Original Research Article

Effect of osmotic dehydration of beetroots (Beta vulgaris L.) under sun drying

ABSTRACT

An Experiment was conducted entitled with **Effect of osmotic dehydration of beetroot (*Beta vulgaris* L.) under sun drying** at the laboratory, Department of Horticulture, with a view to determine the effect of sun drying on osmotic dehydration of beetroot slices for its physio-chemical contents and organoleptic quality after 60 days of storage and to work out the economics of various treatments. Under this experiment, overall 10 treatments by using salt, honey, sugar, and $K_2S_2O_5$ and 4 replications was taken according to 10 days, 30 days, 45 days and 60 days. On the basis of results obtained during the present investigation the best osmotic agent for drying of beetroot slice was treatment combination T_7 Treated beetroot (Sugar 200g/Kg + $K_2S_2O_5$ 0.5%) + Sun drying of beetroot slices) with pH (6.30), TSS (11.46), fat content (0.28), Protein content (2.41), weight (92.5g), Reducing sugar (8.67), and Non-reducing sugar (4.86). T_7 (Treated beetroot (Sugar 200g/Kg + $K_2S_2O_5$ 0.5%) + Sun drying of beetroot slices) had maximum value for reducing sugar content, Flavour and Taste score, overall acceptability. The maximum Benefit cost ratio (1.94) was found for T_7 (Treated beetroot (Sugar 200g/Kg + $K_2S_2O_5$ 0.5%) + Sun drying of beetroot slices).

Keywords: *$K_2S_2O_5$, Physio-chemical, Sun drying, Beetroot, organoleptic.*

Introduction-

Beetroot (vernacular name: chukundar), botanically known as Beta vulgaris L. is one of the well- known plant belonging Amaranthaceae family .It is an erect annual herb with tuberous root stocks. It is a diploid cross-pollinated dicot plant species with chromosome number 2n=2x=18 **(Bennett and Smith, 1976)**. The beetroot is the taproot (bulb) portion of the beet plant. It is grown in temperate countries and biennial plant. The beetroot and its juice are freely consumed for its great taste, nutritional benefit and flavor content.

Osmotic dehydration is a method of partial removal of water in hypertonic solutions by soaking foods, mostly fruits and vegetables **(Shi and Maguer 2002).** The driving force for water diffusion from plant tissue into solution is the distinction between hypertonic solution osmotic pressures and plant tissue. Simultaneous counter- diffusion of solutes from solution to tissue is followed by the diffusion of water **(Lazarides *et al.*, 1995).** Leakage of natural solutes from plant tissue happens because the plant tissue cell membranes responsible for Osmotic transportation are not completely selective, but this flow is negligible, although it may be essential for the organoleptic and nutritional characteristics of the product **(Sahoo *et al.*, 2007**).

The osmotically dehydrated food can be further processed by freezing, vacuum drying and drying air **(Nanjundaswamy *et al.*, 1978)**. The prevalent osmotic agents are sugar, glucose, fructose, maize and sodium chloride, and this sodium chloride solution is widely used for fruit vegetables and sucrose solution. The primary industrial applications of osmotic dehydration are dehydrated fruits and vegetables, making candied products etc.

Dehydrated beetroot sample is used as a value added ingredient in a variety of products including pasta, smoothies, drinks, soup mixes, and so on. Post-harvest losses can be reduced by converting the beetroot into powder, shreads, sweets, jam, preserved juice and pickle etc. Beetroot, as new as it is, is delicious and nutritious. Among all vegetables, it is wealthy in vitamin C, A and K content **(USDA, database 2011).** As a healthy and nutritious vegetable, there is an increasing global demand for beetroot.

Intermediate moisture foods (IMFS) have become more common in latest years as a compared to foods that have been completely dehydrated. Intermediate moisture (IM) has benefits over traditionally dried fruit and vegetables, where, instead of removing most of the water, just enough water is removed or bound by adding a humectant to delay microbial development **(Vibhakara *et al.*, 2006).**

The current fruit production is 92.84 million tons and in India it is 175.08 million tons of vegetables. Due to their perishable nature, a high percentage of food is lost because of the lack of conservation technologies and post-harvest storage, as well as damages caused during handling and transportation. Value addition and conservation can be a best solution of reducing these food losses. These losses can be

avoided by converting the commodities into various value added products and by developing efficient, economic as well as environmentally friendly technologies. This study work deals with the process development studies of ready-to-eat osmotically dried products which allow left over fruits to be preserved.

Maretial and methods-

Experimentsl site –

The experimental work for preparation of osmotically dehydrated beetroot slices was conducted at the post-harvest laboratory of Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during 2021-2022.

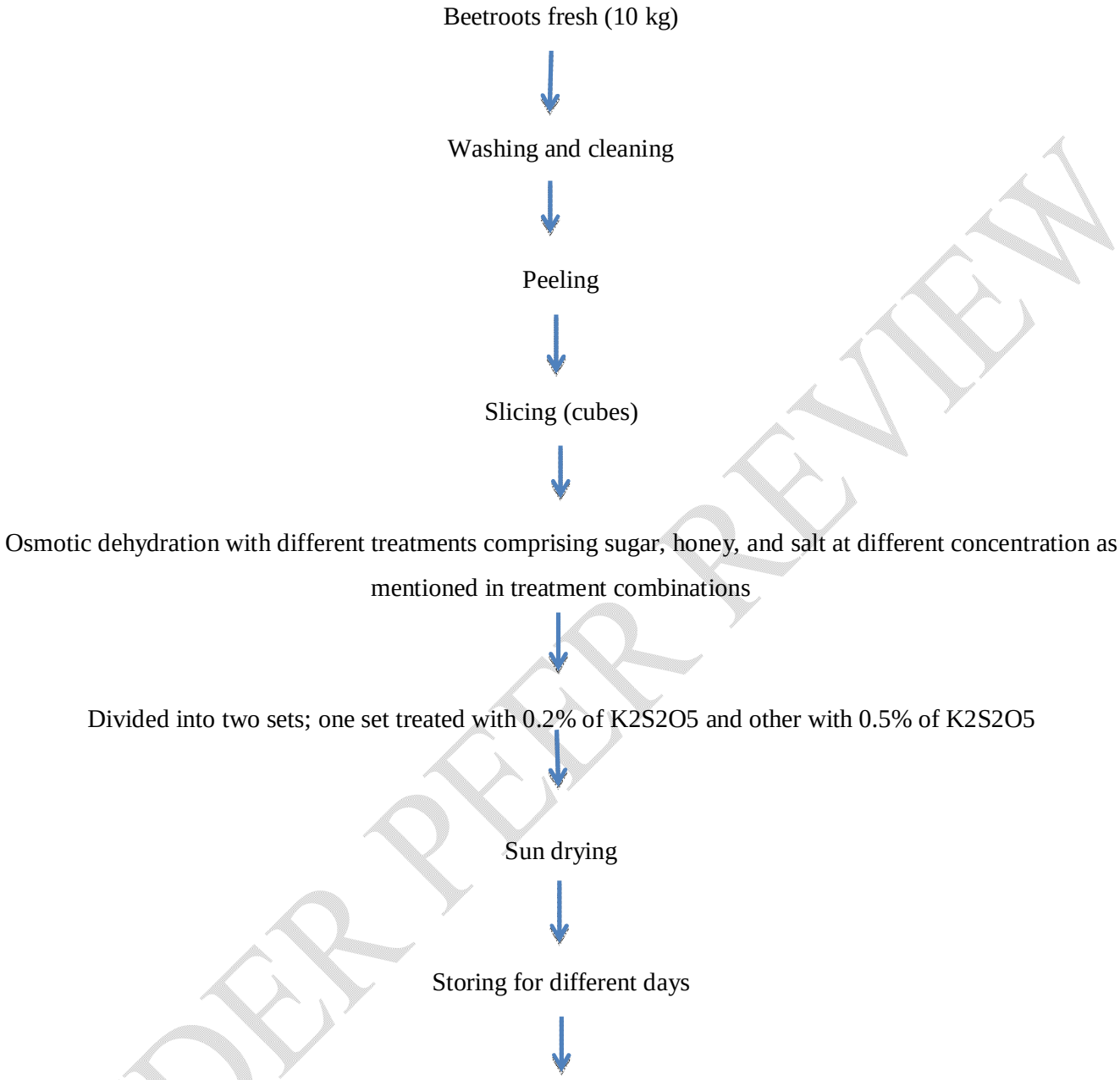
Materials used –

Fresh beetroots were purchased from the local farmer's field of prayagraj district for the preparation of osmotically dehydrated beetroot slices .All the chemicals used in the study were of AR grade and collected from department laboratories. The instruments such as weighing machine, steel containers, PH meter ,Refractometer , knife etc. are used for the osmotically dehydrated beetroots .

Methods -

The beetroots were washed, peeled, and sliced into pieces before being treated with several osmotic agents (treatment combinations)-sugar, honey, salt, and K2S2O5. Solutions prepared by adding water and osmotic agents according to the treatments and beetroot slices were immersed for 25 min with them for osmosis. After that, the osmotically treated beetroot slices were sun dried for 48-72 hours. Dehydrated ready-to-eat beetroot slices were collected in Polypropylene pouches and stored for 60 days to evaluate its storage life, which included proximate and organoleptic analyses.

Chart 1 : The flowchart of preparation of osmotically dehydrated beetroot slices.



Proximate Analysis

In proximate analysis pH, T.S.S., fat content, protein content, Reducing sugar and non-reducing sugar were calculated and analyzed.

pH Estimation

The pH was determined using a pH meter; the pH meter was standardized using standard buffer of pH 4.

The sample was taken in a beaker, the electrodes of the pH meter were dipped into it for 1 minute and the pH was recorded. The electrodes of the pH meter were washed with distilled water after each determination.

Total soluble solid (TSS)

The total soluble solids in beetroot leathers were determined by weighing the ground sample and mixing in 20 ml distilled water and kept for 1 hour. After standing it was centrifuged at 5000 rpm for 5 min (by using research centrifuge R-24). The supernatant was taken in petri dish and evaporated to solid form with constant weight. Weight of total soluble solids was recorded in grams and expressed as gram per 100 g sample. Refractometer was also used to measure T.S.S.

Fat analysis

Five gram of sample was taken in a thimble and then placed in previously weighed soxhlet beaker. The beaker was then placed in the extractor. After that extractor was filled with petroleum ether and their top were covered with cotton plugs. The soxhlet apparatus was then switched on with a set temperature of 70oC for half an hour, after completion of extraction, temperature was increased upto 130^{o}C for 10 minute. For the complete removal of moisture. The cooled beaker were then removed from the apparatus and cooled in dessicator. The beaker were then weighed.

$$\text{Percent fat} = \frac{\text{mass of fat}}{\text{mass of chips}} \times 100\%$$

Sensory evaluation

Prepared fruit bars packed in polythene pouches were evaluated for appearance and colour, flavour and taste, body and texture and overall acceptability by a panel of 15 semi-trained judges (Larmond, 1970). The samples were rated on 9 point Hedonic Scale.

Statistical Analysis

The data recorded during the course of experimental investigation were subjected to statistical analysis of "Analysis of variance" technique **(Fisher and Yates, 1967)** for drawing conclusion. The significance and non-significance of the treatments were judged with the help of 'F' (Variance ratio) test the significant differences between the means were tested with the critical differences at 5% probability level.

Economics

As per the market prices, the input cost and gross income were computed treatment wise and different economic parameters viz. - net income and benefit cost ratio were calculated.

Result and Discussion

The proximate analysis of osomtically dehydrated beetroot slices were done at different days of storage and recorded all the datas.

pH of osmotically dehydrated sundried beetroot slices

At initial day of storage of osmotically dehydrated beetroot, minimum pH was recorded in treatment T_2 with value of 5.20 followed by T_5 with value of 5.30. However, significantly maximum pH was recorded

T_9 with value of 6.80.After 30 days of storage minimum pH was recorded in treatment T_2 with value of 4.89 followed by T_5 with value of 5.04. However, significantly maximum pH was recorded T_9 with value of 6.53. After 45 days of storage minimum pH was recorded in treatment T_2 with value of 4.88 followed by T_5 with value of 4.90. However, significantly maximum pH was recorded T_9 with value of 6.37. After 60 days of storage minimum pH was recorded in treatment T_2 with value of 4.60 followed by T_5 with value of 4.75. However, significantly maximum pH was recorded T_9 with value of 6.08. In general the pH of beetroot fruit decreased during advancement of storage.pH of beetroot is affected by the its chemical composition and also due to various treatment combination used. Therefore, the variation in ranges for different treatment and also at different days of storage was observed

Table 1 : Effect of various treatment combinations on pH of osmotically dehydrated sundried beetroot slices at different days of storage.

Treatment notation	Treatment combination	pH			
		Storage period (Days)			
		0 Days	30 days	45 days	60 days
T_0	Untreated beetroot + Sun drying of beetroot slices	5.80	5.33	5.12	4.90
T_1	Treated beetroot (Sugar 200g/Kg) + Sun drying of beetroot slices	6.90	6.45	6.13	5.88
T_2	Treated beetroot (Honey 200g/Kg) + Sun drying of beetroot slices	5.20	4.98	4.88	4.60
T_3	Treated beetroot (Salt 5g/Kg) + Sun drying of beetroot slices	6.50	6.27	6.04	5.85
T_4	Treated beetroot (Sugar 200g/Kg +$K_2S_2O_5$ 0.2%) + Sun drying of beetroot slices	6.60	6.25	6.06	5.80
T_5	Treated beetroot (Honey 200g/Kg +$K_2S_2O_5$ 0.2%) + Sun drying of beetroot slices	5.30	5.04	4.90	4.75
T_6	Treated beetroot (Salt 5g/Kg +$K_2S_2O_5$ 0.2%) + Sun drying of beetroot slices	6.60	6.42	6.20	6.07
T_7	Treated beetroot (Sugar 200g/Kg +$K_2S_2O_5$ 0.5%) + Sun drying of beetroot slices	6.30	6.09	5.84	5.67
T_8	Treated beetroot (Honey 200g/Kg +$K_2S_2O_5$ 0.5%) + Sun drying of beetroot slices	5.40	5.23	5.09	4.86
T_9	Treated beetroot (Salt 5g/Kg +$K_2S_2O_5$ 0.5%) + Sun drying of beetroot slices	6.80	6.53	6.37	6.08
	'F' Test	**S**	**S**	**S**	**S**
	C.V.	**2.68**	**2.36**	**2.08**	**2.65**
	S.E.(d)	**0.09**	**0.08**	**0.07**	**0.08**
	C.D. at 5%	**0.28**	**0.24**	**0.20**	**0.25**

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Table 2 : Effect of various treatment combinations on Fat content of osmotically dehydrated beetroot at different days of storage (in g/100g)

Treatment notation	Treatment combination	Fat content (g/100g)			
		Storage period (Days)			
		0 Days	30 days	45 days	60 days
T_0	Untreated beetroot + Sun drying of beetroot slices	0.19	0.27	0.12	0.18
T_1	Treated beetroot (Sugar 200g/Kg) + Sun drying of beetroot slices	1.00	1.27	1.35	1.42
T_2	Treated beetroot (Honey 200g/Kg) + Sun drying of beetroot slices	1.21	1.82	1.48	1.89
T_3	Treated beetroot (Salt 5g/Kg) + Sun drying of beetroot slices	0.46	0.87	0.68	0.57
T_4	Treated beetroot (Sugar 200g/Kg +$K_2S_2O_5$ 0.2%) + Sun drying of beetroot slices	0.78	1.08	0.89	1.01
T_5	Treated beetroot (Honey 200g/Kg +$K_2S_2O_5$ 0.2%) + Sun drying of beetroot slices	1.04	1.24	1.32	1.14
T_6	Treated beetroot (Salt 5g/Kg +$K_2S_2O_5$ 0.2%) + Sun drying of beetroot slices	0.31	0.67	0.77	0.78
T_7	Treated beetroot (Sugar 200g/Kg +$K_2S_2O_5$ 0.5%) + Sun drying of beetroot slices	0.28	0.63	0.87	1.00
T_8	Treated beetroot (Honey 200g/Kg +$K_2S_2O_5$ 0.5%) + Sun drying of beetroot slices	0.54	0.76	0.81	0.89
T_9	Treated beetroot (Salt 5g/Kg +$K_2S_2O_5$ 0.5%) + Sun drying of beetroot slices	0.21	0.43	0.65	0.55
	'F' Test	**S**	**S**	**S**	**S**
	C.V.	**3.40**	**3.05**	**3.67**	**2.26**
	S.E.(d)	**0.01**	**0.02**	**0.02**	**0.01**
	C.D. at 5%	**0.03**	**0.05**	**0.06**	**0.04**

The data presented showed significant differences in Fat Content of osmotically dehydrated beetroot present among the different treatment in fresh i.e. 0 days as well as 30, 45 and 60 days of storage. In general the fat content of beetroot fruit first increased then decreased during advancement of storage.Fat Content of beetroot is also affected by various treatment combination used and storage period. The sun drying enhances the surface evaporation that inturn leads to increase in concentration of lipids in slices. Therefore, the variation in ranges for different treatment and also at different days of storage was observed.

Table 3 : Effect of various treatment combinations on Protein content of osmotically dehydrated beetroot at different days of storage (in g/100g)

Treatment notation	Treatment combination	Protein content (g/100g)			
		Storage period (Days)			
		0 Days	30 days	45 days	60 days
T_0	Untreated beetroot + Sun drying of beetroot slices	1.54	2.30	2.36	2.48
T_1	Treated beetroot (Sugar 200g/Kg) + Sun drying of beetroot slices	1.34	1.68	1.88	1.94
T_2	Treated beetroot (Honey 200g/Kg) + Sun drying of beetroot slices	1.41	1.98	2.11	2.05
T_3	Treated beetroot (Salt 5g/Kg) + Sun drying of beetroot slices	2.08	2.89	2.68	2.75
T_4	Treated beetroot (Sugar 200g/Kg +$K_2S_2O_5$ 0.2%) + Sun drying of beetroot slices	1.65	2.01	1.88	2.12
T_5	Treated beetroot (Honey 200g/Kg +$K_2S_2O_5$ 0.2%) + Sun drying of beetroot slices	2.12	2.53	2.18	2.22
T_6	Treated beetroot (Salt 5g/Kg +$K_2S_2O_5$ 0.2%) + Sun drying of beetroot slices	2.00	2.58	2.85	2.39
T_7	Treated beetroot (Sugar 200g/Kg +$K_2S_2O_5$ 0.5%) + Sun drying of beetroot slices	2.41	3.01	3.25	3.12
T_8	Treated beetroot (Honey 200g/Kg +$K_2S_2O_5$ 0.5%) + Sun drying of beetroot slices	2.42	3.10	3.19	3.42
T_9	Treated beetroot (Salt 5g/Kg +$K_2S_2O_5$ 0.5%) + Sun drying of beetroot slices	2.76	3.65	3.74	3.86
	'F' Test	**S**	**S**	**S**	**S**
	C.V.	**2.75**	**2.18**	**1.93**	**3.09**
	S.E.(d)	**0.03**	**0.03**	**0.03**	**0.05**
	C.D. at 5%	**0.09**	**0.10**	**0.09**	**0.14**

The presented data showed significant differences in Protein Content of osmotically dehydrated beetroot present among the different treatment in fresh i.e. 0 days as well as 30, 45 and 60 days of storage. In general the protein content of beetroot fruit increased during advancement of storage. Protein Content of beetroot is also affected by various treatment combination used and storage period. The sun drying enhances the surface evaporation that inturn leads to increase in concentration of amino acids in slices. Therefore, the variation in ranges for different treatment and also at different days of storage was observed. Yet not much protein is present in slices. This is an indication that fruit stored are not good sources of protein.

Overall acceptability score of osmotically dehydrated beetroot at different days of storage.

At initial day of storage of osmotically dehydrated beetroot maximum Overall acceptability score content was recorded T_8 with value of 8.01 followed by T_7 with value of 8.00. However, significantly minimum Overall acceptability score was recorded in treatment T_0 with value of 5.99. After 30 days of storage

maximum Overall acceptability score content was recorded T7 with value of 8.27 followed by T8 with value of 8.19. However, significantly minimum Overall acceptability score was recorded in treatment with value of 6.12. After 45 days of Significantly maximum Overall acceptability score content was recorded T7) with value of 8.42 followed by T8 with value of 8.38. However, significantly minimum Overall acceptability score was recorded in treatment T0 with value of 6.21. After 60 days of storage of osmotically dehydrated beetroot maximum Overall acceptability score content was recorded T7 with value of 8.68 followed by T8 with value of 8.47. However, significantly minimum Overall acceptability score was recorded in treatment with value of 6.34. Overall acceptability score of beetroot is also affected by various treatment combination used and storage period. Therefore, the variation in ranges for different treatment and also at different days of storage was observed. Similar results were reported for Overall acceptability score osmotically dehydrated fruits and **vegetables Lenart and Lewicki (1988); Yadav *et al.*, (2002); Ghosh *et al.*, (2006) in carrot.**

Economics

Maximum gross returns, net returns and benefit: cost ratio was observed in the treatment T7 (Treated beetroot (Sugar 200g/Kg +K2S2O5 0.5%) + Sun drying of beetroot slices) and recorded the best treatment among all the other treatments.

As the economics is the need of the farmers while taking decision regarding the adoption of the post-harvest processing techniques and scientific knowledge, as T7 (Treated beetroot (Sugar 200g/Kg +K2S2O5 0.5%) + Sun drying of beetroot slices) gave the highest gross return, net return, and cost benefit value, addition by this method in beetroot can be promoted.

Conclusion

On the basis of results obtained during the present investigation the best osmotic agent for drying of beetroot slice was treatment combination T7 (Treated beetroot (Sugar 200g/Kg +K2S2O5 0.5%) + Sun drying of beetroot slices). T7 (Treated beetroot (Sugar 200g/Kg +K2S2O5 0.5%) + Sun drying of beetroot slices) had maximum value for reducing sugar content, Flavour and Taste score, overall acceptability.

The maximum Benefit cost ratio (1.94) was found for T7 (Treated beetroot (Sugar 200g/Kg +K2S2O5 0.5%) + Sun drying of beetroot slices).

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