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DEHYDRATION OF AMLA SLICES USING VARIOUS PRE-TREATMENTS AND OSMOTIC AGENTS

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ABSTRACT

Indian gooseberry (*Emblica officinalis)* is a significant fruit crop. Being the richest source of ascorbic acid (571mg/g) there is a great demand for aonla fruits and its products owing to their nutritional and medicinal properties, but due to its astringency aonla fruits are not consumed fresh. Hence osmo-dried aonla slices were prepared by dipping amla slices overnight in various osmotic solutions i.e., 60% sugar, 30% sugar, 50% glycerol, sugar-glycerol (25%:25%), 1% and 2% salt and then dried at 55^{O}C and packed in LDPE pouches and stored at room temperature and subjected to physico-chemical and sensory evaluation at an interval of 30 days. Maximum retention of ascorbic acid (366 mg/100g) and total phenolic content (141.40mg GAE/g) was observed in aonla slices when steeped in 50% glycerol treatment (T_3) followed by sugar-glycerol (25%:25%) (T_4). Highest content of titratable acidity (0.89%), total sugars (29.73%) and reducing sugars (17.59%) were observed in sugar 60% (T_1), whereas minimum retention of ascorbic acid (225mg/100g), total phenols (81.40 mg GAE/g), total sugars (5.48%) and reducing sugars (2.96%) were observed in control (T_7). In general decreasing trend was observed in moisture, ascorbic acid, titratable acidity and reducing sugars with the advancement of storage period. On the basis of quality, stability during storage and sensory evaluation T_3 (glycerol 50%) was adjusted as the best, having the highest score for colour (8.30), texture (8.07), flavor (8.19), taste (8.27) and overall acceptability (8.29) and observed to be the most effective treatment for maintaining the overall quality of the product for a period of 120 days.

***Key words*:** aonla slices, osmo-dried, glycerol, sugar, salt, storage life.

Introduction

Aonla (*Emblica officinalis*) is also called as the fruit of 21st Century and is popularly known as Amla. Its origin is central to southern India. It is grown in subtropical countries including Indian subcontinent, southern china and South East Asia. India is the largest aonla producing country in the world with area 100 thousand hectares and annual production of 1206 thousand tonnes (Anon, 2021). Aonla fruits are rich in vitamin C (649.92mg/100 g), containing moisture (80.18%), total phenols (24.58 mg GAE/100 g), total fiber (2.31%), reducing sugars (8.88%) and total sugars (10.74%), fat (0.1%), mineral matter (0.7%), ash (0.31%), carbohydrates (14.1%), and iron (12 microgram/g) (Mondal *et al.*, 2017). Because of its promising therapeutic characteristics, it is utilized to treat a number of ailments like Inflammation, cancer, osteoporosis, hypertension, neurological disorders, type 2 diabetes, parasite infections, and other infectious diseases in both human beings and animals. Aonla has free and bound phenolics which has 4-10 times higher antioxidant activity than curcumin, as measured by scavenging free radicals and reducing power tests. Aonla fruits also contain gallic acid, ellagic acid, different tannins, minerals, vitamins, pectin, amino acids, fixed oils, and flavonoids like rutin and quercetin (Variya *et al.*, 2016). Aonla fruits are available for a short period from October to January and fresh consumption of the fruit is not relished due to its sour and astringent nature. There are several techniques of dehydration of different fruits and vegetables but osmotic dehydration has gained more

attention due to its potential implementation in the food processing industry.

Osmotic dehydration is one of the most widely used preservation technique for the production of safe, stable, nutritious food obtained by placing the solid food, whole or in pieces in saturated aqueous solution of high osmotic pressure. It helps to reduce 30 to 70 per cent of water content of the food and decreases colour changes and increases flavour retention in osmo-dried fruits and vegetables (Lenart and Lewicki, 1988). It can be done before drying to enhance the mass transfer rate or to shorten the time duration for the drying, (Akbarian *et al*., 2014). Pre-treatment helps in the retention of most of the chemical constituents in the osmo-dried aonla and increase product stability and storage. It has a potential to eliminate astringency because of less heat damage, good blanching effect, less non enzymatic browning, better retention of colour, flavor and texture and consumes less energy (Mudgal and Pande, 2009). Sugar or salt aqueous solutions are usually used to produce safe, stable, and nutritious food. The product obtained by the process of osmotic dehydration has low water activity due to solute gain and water loss. During osmotic dehydration, the diffusion of water is simultaneously accompanied by counter diffusion of solutes from aqueous solution into the tissue (Shi and Maguer, 2002). Thus, nutrient loss occurs during osmotic treatment, but impregnation of commodities with osmotic agent improves texture, sensory properties and dietary value.

The important factor that determines the rate of diffusion depends on the type of osmotic agent used, glycerol is classified as food additive by the Codex Alimentarius (2012). It is used to improve the texture of foods and has the advantage of being a microbiological protectant (Moreira *et al.*, 2007). It's useful in osmotic dehydration on a large scale. Sugar is a molecule composed of two mono-saccharides namely glucose and fructose connected via glyosidic bond, and is commonly used osmotic agent, it serves as a food thickening agent, and as a food stabilizer. It is used to elevate the shelf life of jam, jellies and also serves as an anti-oxidant, low concentration sugar syrup cause minimum water loss resulting in lower water loss and solid gain ratios (Torte, 2010). Salt is a crystalline solid while in its aqueous solution it is called as a saline solution, addition of small quantity of salt increases the driving force of drying process moreover the solute is harmless and have a good taste, salt is an excellent osmotic agent but its use in concentration fruit pieces is limited since a salty taste is imparted to the food. It is used as an osmotic agent and acts as a food preservative by dewatering and thus reducing the water activity by which microbial growth is retarded (Akbarian *et al.*, 2014).

Patannapa *et al.*, (2010) studied the effect of sugar and glycerol mixtures in osmotic solution and found that in combination of these two osmotic agents maximum dewatering takes place and it was found highest water loss took place when sugar and glycerol were taken in 1:1 ratio because the glycerol has lower molecular weight than sugar, this indicated that decrease in molecular weight of osmotic solute could enhance water loss and solid gain.

Since aonla is a seasonal crop and is available only for a short period of time, due to perishable nature of aonla fruits, insufficient demand and weak infrastructure, the farmers face substantial losses. Osmotic dehydration has also been found quite suitable processing tool to preserve fruits and prevent post-harvest losses. This technology is used on aonla fruit in order to keep it while creating a new minimally processed, ready-to-eat product that is osmotically dehydrated. Therefore, the osmotic dehydration process for aonla fruit in salt and sugar solution was optimized in order to maximize the effects of the osmotic process parameters (solution concentration, blanching treatment, and process duration) on quality responses (water loss and solute gain).

Materials and Methods

Preparation of samples

Fully mature aonla fruits, variety NA-7 were procured from the Rainfed Research sub-station for sub-tropical Fruits, Raya, Samba (J&K) and processed in the division of Food Science and Technology, main campus Chatha.

Preparation of Osmo-dried aonla slices

Osmo-dried aonla slices were prepared using different osmotic agents as given in Table 1. the selected fruits were washed and kept in boiling water for softening. Then the seeds were removed manually. The slices were strained and spread on aluminium trays followed by drying in cabinet dryer at 55^{O}C. The IMF aonla slices were then packed in LDPE pouches and stored for a period of four months at ambient temperature. The stored osmo-dried aonla slices were analysed for various physico-chemical constituents and sensory characteristics at an

Table 1: Treatment details.

T1	60 % sugar syrup
T2	30 % sugar syrup
T3	50 % glycerol solution
T4	25% sugar + 25% glycerol solution
T5	1.0% salt solution
T6	2.0% salt solution
T7	Control

Table 2: Effect of treatments and storage on moisture (%) of osmo-dried aonla segments.

Treatment	Storage period (days)					Mean
	0	30	60	90	120	
T1 (S: 60%)	32.43	30.57	28.41	27.11	25.22	**28.75**
T2 (S: 30%)	36.21	34.30	32.27	30.11	28.00	**32.18**
T3 (G: 50%)	23.67	22.55	21.43	20.18	19.21	**21.40**
T4 (S::G 25%:25%)	28.15	27.33	26.47	25.23	24.10	**26.25**
T5 (ST: 1%)	25.21	24.43	23.30	22.15	21.08	**23.23**
T6 (ST: 2%)	24.55	23.41	22.37	21.25	20.22	**22.36**
T7 (Control)	22.55	21.45	20.60	19.47	18.00	**20.41**
Mean	**27.54**	**26.29**	**24.98**	**23.64**	**22.26**	
Factors: C.D.; Treatment: 0.75; Storage: 0.63; Treatment× Storage:NS						

Table 3: Effect of treatments and storage on water activity (a_w) of osmo-dried aonla segments.

Treatment	Storage period (days)					Mean
	0	30	60	90	120	
T1 (S: 60%)	0.73	0.73	0.72	0.71	0.70	**0.72**
T2 (S: 30%)	0.75	0.75	0.73	0.72	0.72	**0.73**
T3 (G: 50%)	0.69	0.69	0.68	0.67	0.66	**0.68**
T4 (S::G 25%:25%)	0.71	0.71	0.70	0.69	0.68	**0.70**
T5 (ST: 1%)	0.70	0.70	0.69	0.69	0.68	**0.69**
T6 (ST: 2%)	0.67	0.66	0.65	0.65	0.64	**0.65**
T7 (Control)	0.65	0.65	0.64	0.64	0.63	**0.64**
Mean	**0.70**	**0.69**	**0.68**	**0.68**	**0.67**	
Factors: C.D.; Treatment: 0.15; Storage: 0.13; Treatment× Storage:NS; S:Sugar%; G:Glycerol% and ST:Salt%						

interval of 30 days following the standard procedures.

Optimization of osmotic process parameters

The results obtained were statistically analyzed using completely randomized design (OP Stat software) for interpretation of the results through analysis of variance (Gomez and Gomez, 1984). The osmotic process variables selected for the study were concentration of osmotic solution and immersion time.

Quality Analysis

Moisture content was determined by standard AOAC (2012) method by following oven drying method as the loss in weight due to evaporation from the sample at a temperature of 105±1^{O}C Till constant weight was achieved. Water activity was measured using aqua lab water activity meter (Model series 3TE) and readings were corrected at 20^{O}C (AOAC, 2012). Titratable acidity was determined by titrating a known quantity of sample (10g) against standardized solution of 0.1 N Sodium hydroxide (NaOH) to a faint pink colour using phenolphthalein as indicator (Rangana, 1986). Ascorbic acid content was determined by the procedure of Sadasivam and Manicham (2008) using 2,6-dichlorophenol indophenols dye. The sample was extracted in 4 per cent oxalic acid solution and titrated with the standard dye to pink colour persisting for 15 seconds (AOAC, 2012). Crude fiber of the sample was determined by method as described in AOAC (2012). The data obtained was analyesd statistically using Factorial randomized design (CRD) for interpretation of the results through analysis and variance.

Results and Discussion

The osmosis of aonla fruits was was used to assess the effects of the osmotic medium concentration and the appropriateness of the blanching procedure on solid gain and water loss. The water loss increased with increase in osmosis time until equilibrium was attained while the rate of water loss decreased, at all the concentrations.

Moisture

Table 2 revealed that moisture content of osmo-dried aonla slices decreased with the advancement of storage period. The highest moisture content (32.18 per cent) was observed in aonla slices dipped in 30 per cent sugar syrup (T_2), and the lowest 21.40 per cent in T_3 (50% glycerol solution). Which might be due to the small molecular size of glycerol due to which maximum dewatering takes place which resulted in higher rate of moisture loss during drying and due to the evaporation of moisture from the samples during storage. Panwar *et al.*, (2015).

Initially the lowest moisture content of 22.55 per cent was observed in T_7 (Control) whereas, it was highest in T_2 (30% sugar syrup) 36.21 per cent. Initial mean moisture content of 27.54 per cent decreased to 22.26 per cent after four months of storage period. These results are found in agreement with those of Mondal *et al.*, (2017) in aonla candy using varying concentrations of sugar syrups (80%, 70%, 50% and 40%) and they observed that the moisture content decreased significantly during storage period of 120 days, decrease in moisture in aonla candy was also recorded by Tripathi *et al.*, (1998).

Water activity

Initially the highest water activity of 0.75 was found in osmo-dried aonla slices treated with 30 per cent sugar syrup (T_2) and the lowest value of water activity was recorded in T_7 (Control) as depicted in Table 3. Minimum water activity of 0.69 was observed in aonla slices treated with 50 per cent glycerol which may be due to the small molecular size of glycerol due to which maximum dewatering took place and because of the formation of hydrogen bonds with the glycerol which is a polyhydric

Table 5: Effect of treatments and storage on crude fiber (%) of osmo-dried aonla segments.

Treatment	Storage period (days)					Mean
	0	30	60	90	120	
T1 (S: 60%)	3.25	3.14	3.03	3.03	2.82	**3.05**
T2 (S: 30%)	3.00	2.83	2.70	2.70	2.50	**2.74**
T3 (G: 50%)	4.15	4.03	3.91	3.91	3.70	**3.93**
T4 (S::G 25%:25%)	3.30	3.18	3.07	3.07	2.81	**3.09**
T5 (ST: 1%)	3.36	3.24	3.12	3.12	2.91	**3.15**
T6 (ST: 2%)	3.63	3.50	3.70	3.37	3.15	**3.40**
T7 (Control)	4.52	4.41	4.29	4.29	4.07	**4.32**
Mean	**3.60**	**3.48**	**3.36**	**3.35**	**3.13**	
Factors: C.D.; Treatment: 0.01; Storage: 0.01; Treatment× Storage:0.02; S:Sugar%; G:Glycerol% and ST:Salt%						

Table 6: Effect of treatments and storage on titratable acidity (%) of osmo-dried aonla segments.

Treatment	Storage period (days)					Mean
	0	30	60	90	120	
T1 (S: 60%)	1.14	1.04	0.94	0.71	0.64	**0.89**
T2 (S: 30%)	1.00	0.88	0.77	0.66	0.56	**0.77**
T3 (G: 50%)	1.10	1.00	0.86	0.69	0.60	**0.85**
T4 (S::G 25%:25%)	1.12	1.01	0.90	0.79	0.71	**0.90**
T5 (ST: 1%)	1.01	0.89	0.72	0.60	0.50	**0.74**
T6 (ST: 2%)	0.98	0.86	0.69	0.56	0.48	**0.71**
T7 (Control)	1.09	0.98	0.82	0.70	0.57	**0.83**
Mean	**1.06**	**0.95**	**0.81**	**0.67**	**0.58**	
Factors: C.D.; Treatment: 0.12; Storage: 0.10; Treatment× Storage:0.20; S:Sugar%; G:Glycerol% and ST:Salt%						

alcohol and resulted in lowering the water activity of the sample and aonla slices treated with 2 per cent salt, the ability of salt to decrease water activity is because of ionic nature by which it bind with the water molecules (Fennema, 1996). The sugar treatments (T_1 and T_2) showed maximum water activity due to the less ability of the formation of hydrogen bonds. Progressive decrease in water activity was observed after four months of storage period from 0.70 to 0.67. These results are in conformity with those of Panwar *et al.*, 2015 in IMF aonla segments.

Ascorbic acid

The highest ascorbic acid content was found in the aonla segments pre-treated with 50% glycerol 397 mg/100g, due to the lower molecular weight of glycerol which resulted in higher osmotic pressure and maximum dewatering from aonla slices during osmotic dehydration, which resulted in concentration of ascorbic acid in the cellular tissues (Fig. 1). The lowest ascorbic acid content (261 mg/100g) was recorded in aonla slices of control (T_7). Ascorbic acid content decreased significantly in osmo-dried aonla slices during four months of storage period from 332.28 to 251.00 mg/100g. This could be due to thermal degradation during drying process and subsequent oxidation throughout storage period, besides these leaching losses also occurs during processing, which also plays a role in loss of ascorbic acid (Sagar and Kumar, 2009). These results are with the conformity with

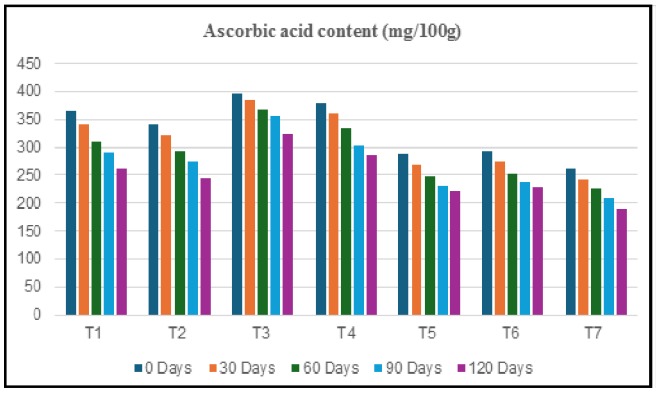

Fig.1: Effect of treatments and storage on Ascorbic acid (mg/100g) of osmo-dried aonla segments.

Plate 1: Fresh aonl

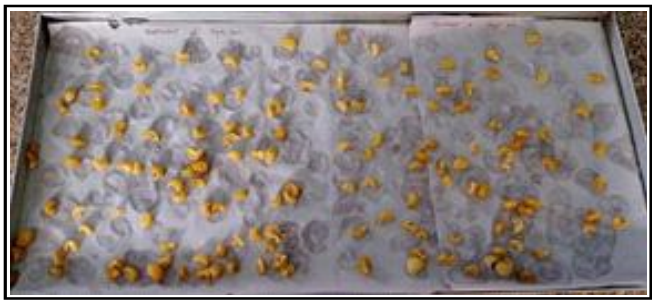

Plate 2: Spreading of osmo-dried aonla slices on aluminium trays.

Plate 3: Osmo-dried aonla slices.

the findings of Panwar *et al.*, (2015) in intermediate moisture aonla segments. The higher ascorbic acid content was observed in aonla segments treated with glycerol, than those treated with sugar which might be due to oxidation and heat sensitive nature of ascorbic acid. The ascorbic acid content decreased similarly, according to Mishra *et al.*, (2021) in green mango powder and in potato by Marwaha and Pandey (2006). The progressive reduction in ascorbic acid content was observed during 120 days of storage. Similar results of decrease in ascorbic acid during storage was also reported by Patil *et al.*, (2019) in amchur and Gulzar *et al.*, (2018) in dehydrated mango slices.

Crude fiber

The higher and lower mean crude fiber content was observed in T_7 (control) and T_2 (30 % sugar syrup) values of 4.32 and 2.74 respectively (Table 5). Degradation of pectin or other fibers like cellulose or hemicelluloses during the drying process may have contributed to the powder's decreasing crude fiber content as the drying temperature increased. Additionally, Sengkhamparn *et al.*, (2013) showed similar outcomes with pitaya powder. The gradual decrease in crude fiber content over the course of the storage period may have been caused by the hemicelluloses and other polysaccharides degrading during storage. (Sharon and Usha, 2006). Similar result of decrease in crude fiber content during storage was also reported by Gurumeenakshi and Varadharaju (2019) in osmo-dried mango slices.

Titratable acidity

Initially highest value of titratable acidity was observed in aonla slices pre-treated with 60 per cent sugar syrup (1.14%), and the lowest content of titratable acidity was recorded in T6 (2% Salt solution) as presented in Table 6. Acidity content decreases during osmotic dehydration due to the flow of the organic acids from the fruit to the hypertonic osmotic solutions and soluble solids in reverse direction through semi permeable membrane resulted in the reduction of the acidity content (Kumar and Sagar, 2009). With the increase in storage period, acidity of osmo-dried aonla slices decrease significantly from initial mean levels of 1.06 to 0.58 per cent. This decrease in acidity in the samples during storage might be due to acid hydrolysis of polysaccharides and non-reducing sugars or complexes in the presence of metal ions. The decrease in titratable acidity with increase in storage period of aonla which might be due to the biochemical interaction in binding of acid with other components with passage of time is also reported by Gulzar *et al.*, (2018, and also reported by Patil *et al.*, (2019) in amchur.

Conclusion

The moisture content and water activity (a_w) in osmo-dried aonla segments decreased significantly during six months storage and was found lowest (20.41%) in T_7 (Control) and (0.64) osmo-dried aonla segments, respectively. Ascorbic acid (mg/100g), and crude fiber (%) declined in all treatments with the advancement of storage period. Titratable acidity was observed to be highest (0.90%) in T_4 (25% sugar: 25% glycerol)) whereas T_6 (2% salt solution) recorded the lowest (0.71%). Titratable acidity value decreased during the storage period of four months respectively.

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