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# Osmotic Dehydration–A Novel Drying Technique of Fruits and Vegetables–A Review

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**Abstract—***Drying is an oldest method of fruits and vegetable preservation for enhancing its shelf life. To reduce the energy utilization and operational cost new dimensions came up in drying techniques. Among them osmotic treatment describes a preparation step to further processing of fruits and vegetables. Osmotic dehydration (OD) is a combination of dehydration and impregnation technique which can modify the functional properties of food materials to create new products utilizing the principle of osmosis. It is the removal of nearly 50% moisture from a produce by placing it in a concentrated osmotic solution. This process involves simultaneous moisture loss and solid gain when immersing in osmotic solutions and results in partial drying. OD involves unique processing steps like osmotic drying for removing 50% of moisture from the product and remaining moisture removal by air drying, vacuum dehydration, freeze drying etc. This helps to retain its colour, flavor, organoleptic characters and also prevents the structural collapse making it a fresh like produce. Osmotic dehydration is not receiving much attention in the food industry due to the lack of under lying principles associated with the counter current flow to improve industrial implementation of this technology. The different aspects of osmotic dehydration technology like, raw material, pre-treatments, osmotic agents, temperature & concentration of osmotic solution as well as the benefits and constraints of the osmotic dehydration process are reviewed in this paper.*

## 1. INTRODUCTION

India has become the 2nd largest producer of fruits and vegetables [26]. But, the magnitude of postharvest loss accounts to be 18.0% for fruits and 12.7% for vegetables [14]. The gap exists between production and net per capita availability of fruits and vegetables can be bridged up by extending the shelf life of fresh produce which is a costly affair or by preserving it for future use by different methods of which drying is the oldest, simplest and the cheapest method.

'Drying' and 'dehydration' means removal of water, the former being done under the influence of solar energy or wind and the latter by the application of artificial heat under controlled conditions of temperature, humidity and air flow [36]. According to Sharma [33] drying procedures involves 3 stages.

1. Pre-drying treatments
2. Drying of commodity
3. Post-drying treatments

Pre-drying treatments include raw material selection, washing, peeling, size reduction, blanching, sulphuring etc. The choice of drying method depends upon various factors such as type of product, availability of dryer, cost of dehydration and final quality of desiccated product. Fruits are said to be dried when no moisture or stickiness exists and attains moisture content of 10-20% whereas vegetables turn brittle with 6-8% moisture content. Dried product can be packed in small amounts in suitable packages which protect the product against moisture, light, air, dust etc. Dried food packages can be stored preferably under lower temperature which increases the shelf life of product. In general, the storage temperature should be below $25^0$C to maintain taste, colour and water rehydration ratio [37].

## 2. OSMOTIC DEHYDRATION

Novel drying technologies include osmotic dehydration, spray drying, freeze drying, microwave drying, infra-red radiation drying, electric or magnetic field drying, superheated steam drying, explosion puffing, foam mat drying and acoustic drying [17]. Research on osmotic dehydration has gained momentum in our country.

Maftoonazad [21] defined osmotic dehydration (OD) as a 'dewatering and impregnation soaking process' (DISP), a combination of dehydration and impregnation which can modify the functional properties of food materials, thereby creating new products. It is the removal of nearly 50% moisture from a produce by placing it in a concentrated osmotic solution. The principle of OD is osmosis – process of diffusion of water from dilute solution (produce) to the concentrated (osmotic) solution through the semi – permeable cell membrane. It is often applied as a pre-processing step before foods are subjected to further processing techniques such as air drying [25], vacuum drying [8], freezing [28], sun drying, pasteurization or acidification and coating by edible surface layers [11].

## 3. FACTORS AFFECTING OSMOTIC DEHYDRATION

Success of OD process depends on several factors [24]. They are, raw material characters, pre – treatments, nature, temperature and concentration of osmotic solution, agitation, immersion time and raw material to osmotic solution ratio.

### 3.1 Raw material characters

#### 3.1. a. Variety and maturity

The variety and maturity of fruits and vegetables mainly control water loss and solid gain in the osmosis process [40]. Among different varieties of mango Dashehari and Totapuri at ripe stage were found suitable for osmotic dehydration [39]. Papaya variety Taiwan Red Lady was found suitable for OD at hard ripe stage [13]. Rasheed [30] prepared banana fig from 3 cultivars- Nendran, Red banana & Palayankodan and founded Red banana is suitable for it. Red banana was best with regard to taste. Nendran maintained quality during storage. The TSS, sugar and moisture content increased during storage while, acidity, vitamin C, total caroteinoids and organoleptic quality decreased during storage. The product was found acceptable up to 5 months. Microbial growth was more at the end of $5^{th}$ month for all the three cultivars**.**

#### 3.1. b. Size, shape and thickness of fruit pieces

Use small fruits as such, bigger fruits can be cut into slices, discs and cubes which increases the surface area for osmosis [7]. Jalalli *et al.* [16] reported that round sliced osmodehydrated banana was preferred with highest sensory score than longitudinal slices. Carrot [3], onion [38] and watermelon [9] are cut into cubes, slices or slabs respectively whereas green peas is cut into cylinders of 6cm length and 8 ± 0.5mm diameter [35]. In general, a sample size of 3 mm to a maximum of 10 mm in rectangle, ring or cube shape was suggested for the use in osmotic dehydration process [3].

### 3.2 Pre-treatments

Different pre-treatment methods have been developed for fruit drying, among which are lemon juice, salt solution, honey dip, ascorbic acid, sulfuring and blanching [18]. If no pre-treatment is done, the fruits will continue to darken after they are dried. Pre-treatment dip of slices in CaCl2 solution improved textural and sensory qualities of osmotically dehydrated papaya slices [15]. Calcium lactate treatment is a potential alternative to calcium chloride for improvement the texture of cantaloupe since it provided tissue firming without providing undesirable bitterness [27]. The blanching treatment in cauliflower was standardized with hot water blanching at 100°C/ 3–5 min followed by dipping into 0.2% potassium metabisulphite solution for 10 minutes [13]. Dipping the papaya and mango slices in 0.4 percent ascorbic acid solution or 0.4 per cent ascorbic acid + 0.1 percent KMS solution for 30 minutes prior to osmosis process affected to obtain a high acceptable product [3].

### 3.3 Osmotic agent

The most commonly used osmotic agents were sucrose, glucose, sodium chloride (vegetables) calcium chloride, lactose, malto dextrin, corn syrup and mixtures of these items. Ferrari and Hubinger [10] reported that melon pieces treated with maltose solutions showed higher water loss and lower sugar uptakes throughout processing than those treated with sucrose. The incorporation of sugars improved the colour stability during air dehydration, with sorbitol showing the highest protective effect in case of apricots [31]. For onion slices 20% salt concentration at 28°C solution temperature for 1 hour was found optimum for further drying of onion slices [38].

### 3.4 Temperature of osmotic solution

Higher process temperatures generally promote faster moisture loss through better mass transfer characteristics on the surface due to lower viscosity of the osmotic medium [29]. It is reported in tomato by Baroni *et al.* [2] and carrot cubes by Singh *et al.* [34]. Although the rate increased with temperature, it was limited up to 60 0C as higher temperature destroyed the cell membranes. Lee *et al.* [20] reported an optimum of 58-$60^0$C sucrose solution for pumpkin slices.

### 3.5 Concentration of osmotic solution

Higher concentration obviously results in a more rapid moisture loss and solids gain. Phisut *et al.* [27] observed a stepwise increment in concentration of osmotic solution would promote an increase in solid gain on cantaloupes. For Kiwi fruits 60% sucrose concentration at 30-$40^0$C for 150 minutes osmotic time [22] whereas for cauliflowers 10% NaCl solution at 60°C for 6 hours [13] is recommended.

### 3.6 Agitation of osmotic solution

If syrup viscosity is high agitation will be necessary in order to decrease the resistance to mass transfer on the solution side which increases the rate of osmosis. During osmotic dehydration of tomato, agitation speed positively influenced water loss throughout the process [21].

### 3.7 Immersion time

At a constant concentration, the increase of the immersion time resulted in the increase of water loss, but the rate of increase was decreased in mango and pineapple slices reported by Tiwari and Jalali [39]. Maximum rate of mass transfer occurs within the first two hours of the osmotic treatment. For OD pumpkins the optimum immersion time is 108-155 minutes at 59-60$^{0}$ B sucrose solution [20] and for bittergourd slices 10% NaCl solution at 60°C for 90 minutes is sufficient [13].

### 3.8 Raw material to osmotic solution ratio

With an increase in solution to sample ratio, the rate of osmosis increases up to a certain extent. However, it is essential to use an optimum ratio since large ratios offer practical difficulties in handling the syrup fruit mixture for processing. A ratio of 1:2 or 1:3 is optimum for practical purposes. For OD guavas high fructose corn syrup at 76 degree B and 2:1 syrup to fruit ratio were selected as osmotic solution [12].

### 3.9 Kinetics of osmotic dehydration

The movement of water (from raw material to solution) and solutes from solution to the raw material is called kinetics of mass transfer. Falade *et al.* [9] studied mass transfer kinetics of water melon slabs and reported that water loss and solid gain is high for high solution concentration and temperature and low for high slice thickness. He reported 10mm slabs in 60$^{0}$B sugar syrup at 40$^{0}$C is optimum for OD watermelons (Figs. 1, 2 & 3).

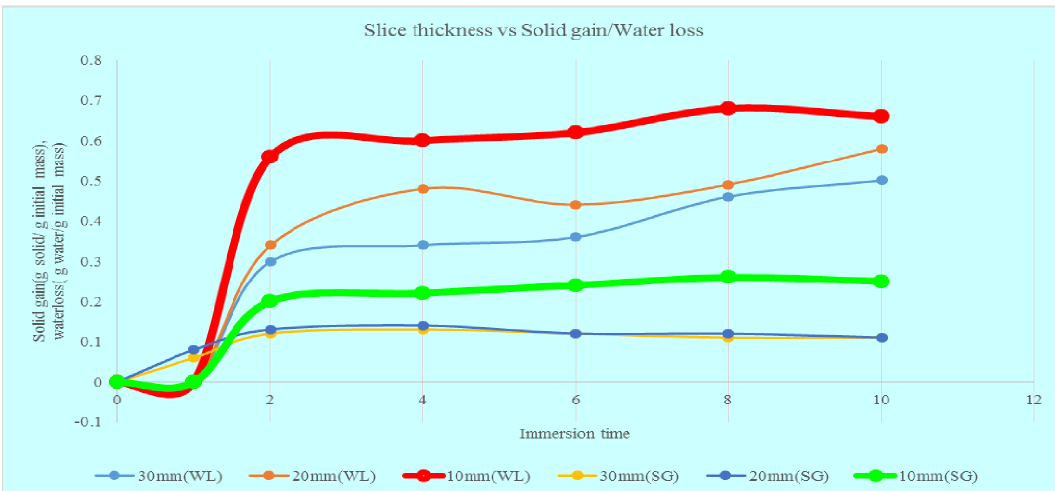


**Fig. 1: Effect of slice thickness on mass transfer kinetics**

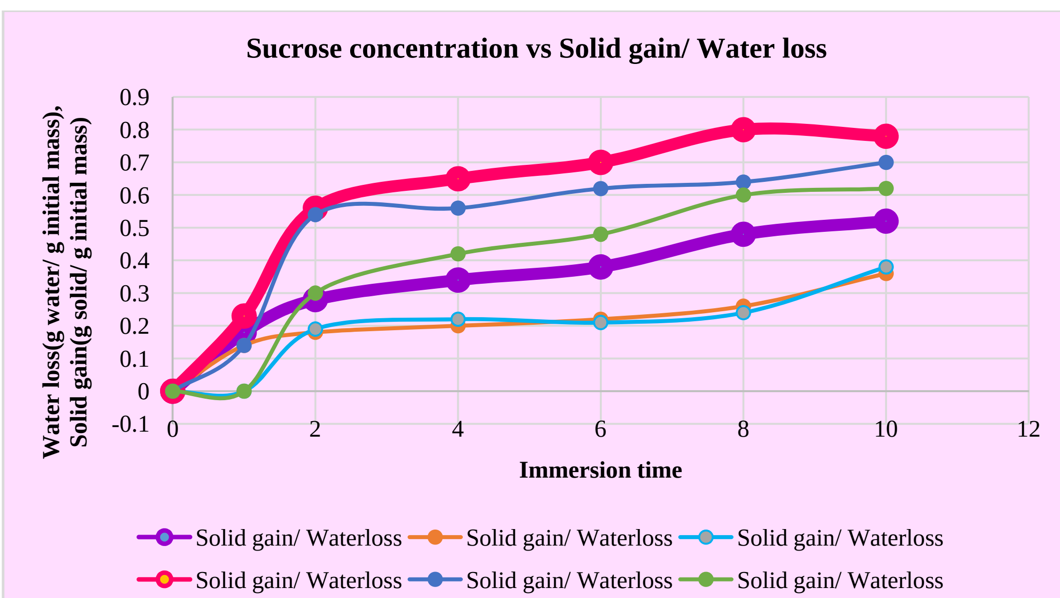


**Fig. 2: Effect of sucrose concentration on mass transfer kinetics**

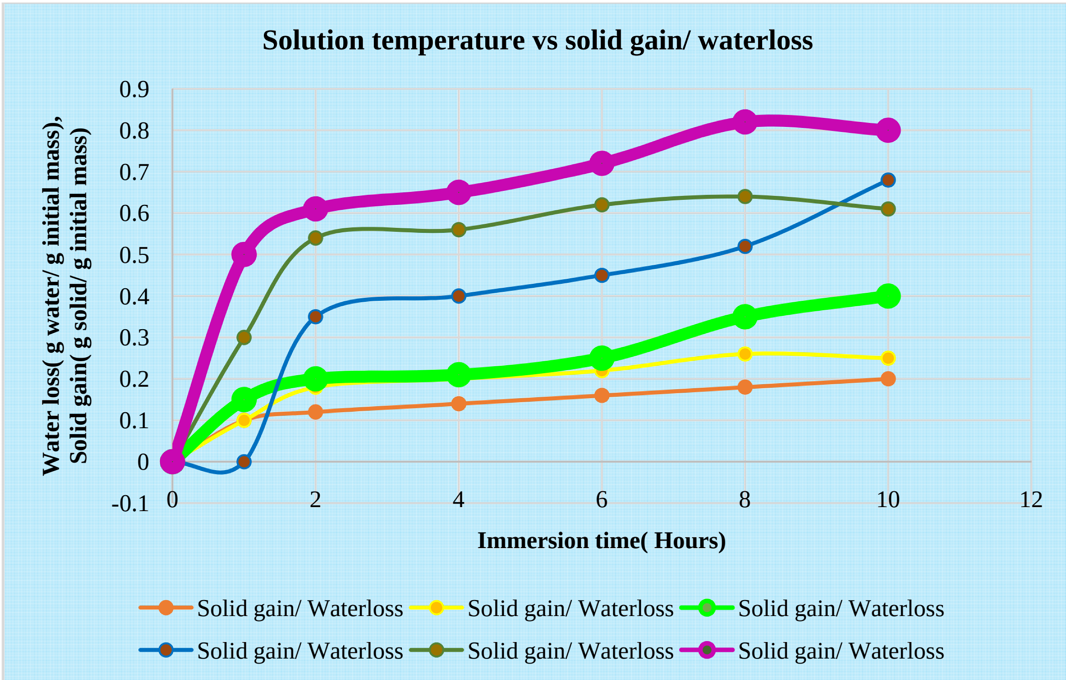


**Fig. 3: Effect of solution temperature on mass transfer kinetics**

OD helps the product to remove nearly about 50% of moisture, to get a stable product it has to be followed with other drying methods like convective drying, freezing, vacuum drying etc. Of these freezing has been reported to be yield firmer and tougher strawberries [5] and watermelon slabs with good colour, texture and lycopene content [6].

Product yield was 32.5% and 38.9% for OD papaya var. Taiwan Red slices and Alphonso mangoes respectively [15].

Mini and Archana [23] studied the osmotic dehydration kinetics of cashew apple by blanching 10mm slices in 375ppm $SO_2$ for 30 seconds and immersed in $60^0$ Brix honey solutions at $50^0$C containing 375ppm $SO_2$ and 0.3% citric acid for 24 hours. Dehydrate at $50^0$C till 15-20% moisture content. The product was then stored under MAP with $N_2$ in laminated pouches.

## 4. PACKAGING AND STORAGE

Aluminum foil, laminated polypropylene pouches are suggested as ideal packing materials [32]. Ahemed and Choudhary [1] used high-density polyethylene pouches for osmo-dried papaya which gave a shelf life of six months at ambient conditions. Storage studies of osmodehydrated banana slices in polypropylene covers by Chavan *et al.* [4] reported a shelf life of six months under ambient conditions. OD Amrapali mango slices can also have six months shelf life when it is stored in 250 guage COEX nitrogen packing and followed by low temperature ($7^+/_-1^0$C) [19].

## 5. BENEFITS OF OSMOTIC DEHYDRATION

Chavan and Amarowicz [3] suggested that OD minimizes the effect of temperature on product & preserves the wholeness. Retains colour, flavor and organoleptic qualities especially when sugar syrup is used as osmotic agent. It prevents the enzymatic browning and inhibits activities of polyphenol oxidases. It improves the texture and rehydration properties. Product gets a candying effect and is ready to eat. Product volume reduces and thus saves cost of storage and transport. It protects against the structural collapse of the product and retain the shape of the dehydrated products. Moreover the process is quite simple and economical (energy requirement is 2-3 times less as compared to the conventional drying).

## 6. CONSTRAINTS IN OSMOTIC DEHYDRATION

Maftoonazad [21] reported that the process lack precise control and design. Also syrup management is a constraint since composition of the osmotic solution will change. Damage to the cells and development of off-flavor may occur due to longer processing time and reuse of osmotic solution. Fruits or vegetable pieces may break during agitation. Moreover, the viscosity of the osmotic solution exerts considerable mass transfer resistance, causing difficulty in agitation and adherence of the solution to the surface of the food material.

## 7. CONCLUSION

20% of the world perishable crops are dried. Dried foods are high in energy, fibre and carbohydrates and low in fat making them healthy food choices. Dried food could be consumed directly or treated as secondary raw material. The novel 'rainbow concept of diet' has considered it as a good ingredient. Also OD fruits & vegetables are good companion with breakfast cereals, confectionaries etc. Since, these demands good quality, novel products the process has achieved newer dimensions with several innovations.

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