EFFECT OF SUCROSE, GLYCEROL AND SPICES ON CHEMICAL CONSTITUENTS OF INTERMEDIATE MOISTURE AONLA SEGMENTS

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Abstract
Aonla is one of the most important medicinal fruits available in North India. It is a rich source of vitamin C and its content of ascorbic acid is next to that of Barbados cherry. Aonla fruits are highly perishable and have limited period of availability (November-February) under North Indian conditions. The intermediate moisture sweet and spiced aonla segments cv. Banarasi were prepared by using three types of osmotic agents i.e., 60 per cent sucrose, 60 per cent sucrose-glycerol (1:1) and 60 per cent glycerol. Chemical constituents of sweet and spiced IMF segments from aonla were analyzed just after processing and at monthly interval during six months storage period. The moisture content was maximum (21.8%) in spiced IMF aonla segments steeped in glycerol. The maximum a_w (0.74) was observed in IMF segments dipped in sucrose. The maximum TSS was observed in segments steeped in glycerol and mixed with spices (38.8%) while minimum was recorded in segments dipped in sucrose (34.1%).The total sugars increased with the increase in the storage period of six months. The ascorbic acid was found to be maximum (354 mg/100 g) in IMF segments steeped in glycerol and the mixed with spices. IMF aonla segments in 60 per cent glycerol syrup, retained maximum nutrients. The 60 per cent sucrose treated IMF aonla segments retained the minimum nutrients.

Keywords: aonla, physiochemical parameters, Intermediate Moisture Foods (IMF), osmotic agents

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1.INTRODUCTION

Aonla (*Phyllanthus emblica* L.) is considered as "Wonder fruit for health". Aonla, a member of family Euphorbiaceae and sub family Phyllanthiodae, is native to India, Ceylon, Malaya and China. It is also known as Indian gooseberry, Amalaki, Amla, Amlet, Amolphal, Aovla, Aurna, Chukna, Dhatriphala, Emblic myrobalan, Nelli and Sobju in different parts of world. India ranks first in the world in area and production of aonla fruits.

The area under aonla cultivation in India is about 1, 08,060 hectares with an annual production of 12,66,460 tonnes. Aonla is one of the most important medicinal fruits available in North India and is, therefore, used as a major constituent in several Ayurvedic preparations. It is a rich source of vitamin C and is next to that of Barbados cherry. Aonla possesses hepatoprotective, expectorant, purgative, spasmolytic, antibacterial, hypoglycemic and hypolipidemic activities (Mishra *et al.*, 2010). IMF are known as fourth generation or minimally processed products. Osmotic dehydration process is widely applied to obtain high quality IMF.

The IMF are semi-moist foods that have some of their water bound by sucrose, glycerol, sorbitol, salt or certain organic acids for a short period of time, thus, preventing the growth of many microorganisms. In 1980s, the committee for IMF of France's National Centre for Coordination of Research on Food and Nutrition proposed the definition for intermediate moisture foods: "food products of soft texture, subjected to one or more technological treatments, consumable without further preparation and with a shelf stability of several months, assured without thermal sterilization, freezing and refrigeration, but by an adequate adjustment of their formulation: composition, pH, additives and mainly a_w (water activity), which must be approximately between 0.65 and 0.90 measured at 25^0C. Generally, IMF contains moderate levels of

moisture of the order of 20 to 50 per cent (Akhtar and Javed, 2013).
When food is available in adundance, it is preserved for future consumption. Preserved food is easier to distribute and can be made available in all places at all time. Aonla fruits are available in plenty during peak harvesting season.
Due to insufficient demand, weak infrastructure, poor transportation and perishable nature of aonla fruits, the farmers sustain substantial losses and do not get remunerative prices of their produce. The efforts made by researchers and processors are still lacking in developing processing techniques for making IMF aonla segments to meet out the growing demand of value added aonla products in domestic and export markets throughout the year. Keeping the above facts in view, the present research work was planned with the objectives to develop sweet and spiced IMF segments from aonla and to evaluate the quality and shelf life of processed products during storage.

2. MATERIAL AND METHODS

Mature aonla fruits cv. Banarasi was procured from local orchards, Hisar during 2012-2013. The fruits were washed thoroughly with clean running water to remove the dirt and other foreign material. Aonla fruits were pricked and steeped in 2% brine solution for 2 days to remove astringency.
After this period, the fruits were dipped in alum solution (2%) for one day. After steeping operation, the fruits were tied in a muslin cloth and placed in boiling water containing 2% potassium metabisulphite (KMS) to inactivate enzymes, remove astringency and soften the fruits for easy separation of segments.
The sucrose and glycerol were used as osmotic agents. The osmotic syrups of 60^0Brix were prepared by mixing sucrose and glycerol on w/w basis with clean potable water.
The citric acid (3 g/kg syrup) was also added during boiling to obtain clear syrup solution. The segments were steeped in sucrose, sucrose+glycerol (1:1) and glycerol syrups of 60^0Brix strength for 16 hours for osmosis. The segments were then spread on aluminium trays and dried in a tray drier at 50^0C overnight to make intermediate moisture (20 to 30%) food product.
The sweet IMF aonla segments were packed in LDPE bags. After steeping, the segments were drained free of syrup and spread on aluminium trays, and dried in a tray drier at 50^0C overnight to make an intermediate moisture food product. The spiced IMF aonla segments were prepared by mixing with citric acid (1 g/kg) and spices like rock salt (10 g/kg), black pepper powder (4 g/kg) and chat masala (10 g/kg) on sweet IMF aonla segments. Chat masala containing ingredients like iodized salt, dried mango powder, black salt, cumin, kachri, coriander seeds, black pepper, pomegranate seeds, mint, red chillies, dries ginger, bishops weed, nutmeg, cloves, caraway and asafoetida was used. The product was then packed in LDPE bags (Fig. I).
The intermediate moisture aonla segments were analysed for quality parameters at monthly interval during six months storage. Moisture content was estimated by Dean and Stark method. Water activity was analysed by water activity meter (Labswift a_w, Novasina, Switzerland).
Total soluble solids (TSS) were estimated at ambient temperature by Abbe's Refractometer (0-95%) or by Hand refractometer (0-32%) Erma, Japan and the values were expressed as per cent TSS after correcting at 20^0C temperature. Total sugars were estimated by Hulme and Narain (1931). The ascorbic acid was determined as per the method given by AOAC (1990).
The data in the present investigation were subjected to analysis of variance (ANOVA) technique and thus analyzed according to two factorial completely randomized designs. The critical difference value at 5 per cent level was used for making comparison among different treatments during storage period**.**
Software OP stat (www.hau.ernet.in) was used to analyze experimental results statistically.

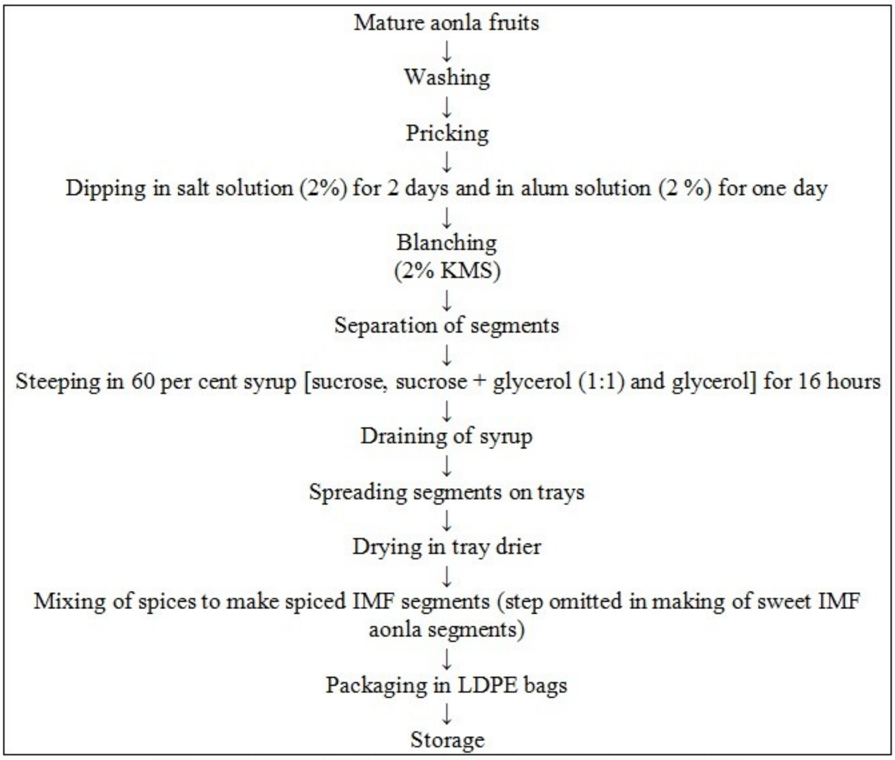

Fig. I Flow sheet for preparation of IMF aonla segments

3. RESULTS AND DISCUTION

Moisture content

The moisture content of IMF aonla segments decreased significantly during six months storage (Table 1). This may be due to evaporation of moisture from the samples during storage. Singh *et al*. (2010) also reported a decline in moisture content of intermediate moisture baby corn during storage. The spiced IMF aonla segments had more moisture content than sweet IMF aonla segments presented in (Table I), which may be due to moisture content of spices, ultimately adding more moisture to the samples.

Minimum moisture content was observed in glycerol treatments (T_3 and T_6) in sweet and spiced IMF aonla segments, respectively. This could be attributed to glycerol having lower molecular weight (92.1 g/mole) than sucrose (molecular weight 342.3 g/mole). Since, 60 per cent glycerol solution prepared on w/w basis had more molarity than 60 per cent sucrose solution, which resulted in higher osmotic pressure and hence, more removal of water from IMF segments. Increasing glycerol concentration caused an increase in osmotic pressure and water loss, and hence, minimum moisture content was observed in IMF aonla segments steeped in glycerol solution. Moisture content was recorded maximum in sucrose treatments (T_1 and T_4) in sweet and spiced IMF aonla segments, respectively and it could be due to lower osmotic pressure of sucrose as compared to glycerol, which resulted in less water loss from the segments. Pattanapa *et al.* (2010) reported similar findings in osmotically dehydrated mandarin steeped in different ratios of sucrose and glycerol.

Water activity (a_w)

The progressive decrease in a_w of IMF aonla segments during six months storage (Table 2) might be due to loss of moisture content from the samples. The spiced IMF aonla segments showed lower a_w as compared to sweet IMF aonla segments, which might be due to presence of NaCl in the spice mix. The ability of salt to decrease water activity is thought to be due to ability of sodium and chloride ions to associate with water molecules (Fennema, 1996).

Table 1. Effect of various treatments and storage on moisture content (%) of IMF segments prepared from aonla fruits cv Banarasi

Treatments	Storage (months)							Mean
	0	1	2	3	4	5	6	
T_1	28.7	28.0	27.0	25.7	25.7	25.0	25.0	**26.4**
T_2	25.0	24.0	24.0	23.3	23.0	23.0	22.0	**23.5**
T_3	22.0	22.0	22.0	20.7	20.7	20.0	19.3	**21.0**
T_4	31.3	30.0	30.0	28.7	28.3	28.0	26.7	**29.0**
T_5	26.0	25.3	25.3	24.7	23.0	23.0	23.0	**24.3**
T_6	23.0	23.0	22.0	22.0	22.0	20.7	19.7	**21.8**
Mean	**26.0**	**25.4**	**25.1**	**24.2**	**23.8**	**23.3**	**22.6**	
CD at 5%	Storage (S) = 0.78				Treatment (T) = 0.72			
	S X T = 0.19							

[a] T_1= Sucrose, [b] T_2= Sucrose + Glycerol (1:1), [c] T_3= Glycerol, [d] T_4= Spices + T_1, [e] T_5= Spices + T_2, [f] T_6= Spices + T_3

Table 2. Effect of various treatments and storage on water activity (a_w) of IMF segments prepared from aonla fruits cv Banarasi

Treatments	Storage (months)							Mean
	0	1	2	3	4	5	6	
T_1	0.77	0.77	0.75	0.74	0.72	0.72	0.71	**0.74**
T_2	0.75	0.75	0.73	0.72	0.72	0.71	0.69	**0.72**
T_3	0.73	0.72	0.70	0.69	0.67	0.67	0.65	**0.69**
T_4	0.75	0.75	0.74	0.73	0.70	0.70	0.69	**0.72**
T_5	0.73	0.73	0.72	0.71	0.70	0.69	0.67	**0.71**
T_6	0.72	0.71	0.69	0.68	0.66	0.65	0.64	**0.68**
Mean	**0.74**	**0.74**	**0.72**	**0.71**	**0.70**	**0.69**	**0.68**	
CD at 5%	Storage (S) = 0.05				Treatments (T) = 0.02			
	S X T= 0.09							

[a] T_1= Sucrose, [b] T_2= Sucrose + Glycerol (1:1), [c] T_3= Glycerol, [d] T_4= Spices + T_1, [e] T_5= Spices + T_2, [f] T_6= Spices + T_3

In sweet and spiced IMF aonla segments, minimum water activity was observed in glycerol treatment (T_3 and T_6), which may be because of glycerol, a polyhydric alcohol, forms hydrogen bonding with water and thus, reduces the free water which resulted in lowering of water activity.The sucrose treatments (T_1 and T_4) showed maximum a_w in sweet and spiced IMF aonla segments, respectively which might be due to less hydrogen bonding capacity of sucrose as compared to glycerol and hence, showed more water activity in the IMF segments. Ayub and Alam (2002) reported that a_w of sweetened guava slices made by steeping in dry crystalline sucrose decreased after combined osmotic and cabinet dehydration. Their values were 0.67, 0.57, 0.43 and 0.36 after 24, 48, 72 and 96 hours of treatment.

Total soluble solids (TSS)

The total soluble solids were found to increase significantly in all the treatments during storage (Table 3). This might be due to conversion of polysaccharides into sugars during hydrolysis process. Increase in TSS might also be attributed to reduction in moisture content of the product during storage. Ayub *et al*. (2005) also showed an increase in TSS of intermediate moisture sweetened guava slices during storage. In sweet and spiced IMF aonla segments, spiced segments showed more TSS, which might be due to soluble solids of spices, subsequently adding to TSS of the products.

In both sweet and spiced IMF aonla segments, the maximum TSS were reported in glycerol treatments (T_3 and T_6), while mimimum in sucrose treatments (T_1 and T_4), respectively in the present study, which could be due to lower molecular weight of glycerol (92.1 g/mole) as compared to sucrose (342.3 g/mole) resulting in more permeation of glycerol during osmosis into IMF aonla segments and enhanced the solid gain. Infact, mass transfer of the solute is dependent on the effective diffusion coefficient that can be affected by the radius of the molecules. A significant increase in solid gain was also observed by Pattanappa *et al.* (2010), when sucrose/glycerol ratio was decreased to 5:5 from 9:1 in osmotically dehydrated mandarin.

Total sugars

There was a gradual and significant increase in total sugars of sweet and spiced IMF aonla segments with the advancement of storage period (Table 4). The increase in level of sugars can be attributed to loss of moisture from the products thereby concentrating sugars. Singh *et al.* (2010) found that there was an increase in total sugars in all treatments (sucrose 50^0brix, sucrose 60^0brix and sucrose 50^0brix + KMS+ sodium benzoate) of intermediate moisture baby corn with the subsequent increase in 60 days of storage period. The spiced IMF aonla segments showed more total sugars as compared to sweet IMF aonla segments, which may be due to sugars of spices, subsequently adding to total sugars of the products.

Table 3. Effect of various treatments and storage on total soluble solids (%) of IMF segments prepared from aonla fruits cv Banarasi

Treatments	Storage (months)							Mean
	0	1	2	3	4	5	6	
T_1	32.1	33.2	34.4	34.4	34.8	35.0	35.0	**34.1**
T_2	34.6	34.7	35.1	35.4	35.4	36.6	36.7	**35.5**
T_3	36.1	36.7	36.7	37.1	37.7	37.7	38.1	**37.2**
T_4	34.7	34.7	35.3	35.8	35.8	36.4	37.7	**35.8**
T_5	35.9	36.4	36.4	37.1	37.7	38.2	38.2	**37.1**
T_6	37.3	37.8	38.5	39.1	39.3	39.7	40.1	**38.8**
Mean	**35.1**	**35.6**	**36.1**	**36.5**	**36.8**	**37.3**	**37.6**	
CD at 5%	Storage (S) = 0.08 Treatment (T) = 0.07 S X T = 0.19							

(a) T_1= Sucrose, (b) T_2= Sucrose + Glycerol (1:1), (c) T_3= Glycerol, (d) T_4= Spices + T_1, (e) T_5= Spices + T_2, (f) T_6= Spices + T_3

Table 4. Effect of various treatments and storage on total sugars (g/100 g) of IMF segments prepared from aonla fruits cv Banarasi

Treat ments	Storage (months)							
	0	1	2	3	4	5	6	Mean
T_1	28.4	29.3	29.3	30.6	30.6	30.6	30.6	**29.9**
T_2	18.3	18.7	18.7	19.6	19.8	19.8	19.8	**19.2**
T_3	6.5	6.5	7.1	7.1	7.1	7.1	8.4	**7.1**
T_4	29.1	29.5	30.0	31.8	31.8	31.8	31.8	**30.8**
T_5	19.2	19.8	19.8	20.1	21.6	21.6	21.6	**20.5**
T_6	7.8	8.4	8.7	8.7	8.7	8.7	9.2	**8.6**
Mean	**18.2**	**18.7**	**18.9**	**19.7**	**19.9**	**19.9**	**20.2**	
CD at 5%	Storage (S) = 0.18 Treatment (T) = 0.16 S X T = 0.44							

(a) T_1= Sucrose, (b) T_2= Sucrose + Glycerol (1:1), (c) T_3= Glycerol, (d) T_4= Spices + T_1, (e) T_5= Spices + T_2, (f) T_6= Spices + T_3

In sweet and spiced IMF aonla segments, total sugars were maximum in sucrose treatments (T_1 and T_4) and minimum in glycerol treatments (T_3 and T_6), respectively and that could be due to steeping of aonla segments in 60 per cent sucrose solution for 16 hours during osmosis which was detected in sugar test (Hulme and Narian, 1931). Total sugars of IMF aonla segments decreased with the increase in glycerol concentration in the osmotic treatments and in segments treated with glycerol solution alone. This might be due to permeation of glycerol into IMF segments but glycerol could not be detected in sugar test (Hulme and Narian, 1931). The present findings are in accordance with those of Ramanuja and Jayaram (1978) in intermediate moisture banana.

Ascorbic acid

The ascorbic acid content (Table 5) in sweet and spiced IMF aonla segments decreased significantly during six months storage period. The possible reason of reduction in vitamin C could be due to oxidation by oxygen, which resulted in formation of dehydroascorbic acid. Ayub *et al.* (2005) also reported a declining trend in ascorbic acid in intermediate moisture sweetened guava slices during storage. The spiced IMF aonla segments retained more ascorbic acid, and it might be due to antioxidants in the spices, which protected ascorbic acid from oxidation. The glycerol treatments (T_3 and T_6) in sweet and spiced IMF aonla segments, respectively showed more retention of ascorbic acid. This effect could be due to lower molecular weight of glycerol (92.1 g/mole) than sucrose (342.3 g/mole), which resulted in higher osmotic pressure and dewatering from the aonla segments during osmosis. This dewatering resulted into more concentration of ascorbic acid in the cellular tissues.

The minimum ascorbic acid was observed in sucrose treatments (T_1 and T_4). This may be due to higher molecular weight of sucrose (342.3 g/mole). The 60 per cent sucrose solution exerted lower osmotic pressure, thus less dewatering and hence, less concentration of ascorbic acid in cellular tissues. The present findings are in accordance with those of Pattanapa *et al.* (2010) in osmotically dried mandarin.

4. CONCLUSIONS

The moisture content and water activity (a_w) in sweet and spiced IMF aonla segments decreased significantly during six months storage and was found minimum in glycerol treatments (T_3 and T_6) in sweet and spiced IMF segments, respectively. Total soluble solids (TSS), and total sugars increased significantly in IMF segments during storage.

The maximum TSS in sweet and spiced IMF segments were found in glycerol treatments (T_3 and T_6), respectively. The total sugars were recorded maximum in sucrose treatments (T_1 and T_4) in sweet and spiced IMF segments, respectively.

Table 5: Effect of various treatments and storage on ascorbic acid (mg/100 g) of IMF segments prepared from aonla fruits cv Banarasi

Treatments	Storage (months)							Mean
	0	**1**	**2**	**3**	**4**	**5**	**6**	
T_1	356	335	305	286	257	244	224	**287**
T_2	378	358	331	301	284	275	257	**312**
T_3	392	384	367	358	328	304	277	**344**
T_4	367	356	346	307	280	264	244	**309**
T_5	384	363	343	320	297	266	273	**321**
T_6	414	390	375	368	338	312	284	**354**
Mean	**382**	**364**	**345**	**323**	**297**	**278**	**260**	
CD at 5%	Storage (S) = 18.7; Treatments (T) = 17.4; S X T = 45.8							

(a) T_1= Sucrose, (b) T_2= Sucrose + Glycerol (1:1), (c) T_3= Glycerol, (d) T_4= Spices + T_1, (e) T_5= Spices + T_2, (f) T_6= Spices + T_3

In sweet and spiced IMF aonla segments, ascorbic acid decreased significantly. The glycerol treatments (T_3 and T_6) showed maximum ascorbic acid. IMF aonla segments in 60 per cent glycerol syrup, retained maximum nutrients. The 60 per cent sucrose treated IMF aonla segments retained the minimum nutrients. The 60 per cent sucrose+glycerol (1:1) treatment was found to retain more nutrients than 60 per cent surose treatment.

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