present research focus on optimize process conditions for osmotic dehydration of orange segments. Fresh orange fruits were peeled and segments were separated. These segments were osmotically dehydrated at different sugar syrup concentrations 40 to 70B, time 60 - 300 min. and fruit solution ratio 1:3 to 1:5. The observation recorded with respect to water loss (WL), solid gain (SG) and weight reduction (WR). The results showed 50B sugar syrup concentration, 300 min. time, and 1:4 fruit to solution ratio were optimum conditions to obtain water loss of 44.49%, solid gain 6.91% and weight reduction of 51.40%. Osmotic dehydration can be one of the alternative methods for the orange preservation than the traditional methods of food preservation. Also, it will be helpful to preserve orange segments for the longer time, which will be beneficial to small scale entrepreneur to improve their socio- economical status.

Key words: Orange, Osmotic dehydration, Solid gain, Water loss, Weight reduction.

INTRODUCTION
Orange is the most important tropical fruit in the world. India stand fifth in production of oranges after Brazil, China, United States and Mexico. Total orange production of the world was 121273.2 metric tonnes in 2015 year (FAO 2009). The leading orange producing parts in India are Punjab, Madhya Pradesh, Andhra Pradesh and Rajasthan. The processing of orange maintains its freshness and increase in shelf life which gives platform to increased commercialization. Among the all processing methods osmotic dehydration is a one of the method for increase the shelf life of orange (Sapata et al., 2009).

According to the reviewers, the immersion of fruit in concentrated osmotic agent’s solutions resulted in water loss from the immersed object to solution and solute agents the immersed object from the solution. The leaching out of the product solutes influences the composition of the final product. The solution concentration, temperature, specific period of osmotic treatment and fruit to solution ratio are those factors which affects the process of osmotic dehydration. The removal of water from food material is considered as one of best method of food preservation and removal of moisture increases the shelf life and inhibits growth of microorganisms; whereas fresh food contains higher amount of moisture. (LeMaguer, 1988; Raoult-Wack et al., 1994; Yao and Le Maguer, 1995; Panagiotou et al., 1999; Fazli and Ahani, 2010, Singh et al., 2014, Srijaya and Priya, 2017). Most of the previous studies have focused on rapid and effective removal of water from food materials with different means such as temperature, drying time, relative humidity etc.. (El-Aouar et al., 2006; Moreira et al., 2007, Ispir and Togrul, 2009; Devic et al., 2010; Bchir et al., 2011).

The purpose of this work was to study the effects of sugar syrup concentration, time and fruit to solution ratio with respect to the water loss, solid gain and weight reduction during osmotic dehydration process of orange to observe optimum osmotic dehydration conditions.

MATERIALS AND METHODS
Fully mature and ripened orange (Citrus aurantium) were obtained from the local market, Kolhapur, Maharashtra, India. Fruits were hand peeled, lobes were separate and 100g samples were taken for each set of experiments in triplicate. Moisture, total carbohydrates, crude fiber, crude protein, crude fat and total ash content were determined as standard procedure suggested by Ranganna, (1986). The orange segments were immersed in the osmotic solution (glucose syrups) of different concentration (40, 50, 60 and 70B Brix) for different times of treatment (1, 2, 3, 4 and 5 h) at 40°C. The fruit to solution ratio (1:3, 1:4 and 1:5) was maintained. After completion of osmotic dehydration process, the samples were removed from sugar syrup solution and placed as it is to drain out to excess syrup and weighed. To calculate the percent water loss (% WL), percent solid gain (% SG)
and percent weight reduction (% WR), the following equation were used (Mini and Archan, 2016).

$$ WL(\%) = \frac{(M_o \cdot m_o) - (M - m)}{M_o} \times 100 $$

$$ SG(\%) = \frac{(M - m)}{M_o \cdot m_o} \times 100 $$

$$ WE(\%) = \frac{M_o - m}{M_o} \times 100 $$

Where,

- $M_o$ = initial mass of fresh fruit prior to osmotic dehydration (g), $M$ = mass of sample after time t of osmotic dehydration (g), $m$ = dry mass of fruit after time t of osmotic dehydration (g), $m_o$ = dry mass of fresh fruit prior to osmotic dehydration (g) (Singh et al. 2008).

The Response surface methodology (RSM) software was applied to generate surface plots using a 45 days trial version of Design Expert version 8.0.7.1.

RESULTS AND DISCUSSION

The orange fruits were subjected to physico-chemical analysis and obtained results are presented Table 1. The data revealed that the orange fruits were rich in vitamin A (1098 ± 0.19 mg / 100 g) and C (28.6 ± 0.18 mg / 100 g). The results also showed that oranges were content ample amount of minerals like potassium (162 ± 0.16 mg / 100 g) and calcium (43 ± 0.12 mg / 100 g). The β-carotene (68 ± 0.13 µg / 100 g) content was high in orange fruits. Whereas, these fruits were poor source of proteins (0.68 ± 0.12%) and fat (0.18 ± 0.09 %) and moderate source of carbohydrate (11.08 ± 0.17%), particularly fruit sugar (4.09 ± 0.18%).

Topuz et al. 2005 studied four different cultivars (Alanya, Finike, W. Navel, and Shamouti) of oranges and reported that these cultivars were good source of Vitamin A and C along with minerals.

| Parameter                  | Values (g / 100g) |
|---------------------------|-------------------|
| Total Solids (%)          | 12.81 ± 0.18      |
| Total carbohydrates (%)   | 11.08 ± 0.17      |
| Crude fat (%)             | 0.18 ± 0.09       |
| Crude protein (%)         | 0.68 ± ±0.12      |
| Total ash (%)             | 0.26 ± 0.19       |
| Crude fiber (%)           | 0.38 ± ±0.16      |
| Vitamin C (mg/100g)       | 28.6 ± 0.18       |
| Vitamin A (mg/100g)       | 1098 ± 0.19       |
| Potassium (mg/100g)       | 162± 0.16         |
| Calcium (mg/100g)         | 43±0.12           |
| Magnesium (mg/100g)       | 8±0.18            |
| β-carotene (µg/100g)      | 68±0.13           |
| Reducing sugar (%)        | 4.09±0.18         |

* Each value is mean ± SD of three determinations.

The combined effect of sugar, time and fruit to solution ratio on orange fruit with respect to water loss (WL), solid gain (SG) and weight reduction (WR) are shown in Figure 1a-3c. The maximum water loss of the osmotic dehydrated orange sample was 45.46%, 51.40% and 50.18%, while minimum was 7.23%, 9.54% and 12.63% when fruit to solution ratio was 1:3, 1:4 and 1:5 (Figure 1a, 2a and 3a), respectively. As the immersion time (60 min. to 300 min.) of fruit into sugar syrup increased, there water loss was increased continuously at constant temperature. The maximum WL and minimum SG was more effectively seen at 50°B as compared to the sugar syrup concentration 60°B. Water loss increased constantly with increase in sugar syrup concentration, time and fruit to solution ratio. Also, from the results it was seen that the increase in time leads to more water loss most.

Osmotic dehydration is a water removal technique, which is generally applied to horticultural products such as fruits and vegetables. Immersion of food materials in hypertonic or high concentrated solutions lids to modify some food properties. The osmotic solution was made of salt or different types of sugars or in sometimes combination may be used (Fazli and Ahani, 2010).

The maximum solid gain observed during osmotic dehydration was 11.99%, 11.97% and 12.01% while minimum was 1.69%, 1.44% and 1.37% with respect to 1:3, 1:4 and 1:5 fruit to solution ratio (Figure 1b, 2b and 3b), respectively. When sugar syrup concentration was increase from 40°B to 70°B, the solid gain was decreased. As the immersion time of fruit into sugar syrup was increased from 120 min. to 300 min., there was significant decrease in the solid gain, whereas increase in fruit to solution ratio did not showed any significant effect on solid gain at constant temperature.

The effect of the kind and concentration of solutes on the solid gain of plant tissues during osmotic process has been reviewed by Lazarides (2001) and stated that it was dependent on the product characteristics. The observed effects in orange segments may be inuence of solution viscosity and hydrodynamic mechanisms in the tissue pores, which was greatly contributes to solute gain (Chafer et al. 2001). In highly diluted OS, this viscous eûect on solute gain might not be evident due to the fact that the hydrodynamic gain of solution did not represent a notable solute gain, as seems to occur with treatments Giraldo et al. (2003).

The minimum values are 2.74%, 3.43% and 4.30 as well as maximum values are 38.46%, 44.49% and 43.21% for weight reduction was observed with respect to fruit to solution ratio 1:3, 1:4 and 1:5 (Figure 1c, 2c and 3c), respectively. When sugar syrup concentration and immersion time span of fruit into syrup was increased, the weight
Fig 1a-c: Response surface plots showing effect of sugar and time on (a) water loss (b) solid gain (c) weight reduction for F:S ratio 1:3 with constant temperature 40°C
Fig 2a-c: Response surface plots showing effect of sugar and time on (a) water loss (b) solid.
Fig 3a-c: Response surface plots showing effect of sugar and time on (a) water loss (b) solid gain (c) weight reduction for F:S ratio 1:5 with constant temperature 40°C.
reduction was increased. With increase in fruit to solution ratio, the weight reduction increased and the difference in the weight reduction was significantly observed in between 50%B and 60%B of sugar syrup concentration. As the immersion time period of osmotic dehydration increased, the weight reduction also increased and this was more significant to the fruit to solution ratio. This behaviour agrees with the coupling of diffusion and hydrodynamic mechanism at the beginning of the process that implies fluctuations in water and sugar fluxes, whereas when osmotic-diffusion mechanisms control mass transfer, the opposite sugar–water fluxes was almost balanced Giraldo et al. (2003).

CONCLUSION

Orange segments were osmotically dehydrated in different sugar syrup concentration of 40%B-70%B for dipping time of 60-300 min. with fruit to solution ratio 1:3-1:5. The observation was recorded in terms of WL, SG and WR and results were noted in the range of 7.23 to 51.40% for water loss, 1.37 to 12.01% for solid gain and 2.74 to 44.49% for weight reduction. The results reviewed that, the optimum WL, SG and WR, i.e. 51.40%, 6.91% and 44.49%, respectively was recorded at sugar syrup concentration 50%B, fruit to solution ratio 1:4, time 300 min. with constant temperature 40°C. This will be benefited to set parameters for osmotically dehyerdrate of oranges segments.

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