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# Techno-economic feasibility for cottage level production of osmo-convective dried orange slices

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## Abstract
In the present investigation, the study was undertaken for techno-economic feasibility for cottage level production of osmo-convectively dried orange slices with peel. Osmotic dehydration is a preservative method that offers a high quality product, which produce shelf stable products and can be used during off- season. Optimization of process parameters was done using Design Expert software. The optimum process parameters obtained by computer generated response surfaces and contour plot interpretation were: sugar concentration (59ºBrix), sugar syrup temperature (50 °C) and immersion time (4h) for maximum water loss and targeted sugar gain. The drying temperature was standardized at 60 °C on the basis of phsico-chemical and sensory parameters. The coextruded packaging material was found to be the most effective packaging material for better storability of osmo-convective dried orange slices. The total capital investment for production of osmo-convective dried orange slices was Rs. 787094 for 6 months. Total cost of production of 1 kg of osmo-convective dried orange slices was found as Rs. 525. Further the net profit of Rs. 52617.66/month was noted for production of osmo-convective dried orange slices. The benefit cost ratio and breakeven point was observed 1.4 and 43.76%, respectively for the production of osmo-convective dried orange slices.

**Keywords:** Orange slices, optimization, osmotic dehydration, packaging

## Introduction
Orange (*Citrus reticulata* Blanco) is most common among citrus fruits grown in India. It is commonly known as Narangi or Santra belongs to the family *Rutaceae*. It is among the popular fruit and of a high economical value. Oranges are cherished around the globe due to their nutritional value, physicochemical properties, natural antioxidants, and sensory attributes. The natural polyphenols in oranges comprise some bioactive compounds like hesperidins, vitamin C, carotenoid, naringin and ferulic acid. It boost your immune system and improve skin, it also aid with heart health, cholesterol levels. It may additionally help to reduce the risk of respiratory diseases, certain cancers and rheumatoid arthritis (Okwu, 2008) [3]. Recently, more attention has been dedicated to the utilization of fruit byproducts processing. The use of byproducts is of interest due to its essential functional and nutritional properties, available at lower costs and reducing industrial environmental contamination.

Orange is seasonal, and has a limited shelf life at ambient conditions. It creates heavy glut during production season and becomes scanty during off season. Limited shelf life coupled with inadequate processing facilities resulted in heavy revenue loss in the country. It is a food with high content of healthy nutrients and it has great tradition and economic importance. Orange and its peels contain essential nutrient (Vitamin C, calcium, Iron, magnesium, zinc, copper, potassium, phosphorous) that make it an excellent diet for keeping the body fit and healthy. Therefore the development of new products from orange with peel would be a good way to promote the consumption of this fruit, improving the nutritional health of society.

Osmotic dehydration is a process in which partial water is removed by immersion of water containing cellular solid in a concentrated aqueous solution of soluble solute (Singh *et al.*, 2008) [4]. Drying and dehydration is one of the most important techniques that are widely practiced. So, there is a need for simple and inexpensive process to offer a way to make this product available during off season. Therefore, novel techniques for drying and, more recently combination-based dehydration techniques have been adopted to make an impact commercially.

The osmotic dehydration (OD) has been widely used for conservation and design of new products from fruits. This treatment depresses the food water activity and improves the biochemical and microbiological stability. Hence processing of orange to make it a value added product with longer shelf life would help in proper utilization of surplus oranges, to satisfy the increasing demand for processed food in urban areas and at the same time to create new entrepreneurship. Further, this would help to reduce the bulkiness, which facilitates packaging and transportation. Nowadays there is huge demand for high quality products in the food market and osmo-convective dried orange slices could be very appreciated by consumers.

## Materials and Method

### Materials

Fresh, ripe, firm oranges (variety- Nagpur Mandarin) were purchased from local market of Nagpur (Maharashtra). Sugar and packaging materials for analysis were procured from local market of Parbhani (Maharashtra).

### Process design

The process of production of osmo-convective dried orange slices with peel were carried out on the basis results the optimum levels of process variables. The selected variety of Nagpur oranges were washed with water and unwanted material like dust, dirt, and surface adhering were removed. The oranges were cut with peel using a sharp stainless steel knife into circular slices of approximate 5 mm ± 1mm thickness. The initial moisture content of raw and treated orange slices was determined by using oven method (AOAC, 2012) [1].

Osmotic dehydration was done in sugar solution with concentrations of solution during the experiments (59°Brix). The sample to solution ratio was constant 1:5 (w/w). The orange slices were individually weighed and submerged in the sugar solution in a temperature (50ºC). The agitation was necessary to improve mass transfer and maintain uniform concentration. The samples were removed from the solution at time intervals of 4 h (Thakre *et al*., 2019) [6]. The orange slices were drained after removing from sugar solution and the excess solution at the surface of orange slices adhered with tissue paper for subsequent weight measurement. To make it shelf stable it was dried in hot air dryer at 60°C drying temperature and packed by using COEX packaging material by vacuum sealing for 150 days at ambient temperature.

### Experimental setup for osmotic dehydration

A laboratory model osmotic dehydrator (Fig.1) was used in all the dehydration experimental studies. The osmotic dehydrator comprised of a dehydrating chamber, heating unit, stirrer and sieve. The details of the osmotic dehydrator are described below:

### Osmotic dehydrating chamber

It consists of two stainless steel (SS-304 food grade) intrinsic cylindrical containers of 3 mm thickness with an inlet and outlet opening at the top and back side of instrument. An adjustable speed axial flow stirrer was provided on the middle side of osmotic dehydrating chamber for controlling the speed of stirrer. A heating unit (induction coil) for increasing the syrup temperature was also provided. The inner stainless steel cylindrical container is removable. The sample after processing is removed by removing the inner cylinder.


**Fig 1:** Osmotic Dehydrator

### Heating unit

It consisted of an electric induction coil of 1000 watt placed below the dehydration chamber. A thermostatic controller was used in the heating unit for controlling the temperature of the sugar syrup inside the osmotic dehydrator. The temperature of the sugar solution was preset and it was controlled through a temperature indicator cum controller provided on the control panel of the osmotic dehydrator. It controlled and maintained the temperature of sugar solution by controlling the power supply to the heating unit.

### Stirrer

An axial flow stirrer with 150 mm in length was provided at the centre of dehydrating chamber to rotate inside the dehydrating chamber. This caused effective in dehydration of the product. The stirrer was operated by a single phase, 20 Watt AC motor. The revolution per minute was varied with the help of speed regulator provided at the control panel.

### Sieve

A stainless steel square shaped sieve having dimension 170×170 mm is used inside the dehydrating chamber, which help to avoid the floating of orange slices on the top of sugar solution.

### Cost analysis of osmo-convective dried orange slices

Cost analysis of osmo-convective dried orange slices was estimated. Production cost was computed by considering cost of raw material, processing, electricity charges and packaging materials.

$$\text{Benefit cost ratio} = \frac{\text{Benefit}}{\text{Cost of production}}$$

$$\text{Break} - \text{even point (BEP)} = \frac{\text{Fixed cost}}{\text{Fixed cost} + \text{Net profit/year}} \times 100$$

## Results and discussion

### Cost estimation of osmo-convective dried orange slices cottage level

Table 1 shows the cost analysis for production of osmo-convective dried orange slices considering a capacity of 10Kg/day. The cost for production of osmo-convective dried orange slices was calculated for 6 months (seasonal fruit) by taking into consideration the cost of all the inputs used and all the expenditure involved. The prototype of osmotic dehydrator was developed for production of osmo-convective dried orange slices and it can be used for osmotic dehydration of all the fruit and vegetable.

The designed osmotic dehydrator is the laboratory level model having capacity 17 liter, which is not feasible for production of osmo-convective dried orange slices at cottage level. Considering the osmotic dehydrator having capacity of 135 liter for production of osmo-convective dried orange slices of 10Kg/day and computed the economic aspects for production of osmo-convective dried orange slices at cottage level should be feasible. The osmotic dehydrator is operated for 4 hours/day for osmotic dehydration. Sugar is used as an osmotic agent for osmotic dehydration of orange slices. 86 kg sugar is required for preparation of syrup (59 ˚Brix) for production per 10Kg/day osmo-convective dried orange slices. Total 8 to 9 cycles that prepared syrup can reuse by adjusting its total soluble solids (TSS) by adding sugar (Sapata *et al*., 2009) [5]. After osmotic dehydration orange slices were dried in tray dryer. For osmotic dehydrator, tray dryer and other electrical appliances consume 40 units of electricity per day.

**Table 1:** Cost analysis of osmo-convective dried orange slices with peel

| S. No | Particulars | Quantity / day | Quantity/ Month | Rate (Rs) | Total cost (Rs) |
|---|---|---|---|---|---|
| | **Assuming 25 working days/month** | | | | |
| A | **Raw material for production of 10 Kg/day Osmo-convective dried orange slices** | | | | |
| 1 | Oranges, Kg (considering 5% losses during slicing) | 30 | 750 | 50 | 37500 |
| 2 | Sugar, Kg (8 to 9 times syrup used) | 86 | 270 | 42 | 11340 |
| 3 | Packaging & Labeling (4 packets of 250gm/kg) | 40 | 1000 | 5 | 5000 |
| | | | | Sub Total (A) | 53840 |
| B | **Labor cost** | | | | |
| 6 | Skilled labor for operating machine @ Rs.500/day | | 1 | 500 | 12500 |
| 7 | Unskilled labor for packaging & marketing @ Rs.300/day | | 1 | 300 | 7500 |
| | | | | Sub Total (B) | 20000 |
| C | **Other basic requirement** | | | | |
| 8 | Electricity (Rs.10/unit) | 45 units | 1125 units | 10 | 11250 |
| 9 | Water charges | | | | 5000 |
| 10 | Shade rent | | | | 25000 |
| | | | | Sub Total (C) | 41250 |
| | **Working capital (Monthly)** | | **Sub Total (A+B+C)** | | **115090** |
| **D** | **Total capital investment (Rs)** | | | | |
| **D (I)** | **Equipment's & Utensils** | | | | |
| 14 | Osmotic dehydrator | | 1 | 80000 | 80000 |
| 15 | Heat sealing machine | | 1 | 5000 | 5000 |
| | Vacuum packaging machine | | | 60000 | 60000 |
| 16 | Weighing balance | | 1 | 7000 | 7000 |
| | Tray Dryer | | 1 | 50000 | 50000 |
| | Deep freezer | | 1 | 40000 | 40000 |
| 17 | Utensils | | | 8000 | 8000 |
| 18 | Furniture | | | 20000 | 20000 |
| 19 | Advertisement & Publicity | | | 3000 | 3000 |
| 20 | Transportation | | | 2000 | 2000 |
| | | | | Sub Total D(I) | 275000 |
| **D (II)** | **Working capital for 6 months** | | | | |
| 21 | Working capital for 6 months | | 6 | 115090 | 690540 |
| | | | | Sub Total D(I) | 275000 |
| | **Total Capital Investment** | | **Sub Total D (I+II)** | | **965540** |
| **E** | **Production Cost (6 month)** | | | | |
| 22 | Working capital for 6 months | | | | 690540 |
| 23 | Depreciation cost of equipment's @ 10% | | | | 27500 |
| 24 | Interest @ 10 % on working capital investment for 6 month | | | | 69054 |
| | | | | Sub Total E | 787094 |
| **F** | **Cost analysis** | | | | |
| 25 | Total cost of production/6month | | | | 787094 |
| 26 | Total cost of production/month | | | | 131182.33 |
| 27 | Total cost of production/day | | | | 5247.29 |
| 28 | Total cost of production/Kg | | | | 525 |
| **G** | **Returns (Rs)** | | | | |
| 29 | Sale @735/Kg | | | | 1102500 |
| 30 | Net profit/ 6month | | | | 315706 |
| 31 | Net profit/month | | | | 52617.66 |
| 32 | Net profit/day | | | | 2104.70 |
| **H** | **B/C ratio** | | | | |
| | Benefit/cost | | | | 1.40 |
| **I** | **Breakeven point (BEP)** | | | | |
| 33 | Depreciation cost of equipment's @ 10% | | | | 27500 |
| 34 | Interest @ 10% on working capital investment for 6 months | | | | 69054 |
| 35 | 40 % Labour cost (Salary ) | | | | 48000 |
| 36 | 40 % Other basic requirements | | | | 96000 |
| | | | Fixed Cost | Sub Total I | 240554 |

| | | | | | |
|---|---|---|---|---|---|
| 37 | Fixed cost | | | | 240554 |
| 38 | Net profit / 6 month | | | | 315706 |
| | BEP = {(Fixed cost x 100) / (Fixed cost + Net profit/6 month)} | | | | |
| | Breakeven point (BEP) | | | | 43.24% |

It is clear from the Table 1 that, the total capital investment for production of osmo-convective dried orange slices was Rs. 787094 for 6 months. Total cost of production of 1 kg of osmo-convective dried orange slices was found as Rs.525. Selling price of osmo-convective dried orange slices was assumed per Kg Rs.735/kg. Further the net profit of Rs. 52617.66 /month was noted for production of osmo-convective dried orange slices. The benefit cost ratio and breakeven point was observed 1.4 and 43.24%, respectively for the production of osmo-convective dried orange slices.

**Standardized flow chart for production of osmo-convectively dried orange slices**

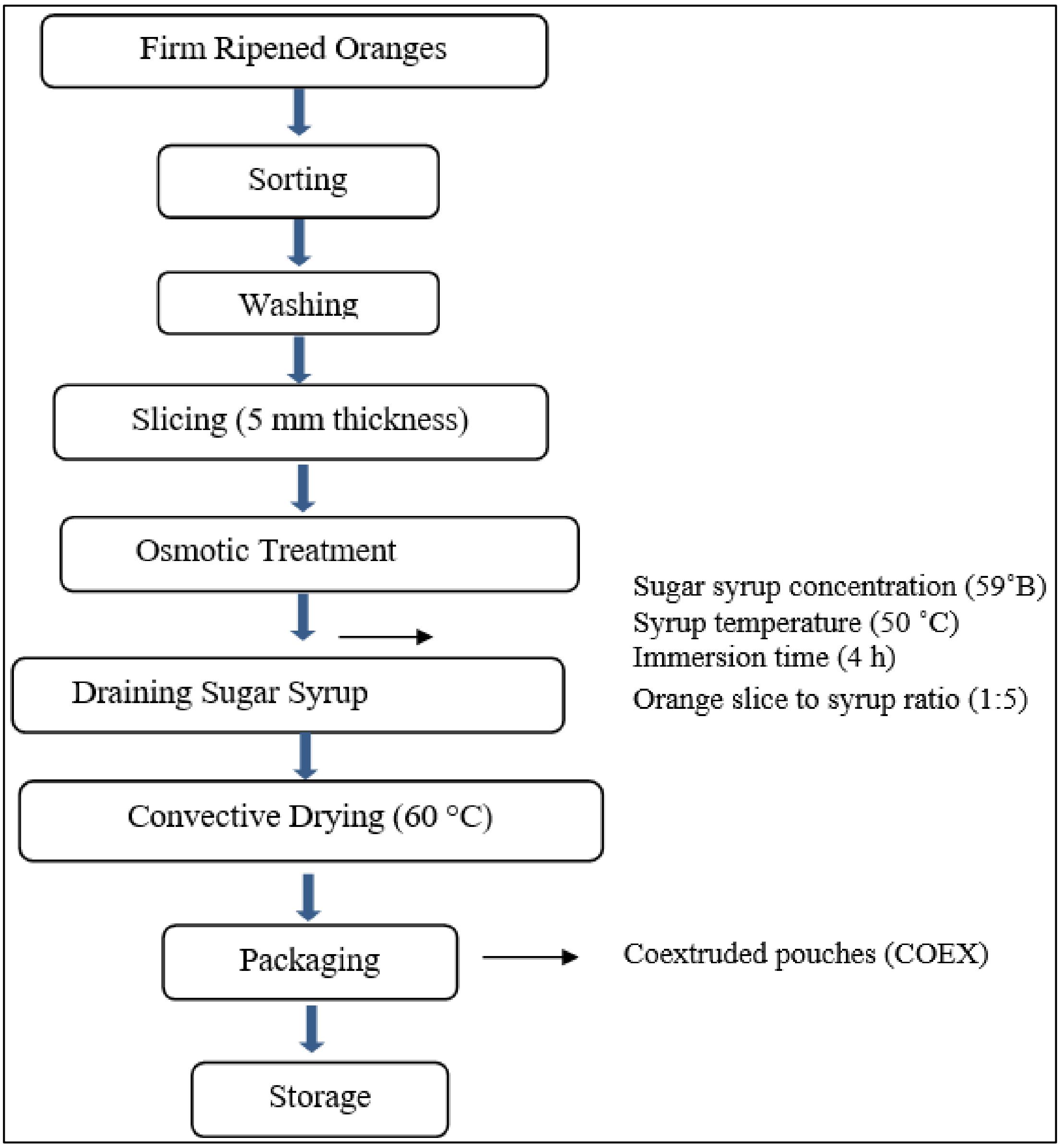


**Fig 2:** Process flow chart for production of osmo-convectively dried orange slices with peel by using optimized process parameters

## Conclusion

In view of improving the food security and harnessing the climate change, innovative use of food resources should be developed and practiced. Orange peel is an underutilized but nutrient rich material that can be processed as food material using different processing methods like the combined osmotic dehydration and hot air drying. The integration of osmotic dehydration processes results in about 50% reduction in energy input required in the preparation of osmo-convective dried orange slices with peel when compared to the stand-alone hot air drying. Analysis of economic parameters shows that the production of dried orange slices can be considered as a very profitable business. In the 6 months production of osmo-convective dried slices is realized a profit of around Rs. 52617.66 /month with the benefit cost ratio 1.4.

## References

1. AOAC. Official methods of analysis of AOAC international. 19th edn. Washington, D.C.: Association of official analytical chemists, 2012.
2. Bhatnagar P, Singh J, Jain MC, Singh B, Manmohan JR, Dashora LK. Studies on seasonal variations in developing

fruits of Nagpur Mandarin (*Citrus reticulata* Blanco) under Jhalawar conditions. The Asian Journal of Horticulture. 2012; 7(2):263-265.
3. Okwu DE. Citrus fruits: A rich source of phytochemicals and their roles in human health. International Journal of Chemical Sciences. 2008; 6(2):451-471.
4. Singh B, Panesar PS, Nanda V. Optimization of osmotic dehydration process of carrot cubes in sucrose solution. Journal of Food Process Engineering. 2008; 31:1-20.
5. Sapata ML, Ferreira A, Andrada L, Leitao AE, Candeias M. Osmotic dehydration of mandarins: influence of reutilized osmotic agent on behaviour and product quality. Acta Scientiarum Polonorum, Technologia Alimentaria. 2009; 8(3):23-35.
6. Thakre S, Khodke S, Housalmal S. Mass transfer phenomena during osmotic dehydration of orange slices. Multilogic in Sciences. 2019; 8:116-121.