Environment and Ecology 42 (2A) : 584—592, April—June 2024
Article DOI: https://doi.org/10.60151/envec/ZUQS8040
ISSN 0970-0420

Influence of Storage Period on Biochemical Parameters of Aonla Based Fortified Squash

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Received 20 July 2023, Accepted 1 December 2023, Published on 6 May 2024

ABSTRACT

Aonla is an excellent source of vitamins and minerals, aonla has got enormous pharmaceutical values. Consumption of fresh aonla fruits has immense benefits, but due to high acidic and astringent content in the fruits, it has very limited table value. Preparation of various value added products specially blended beverages such as RTS, nectar and squash from aonla fruit helps to overcome astringent taste and poor color and flavor. The present investigation "Influence of storage period on biochemical parameters of aonla based fortified squash" was conducted at the Horticulture Processing Laboratory, Department of Fruit Science, IGKV, Raipur (CG) during the experimental year 2021-2022 and 2022-2023. Analysis of bio-chemical parameters under 13 treatments of fortified Aonla squash unveiled that the treatment T_{10} (25% Aonla + 73% Pomegranate + 2% Ginger) documented maximum total soluble solids content and TSS: Acid ratio among all the other treatments. Further, the treatment T_4 (25% Aonla + 75% Pomegranate) reported maximum pH value and minimum acidity and ascorbic acid content. However, the treatment T_{13} (100% Aonla) recorded maximum acidity and ascorbic acid content as well as minimum total soluble solids content, pH and TSS: Acid ratio.

Keywords Edaphic, Xerophytic, Ascorbic acid, Refractometer, Polysaccharides.

INTRODUCTION

Aonla (*Emblica officinalis* Gaertn) popularly known as "Amritphal" belongs to the family Euphorbiaceae. Aonla is a minor and hardy plant grown in diverse range of climatic and edaphic condition due to xerophytic characteristics. Being rich source of vitamins and minerals, aonla has got enormous pharmaceutical values. In India, Uttar Pradesh is the leading producer (4.02 lakh tonnes) of aonla as well as it covers maximum area under aonla cultivation, followed by Madhya Pradesh (Anon 2020). Consumption of fresh aonla fruits has immense benefits, but due to high acidic and astringent content in the fruits, it has very limited table value. Preparation of various value added products specially blended beverages such as RTS, nectar and squash from aonla fruit helps to overcome astringent taste and poor color and flavor. Blending of different fruit juices is generally adapted these days to minimize the cost of expensive fruits, overcome seasonal availability, balance taste and flavor, minimize acidity and improve TSS %.

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Table 1. Treatment details for fortified aonla squash.

Sl. No.	Treatment details	Notations to be used
1	Aonla Juice : Mandarin Juice (25 : 75)	T_1
2	Aonla Juice : Mandarin Juice (50 : 50)	T_2
3	Aonla Juice : Mandarin Juice (75 : 25)	T_3
4	Aonla Juice : Pomegranate Juice (25 : 75)	T_4
5.	Aonla Juice : Pomegranate Juice (50 : 50)	T_5
6	Aonla Juice : Pomegranate Juice (75 : 25)	T_6
7	Aonla Juice : Mandarin Juice : Ginger Juice (25 : 73 : 2)	T_7
8	Aonla Juice : Mandarin Juice : Ginger Juice (50 : 48 : 2)	T_8
9	Aonla Juice : Mandarin Juice : Ginger Juice (75 : 23 : 2)	T_9
10	Aonla Juice : Pomegranate Juice : Ginger Juice (25 : 73 : 2)	T_{10}
11	Aonla Juice : Pomegranate Juice : Ginger Juice (50 : 48 : 2)	T_{11}
12	Aonla Juice : Pomegranate Juice : Ginger Juice (75 : 23 : 2)	T_{12}
13	Control (100% Aonla juice)	T_{13}

MATERIALS AND METHODS

The present investigation "Influence of storage period on biochemical parameters of aonla based fortified squash" was conducted at the Horticulture Processing Laboratory, Department of Fruit Science, IGKV, Raipur (CG) during the experimental year 2021-2022 and 2022-2023. The research trial was carried out in Completely Randomized Design with 13 treatments combinations and 3 replications, the treatment detail is given in the Table 1. Total soluble solids of aonla based blended squash was measured using ERMA Hand Refractometer and the value was recorded in °Brix. The acidity of aonla based fortified squash was estimated using the procedure given by Ranganna (2003). The pH of the aonla based fortified squash was directly determined by a digital pH meter. The ascorbic acid content of aonla based fortified squash was estimated by the procedure given by Ranganna (1986). The TSS: Acid ratio of the aonla based squash was taken out by dividing total soluble solids with the acidity content of squash.

RESULTS AND DISCUSSION

Total soluble solids

The data with reference to change in total soluble solids of fortified aonla squash with the advancement in storage period during the experimental year 2021-2022 and 2022-2023 is presented in the Table 2. The data gathered during the present investigation revealed that there was a gradual rise in the TSS value of the aonla based fortified squash under different treatments. Initially, the TSS value of all the treatments were maintained to 45 °Brix, which started rising with the increase in storage duration

Table 2. Changes in total soluble solids of fortified aonla squash during storage.

	Total soluble solids (°Brix) in fortified squash of aonla								
	0 DAP			30 DAP			60 DAP		
Treatments	2022	2023	Pooled mean	2022	2023	Pooled mean	2022	2023	Pooled mean
T_1	45.00	45.00	45.00	45.15^{ab}	45.27^{ab}	45.21^{ab}	45.47^{bc}	45.51^{b}	45.49^{bc}
T_2	45.00	45.00	45.00	45.14^{a}	45.44^{bcd}	45.29^{abcd}	45.50^{bcd}	45.68^{def}	45.59^{cde}
T_3	45.00	45.00	45.00	45.32^{e}	45.28^{ab}	45.30^{bcd}	45.40^{b}	45.37^{a}	45.39^{ab}
T_4	45.00	45.00	45.00	45.23^{cd}	45.54^{cd}	45.39^{cd}	45.64^{fg}	45.78^{fg}	45.71^{fgh}
T_5	45.00	45.00	45.00	45.16^{abc}	45.46^{bcd}	45.31^{bcd}	45.60^{defg}	45.70^{def}	45.65^{efg}
T_6	45.00	45.00	45.00	45.13^{a}	45.42^{bcd}	45.27^{abc}	45.57^{cdef}	45.66^{de}	45.61^{def}
T_7	45.00	45.00	45.00	45.22^{bcd}	45.46^{bcd}	45.34^{bcd}	45.51^{bcde}	45.54^{bc}	45.52^{cd}
T_8	45.00	45.00	45.00	45.16^{abc}	45.37^{abc}	45.26^{abc}	45.60^{defg}	45.61^{bcd}	45.60^{cdef}
T_9	45.00	45.00	45.00	45.28^{de}	45.57^{cd}	45.42^{de}	45.54^{cdef}	45.63^{cde}	45.59^{cde}
T_{10}	45.00	45.00	45.00	45.58^{g}	45.79^{e}	45.68^{f}	45.71^{g}	45.93^{h}	45.82^{h}
T_{11}	45.00	45.00	45.00	45.49^{f}	45.58^{d}	45.53^{e}	45.63^{efg}	45.82^{g}	45.73^{gh}
T_{12}	45.00	45.00	45.00	45.15^{ab}	45.49^{cd}	45.32^{bcd}	45.58^{cdef}	45.73^{efg}	45.66^{efg}
T_{13}	45.00	45.00	45.00	45.11^{a}	45.21^{a}	45.16^{a}	45.27^{a}	45.36^{a}	45.32^{a}
SE (m) ±				**0.03**	**0.07**	**0.05**	**0.04**	**0.04**	**0.04**
CD at 5%				**0.07**	**0.20**	**0.13**	**0.12**	**0.10**	**0.11**

Table 2. Continued.

Treatments	Total soluble solids (°Brix) in fortified squash of aonla								
	90 DAP			120 DAP			% increased during storage		
	2022	2023	Pooled mean	2022	2023	Pooled mean	2022	2023	Pooled mean
T_1	45.52^{ab}	45.83^{b}	45.68^{ab}	45.83^{a}	46.15^{ab}	45.99^{ab}	1.84	2.56	2.20
T_2	46.01^{abc}	46.00^{b}	46.00^{bcd}	46.31^{ab}	46.32^{ab}	46.32^{abc}	2.92	2.94	2.93
T_3	46.46^{c}	46.40^{cd}	46.43^{d}	46.61^{bc}	46.58^{bc}	46.60^{bcd}	3.58	3.52	3.55
T_4	46.19^{bc}	46.10^{bcd}	46.15^{bcd}	46.74^{bc}	46.43^{b}	46.58^{bcd}	3.86	3.17	3.52
T_5	46.52^{cd}	46.02^{b}	46.27^{cd}	47.08^{c}	46.34^{ab}	46.71^{cd}	4.62	2.99	3.80
T_6	46.11^{bc}	45.98^{b}	46.05^{bcd}	46.66^{bc}	46.30^{ab}	46.48^{bc}	3.70	2.90	3.30
T_7	45.65^{ab}	45.86^{b}	45.75^{abc}	46.20^{ab}	46.18^{ab}	46.19^{abc}	2.67	2.62	2.64
T_8	46.14^{bc}	45.93^{b}	46.04^{bcd}	46.70^{bc}	46.25^{ab}	46.47^{bc}	3.77	2.78	3.27
T_9	46.09^{abc}	45.95^{b}	46.02^{bcd}	46.64^{bc}	46.27^{ab}	46.45^{bc}	3.64	2.83	3.23
T_{10}	47.19^{d}	47.01^{c}	47.10^{e}	48.26^{d}	47.92^{d}	48.09^{e}	7.23	6.50	6.87
T_{11}	46.47^{c}	46.43^{d}	46.45^{d}	47.32^{c}	47.05^{c}	47.18^{d}	5.15	4.56	4.85
T_{12}	46.13^{bc}	46.05^{bc}	46.09^{bcd}	46.68^{bc}	46.37^{ab}	46.53^{bc}	3.74	3.05	3.39
T_{13}	45.39^{a}	45.41^{a}	45.40^{a}	45.68^{a}	45.89^{a}	45.78^{a}	1.50	1.98	1.74
SE (m) ±	**0.24**	**0.12**	**0.18**	**0.26**	**0.17**	**0.21**			
CD at 5%	**0.71**	**0.35**	**0.53**	**0.75**	**0.48**	**0.62**			

*DAP- Days after processing.

*The superscript letter indicates that the treatment means with same letters are at par at 5% level of significance, while the means with different letters are significantly different at 5% level of significance. These letters have been affixed based on CD- value comparison of treatment means.

(up to 120 DAP). Maximum TSS value (45.58, 45.71, 47.19 and 48.26 and 45.79, 45.93, 47.01and 47.92 and 45.68, 45.82, 47.10 and 48.09 °Brix) during both the years of investigation as well as pooled mean data were recorded under the treatment T_{10} (25% Aonla + 73% Pomegranate + 2% Ginger), while the minimum TSS (45.11, 45.27, 45.39 and 45.68 and 45.21, 45.36, 45.41and 45.89 and 45.16, 45.32, 45.40 and 45.78 °Brix) was documented under T_{13} (100% Aonla) at 30, 60, 90 and 120 days after processing (DAP). There was upsurge noticed in the TSS value of fortified squash of aonla, the major reason behind rising of TSS value with the advancement in storage period (0 to 120 days) is due to the hydrolysis of

Table 3. Changes in acidity of fortified Aonla squash during storage.

Treatments	Acidity in fortified squash of aonla								
	0 DAP			30 DAP			60 DAP		
	2022	2023	Pooled mean	2022	2023	Pooled mean	2022	2023	Pooled mean
T_1	1.00	1.00	1.00	1.12^{efg}	1.15^{d}	1.13^{ef}	1.19^{cd}	1.19^{ef}	1.19^{def}
T_2	1.00	1.00	1.00	1.10^{def}	1.11^{c}	1.10^{de}	1.17^{bcd}	1.16^{de}	1.16^{cde}
T_3	1.00	1.00	1.00	1.15^{g}	1.17^{de}	1.16^{f}	1.23^{de}	1.22^{fg}	1.22^{efg}
T_4	1.00	1.00	1.00	1.01^{a}	1.02^{a}	1.02^{a}	1.09^{a}	1.06^{a}	1.07^{a}
T_5	1.00	1.00	1.00	1.02^{ab}	1.02^{a}	1.02^{a}	1.09^{a}	1.06^{a}	1.08^{a}
T_6	1.00	1.00	1.00	1.06^{bcd}	1.06^{b}	1.06^{bc}	1.13^{abc}	1.10^{abc}	1.12^{abc}
T_7	1.00	1.00	1.00	1.11^{efg}	1.17^{de}	1.14^{f}	1.19^{cd}	1.22^{fg}	1.20^{def}
T_8	1.00	1.00	1.00	1.08^{cde}	1.11^{c}	1.09^{cd}	1.16^{abcd}	1.15^{cde}	1.15^{bcd}
T_9	1.00	1.00	1.00	1.14^{fg}	1.19^{ef}	1.16^{f}	1.22^{d}	1.23^{fg}	1.23^{fg}
T_{10}	1.00	1.00	1.00	1.02^{ab}	1.02^{a}	1.02^{a}	1.09^{a}	1.06^{a}	1.07^{a}
T_{11}	1.00	1.00	1.00	1.03^{ab}	1.05^{ab}	1.04^{ab}	1.10^{ab}	1.09^{ab}	1.09^{ab}
T_{12}	1.00	1.00	1.00	1.05^{abc}	1.08^{bc}	1.07^{bcd}	1.13^{abc}	1.12^{bcd}	1.12^{abc}
T_{13}	1.00	1.00	1.00	1.22^{h}	1.21^{f}	1.21^{g}	1.30^{e}	1.26^{g}	1.28^{g}
SE (m) ±				**0.01**	**0.01**	**0.01**	**0.02**	**0.02**	**0.02**
CD at 5%				**0.04**	**0.03**	**0.03**	**0.07**	**0.05**	**0.06**

Table 3. Continued.

Treatments	Acidity in fortified squash of aonla								
	90 DAP			120 DAP			% increased during storage		
	2022	2023	Pooled mean	2022	2023	Pooled mean	2022	2023	Pooled mean
T_1	1.28^{ef}	1.27^{de}	1.28^{de}	1.37^{bc}	1.32^{bcd}	1.35^{bcd}	36.63	32.44	34.54
T_2	1.26^{cdef}	1.24^{cde}	1.25^{cde}	1.34^{abc}	1.28^{abcd}	1.31^{abcd}	34.34	28.47	31.41
T_3	1.31^{f}	1.30^{e}	1.31^{e}	1.40^{c}	1.36^{d}	1.38^{d}	40.25	35.52	37.88
T_4	1.16^{a}	1.13^{a}	1.14^{a}	1.24^{a}	1.17^{a}	1.21^{a}	24.14	17.21	20.67
T_5	1.17^{a}	1.13^{a}	1.15^{ab}	1.25^{ab}	1.18^{ab}	1.22^{ab}	25.15	17.97	21.56
T_6	1.21^{abcd}	1.18^{abcd}	1.20^{abcd}	1.30^{abc}	1.23^{abcd}	1.26^{abcd}	29.64	22.80	26.22
T_7	1.27^{def}	1.30^{e}	1.29^{e}	1.36^{abc}	1.35^{cd}	1.36^{cd}	35.91	35.16	35.54
T_8	1.24^{bcde}	1.23^{bcde}	1.23^{bcde}	1.32^{abc}	1.28^{abcd}	1.30^{abcd}	32.19	27.79	29.99
T_9	1.30^{ef}	1.32^{ef}	1.31^{e}	1.40^{c}	1.37^{d}	1.38^{d}	39.59	37.20	38.39
T_{10}	1.16^{a}	1.14^{ab}	1.15^{ab}	1.24^{a}	1.18^{ab}	1.21^{a}	24.29	18.32	21.31
T_{11}	1.18^{ab}	1.16^{abc}	1.17^{abc}	1.26^{ab}	1.21^{abc}	1.23^{abc}	25.98	20.88	23.43
T_{12}	1.20^{abc}	1.20^{abcd}	1.20^{abcd}	1.29^{abc}	1.25^{abcd}	1.27^{abcd}	28.67	24.96	26.82
T_{13}	1.43^{g}	1.41^{f}	1.42^{f}	1.78^{d}	1.90^{e}	1.84^{e}	78.24	89.60	83.92
SE (m) ±	**0.02**	**0.03**	**0.03**	**0.04**	**0.05**	**0.04**			
CD at 5%	**0.06**	**0.09**	**0.08**	**0.12**	**0.14**	**0.13**			

*DAP- Days after processing.

*The superscript letter indicates that the treatment means with same letters are at par at 5% level of significance, while the means with different letters are significantly different at 5% level of significance. These letters have been affixed based on CD- value comparison of treatment means.

polysaccharides i.e. pectin, starch and hemicellulose in to simple soluble substance. These findings were in close agreement with the findings of Reddy and Chikkasubbunna (2008), Singh *et al.* (2013) and Purandar *et al.* (2013) in aonla blended squash and Purewal *et al.* (2022) in aonla blended RTS.

Acidity

The data assembled on change in acidity content of aonla based fortified squash is presented in the Table 3. It was noticed from the present study that there was sharp increase in the acidity % of the aonla based fortified squash under different treatments with the advancement in the storage period. Initially, the acidity of all the treatments were maintained to 1 %, which started rising with the increase in storage duration (up to 120 DAP). Minimum acidity (1.01, 1.09, 1.16 and 1.24 and 1.02, 1.06, 1.13 and 1.17 and 1.02, 1.07, 1.14 and 1.21 %) was documented under T_4 (25% Aonla + 75% Pomegranate), which was strictly followed by the treatments T_5, T_{10} and T_{11}, while the maximum acidity (1.22, 1.30, 1.43 and 1.78 and 1.21, 1.26, 1.41 and 1.90 and 1.21, 1.28, 1.42 and 1.84 %) during both the years of investigation as well as pooled mean data were recorded under the treatment T_{13} (100% Aonla) at 30, 60, 90 and 120 days after processing (DAP). The major reason behind rising of acidity with the advancement in storage period (0 to 120 days) is due to the hydrolysis of polysaccharides i.e. pectin, starch and hemicellulose as well as degradation of ascorbic acid which leads to formation of acidic compounds. Similar findings were reported by Jain *et al*. (2006), Rajesh *et al*. (2009), Choudhary *et al*. (2013) and Sangeeta and Ansia (2014) in aonla blended squash and Das *et al*. (2021) in aonla blended RTS.

pH

The observations pertaining to change in pH of fortified squash of aonla under different treatments at 0, 30, 60, 90 and 120 days after processing during both the years as well as pooled means are demonstrated in Table 4. It is evident from the research trial that the maximum pH value (3.78, 3.62, 3.39, 3.25 and 3.19 and 3.86, 3.76, 3.61, 3.38 and 3.15 and 3.82, 3.69, 3.50, 3.32 and 3.17) during both the years of investigation as well as pooled mean data were recorded under the treatment T_4 (25% Aonla + 75% Pomegranate), while the minimum score (2.42, 2.33,

Table 4. Changes in pH of fortified Aonla squash during storage.

Treatments	pH in fortified squash of aonla								
	0 DAP			30 DAP			60 DAP		
	2022	2023	Pooled mean	2022	2023	Pooled mean	2022	2023	Pooled mean
T_1	2.90^{bc}	2.85^{d}	2.88^{cd}	2.83^{cd}	2.66^{de}	2.75^{cde}	2.71^{de}	2.50^{cde}	2.61^{cd}
T_2	2.82^{bc}	2.79^{cd}	2.80^{bcd}	2.76^{bcd}	2.58^{cd}	2.67^{bcd}	2.62^{cd}	2.41^{abcd}	2.52^{bc}
T_3	2.75^{b}	2.63^{b}	2.69^{b}	2.70^{bc}	2.51^{bc}	2.61^{b}	2.53^{bc}	2.39^{abc}	2.46^{b}
T_4	3.78^{f}	3.86^{h}	3.82^{g}	3.62^{f}	3.76^{i}	3.69^{h}	3.39^{h}	3.61^{i}	3.50^{h}
T_5	3.33^{d}	3.21^{e}	3.27^{e}	3.23^{e}	3.07^{g}	3.15^{f}	3.05^{g}	2.92^{g}	2.99^{e}
T_6	2.96^{c}	2.83^{d}	2.89^{cd}	2.82^{bcd}	2.77^{ef}	2.80^{de}	2.71^{de}	2.63^{ef}	2.67^{d}
T_7	2.88^{bc}	2.87^{d}	2.87^{cd}	2.80^{bcd}	2.79^{f}	2.79^{de}	2.64^{cde}	2.66^{f}	2.65^{cd}
T_8	2.82^{bc}	2.68^{bc}	2.75^{bc}	2.70^{bc}	2.53^{bc}	2.62^{bc}	2.51^{bc}	2.42^{bcd}	2.47^{b}
T_9	2.76^{b}	2.57^{ab}	2.67^{b}	2.67^{b}	2.44^{ab}	2.55^{b}	2.48^{b}	2.34^{ab}	2.41^{b}
T_{10}	3.56^{e}	3.48^{f}	3.52^{f}	3.47^{f}	3.37^{h}	3.42^{g}	3.36^{h}	3.23^{h}	3.30^{g}
T_{11}	3.43^{de}	3.63^{g}	3.53^{f}	3.28^{e}	3.48^{h}	3.38^{g}	2.99^{fg}	3.29^{h}	3.14^{f}
T_{12}	2.96^{c}	2.90^{d}	2.93^{d}	2.89^{d}	2.77^{ef}	2.83^{e}	2.76^{e}	2.54^{def}	2.65^{cd}
T_{13}	2.42^{a}	2.46^{a}	2.44^{a}	2.33^{a}	2.36^{a}	2.34^{a}	2.27^{a}	2.28^{a}	2.27^{a}
SE (m) ±	**0.06**	**0.04**	**0.05**	**0.05**	**0.04**	**0.05**	**0.05**	**0.04**	**0.05**
CD at 5%	**0.16**	**0.13**	**0.15**	**0.15**	**0.12**	**0.13**	**0.13**	**0.13**	**0.13**

Table 4. Continued.

Treatments	pH in fortified squash of aonla						% decreased during storage		
	90 DAP			120 DAP					
	2022	2023	Pooled mean	2022	2023	Pooled	2022 mean	2023	Pooled mean
T_1	2.67^{de}	2.41^{cd}	2.54^{de}	2.49^{cd}	2.19^{bcd}	2.34^{bc}	14.30	23.15	18.72
T_2	2.55^{bcd}	2.30^{bc}	2.42^{cd}	2.39^{bc}	2.16^{bc}	2.28^{b}	15.27	22.43	18.85
T_3	2.45^{b}	2.31^{bc}	2.38^{c}	2.33^{b}	2.18^{bc}	2.25^{b}	15.28	17.15	16.21
T_4	3.25^{g}	3.38^{g}	3.32^{h}	3.19^{f}	3.15^{h}	3.17^{f}	15.49	18.34	16.91
T_5	2.87^{f}	2.79^{e}	2.83^{f}	2.76^{e}	2.58^{f}	2.67^{d}	17.12	19.71	18.41
T_6	2.62^{cde}	2.50^{d}	2.56^{e}	2.55^{d}	2.31^{de}	2.43^{c}	13.62	18.51	16.07
T_7	2.47^{b}	2.51^{d}	2.49^{cde}	2.39^{bc}	2.37^{e}	2.38^{bc}	16.75	17.30	17.03
T_8	2.43^{b}	2.31^{bc}	2.37^{bc}	2.35^{bc}	2.14^{bc}	2.25^{b}	16.70	19.97	18.33
T_9	2.27^{a}	2.23^{ab}	2.25^{ab}	2.11^{a}	2.10^{b}	2.10^{a}	23.66	18.26	20.96
T_{10}	3.19^{g}	3.06^{f}	3.13^{g}	3.10^{f}	2.90^{g}	3.00^{e}	12.95	16.67	14.81
T_{11}	2.73^{e}	3.10^{f}	2.92^{f}	2.57^{d}	2.97^{g}	2.77^{d}	25.14	18.18	21.66
T_{12}	2.53^{bc}	2.35^{c}	2.44^{cde}	2.42^{bcd}	2.26^{cde}	2.34^{bc}	18.29	22.04	20.17
T_{13}	2.18^{a}	2.16^{a}	2.17^{a}	2.06^{a}	1.90^{a}	1.98^{a}	14.82	22.57	18.69
SE (m) ±	**0.04**	**0.04**	**0.04**	**0.05**	**0.04**	**0.05**			
CD at 5%	**0.12**	**0.11**	**0.12**	**0.15**	**0.12**	**0.13**			

*DAP- Days after processing.

*The superscript letter indicates that the treatment means with same letters are at par at 5% level of significance, while the means with different letters are significantly different at 5% level of significance. These letters have been affixed based on CD- value comparison of treatment means.

2.27, 2.18 and 2.06 and 2.46, 2.36, 2.28, 2.16 and 1.90 and 2.44, 2.34, 2.27, 2.17 and 1.98) was documented under T_{13} (100% Aonla) at 0, 30, 60, 90 and 120 days after processing (DAP). There was slight decline in the pH value in various treatments during the storage period at ambient condition, the major reason behind declining of pH value with the advancement in storage period is due to degradation of ascorbic acid or hydrolysis of pectin. With the rise in acidity, the pH value decreases, this might be due to formation of acidic compounds by degradation of reducing sugar present in fortified squash of aonla. These findings were in close agreement with the findings of Choudhary *et al.* (2013) and Vaishnavi (2016) in aonla blended squash and Devra *et al.* (2017) and Das *et al.* (2021) in aonla blended RTS.

Table 5. Changes in ascorbic acid content of fortified aonla squash during storage.

Treatments	Ascorbic acid (mg/100g) in fortified squash of aonla								
	0 DAP			30 DAP			60 DAP		
	2022	2023	Pooled mean	2022	2023	Pooled mean	2022	2023	Pooled mean
T_1	73.17^{i}	70.84^{gh}	72.00^{i}	69.97^{f}	67.74^{g}	68.85^{g}	63.40^{f}	61.55^{d}	62.48^{h}
T_2	65.37^{e}	61.70^{d}	63.54^{e}	62.09^{e}	58.62^{d}	60.35^{cd}	55.45^{d}	51.59^{b}	53.52^{ef}
T_3	63.89^{d}	58.84^{cd}	61.37^{d}	60.18^{c}	55.43^{c}	57.80^{c}	54.31^{d}	51.39^{b}	52.85^{de}
T_4	48.98^{a}	53.66^{a}	51.32^{a}	46.33^{a}	50.71^{a}	48.52^{a}	40.02^{a}	45.19^{a}	42.61^{a}
T_5	58.27^{c}	57.43^{bc}	57.85^{c}	54.58^{b}	53.79^{bc}	54.19^{b}	50.09^{c}	50.91^{b}	50.50^{cd}
T_6	70.74^{h}	72.01^{h}	71.38^{i}	66.81^{ef}	68.00^{g}	67.40^{fg}	60.77^{e}	61.94^{d}	61.36^{h}
T_7	71.96^{hi}	68.11^{fg}	70.04^{hi}	66.21^{de}	62.66^{ef}	64.44^{ef}	59.16^{e}	56.07^{c}	57.62^{g}
T_8	65.64^{ef}	65.16^{e}	65.40^{ef}	62.13^{c}	61.60^{e}	61.87^{de}	53.63^{d}	55.40^{c}	54.51^{ef}
T_9	66.66^{fg}	66.91^{ef}	66.78^{fg}	63.05^{cd}	63.27^{ef}	63.16^{de}	54.47^{d}	55.21^{c}	54.84^{ef}
T_{10}	52.33^{b}	55.45^{ab}	53.89^{b}	49.29^{a}	52.24^{ab}	50.77^{a}	44.48^{b}	46.66^{a}	45.57^{b}
T_{11}	67.38^{g}	70.13^{gh}	68.75^{gh}	62.06^{c}	64.60^{f}	63.33^{de}	54.60^{d}	56.95^{c}	55.78^{fg}
T_{12}	59.31^{c}	60.79^{d}	60.05^{d}	53.44^{b}	54.76^{bc}	54.10^{b}	48.07^{c}	50.54^{b}	49.31^{c}
T_{13}	96.65^{j}	105.33^{i}	100.99^{j}	89.05^{g}	99.01^{h}	94.03^{h}	82.69^{g}	91.45^{e}	87.07^{i}
SE (m) ±	**0.43**	**1.01**	**0.72**	**1.25**	**1.01**	**1.13**	**0.89**	**0.90**	**0.90**
CD at 5%	**1.26**	**2.93**	**2.10**	**3.65**	**2.93**	**3.29**	**2.60**	**2.62**	**2.61**

Table 5. Continued.

Treatments	Ascorbic acid (mg/100g) in fortified squash of aonla								
	90 DAP			120 DAP			% decreased during storage		
	2022	2023	Pooled mean	2022	2023	Pooled mean	2022	2023	Pooled mean
T_1	57.34^{f}	55.67^{d}	56.51^{g}	52.72^{f}	49.59^{f}	51.16^{g}	27.94	29.99	28.97
T_2	50.15^{d}	46.66^{b}	48.41^{e}	46.11^{e}	40.73^{bc}	43.42^{de}	29.46	34.00	31.73
T_3	49.07^{d}	46.44^{b}	47.75^{de}	47.14^{e}	41.14^{cd}	44.14^{de}	26.22	30.09	28.15
T_4	35.84^{a}	40.47^{a}	38.15^{a}	30.63^{a}	34.58^{a}	32.61^{a}	37.46	35.55	36.51
T_5	45.26^{c}	46.00^{b}	45.63^{cd}	40.52^{cd}	41.18^{cd}	40.85^{cd}	30.47	28.28	29.38
T_6	55.37^{ef}	56.44^{d}	55.91^{g}	47.26^{e}	49.52^{f}	48.39^{fg}	33.19	31.22	32.21
T_7	53.91^{e}	51.09^{c}	52.50^{f}	46.93^{e}	46.27^{ef}	46.60^{ef}	34.79	32.07	33.43
T_8	48.68^{d}	50.28^{c}	49.48^{e}	42.93^{de}	44.35^{de}	43.64^{de}	34.59	31.94	33.27
T_9	49.27^{d}	49.93^{c}	49.60^{e}	43.07^{de}	43.65^{cde}	43.36^{de}	35.39	34.76	35.08
T_{10}	40.19^{b}	42.16^{a}	41.18^{b}	35.57^{b}	37.31^{ab}	36.44^{ab}	32.03	32.71	32.37
T_{11}	49.08^{d}	51.20^{c}	50.14^{ef}	43.89^{de}	44.47^{de}	44.18^{de}	34.86	36.59	35.72
T_{12}	43.21^{c}	45.43^{b}	44.32^{c}	38.12^{bc}	40.08^{bc}	39.10^{bc}	35.73	34.07	34.90
T_{13}	77.79^{g}	89.38^{e}	83.58^{h}	74.25^{g}	85.43^{g}	79.84^{h}	23.18	18.89	21.03
SE (m) ±	**0.97**	**0.75**	**0.86**	**1.54**	**1.23**	**1.39**			
CD at 5%	**2.83**	**2.18**	**2.50**	**4.48**	**3.59**	**4.04**			

*DAP- Days after processing.

*The superscript letter indicates that the treatment means with same letters are at par at 5% level of significance, while the means with different letters are significantly different at 5% level of significance. These letters have been affixed based on CD- value comparison of treatment means.

Ascorbic acid

The data with respect to change in ascorbic acid of fortified squash of aonla under different treatments at 0, 30, 60, 90 and 120 days after processing during both the years as well as pooled means are demonstrated in Table 5. It is revealed from the research trial that the maximum ascorbic acid value (96.65, 89.05, 82.69, 77.79 and 74.25 and 105.33, 99.01, 91.45, 89.38 and 85.43 and 100.99, 94.03, 87.07, 83.58 and 79.84 mg/100g) during both the years of investigation as well as pooled mean data were recorded under the treatment T_{13} (100% Aonla), while the minimum value (48.98, 46.33, 40.02, 35.84 and 30.63 and 53.66,

Table 6. Changes in TSS: acid ratio of fortified Aonla squash during storage.

Treatments	TSS: acid ratio in fortified squash of aonla								
	0 DAP			30 DAP			60 DAP		
	2022	2023	Pooled mean	2022	2023	Pooled mean	2022	2023	Pooled mean
T_1	45.00	45.00	**45.00**	40.42^{bc}	39.50^{b}	**39.96^{bc}**	38.07^{bcd}	38.23^{bc}	**38.15^{bcd}**
T_2	45.00	45.00	**45.00**	41.12^{cd}	40.86^{c}	**40.99^{cd}**	38.74^{bcde}	39.54^{cd}	**39.14^{cde}**
T_3	45.00	45.00	**45.00**	39.56^{b}	38.57^{b}	**39.06^{b}**	37.04^{b}	37.21^{ab}	**37.13^{ab}**
T_4	45.00	45.00	**45.00**	44.59^{g}	44.46^{g}	**44.52^{h}**	42.06^{g}	43.06^{gh}	**42.56^{fg}**
T_5	45.00	45.00	**45.00**	44.16^{fg}	44.54^{g}	**44.35^{h}**	41.69^{g}	43.09^{gh}	**42.39^{fg}**
T_6	45.00	45.00	**45.00**	42.64^{e}	42.75^{ef}	**42.70^{fg}**	40.23^{defg}	41.36^{efg}	**40.79^{efg}**
T_7	45.00	45.00	**45.00**	40.71^{bcd}	38.82^{b}	**39.77^{bc}**	38.31^{bcde}	37.45^{ab}	**37.88^{bcd}**
T_8	45.00	45.00	**45.00**	41.81^{de}	41.02^{cd}	**41.42^{de}**	39.46^{cdef}	39.70^{cde}	**39.58^{de}**
T_9	45.00	45.00	**45.00**	39.69^{b}	38.38^{ab}	**39.04^{b}**	37.32^{bc}	36.99^{ab}	**37.16^{abc}**
T_{10}	45.00	45.00	**45.00**	44.89^{g}	44.73^{g}	**44.81^{h}**	42.08^{g}	43.19^{h}	**42.63^{g}**
T_{11}	45.00	45.00	**45.00**	44.17^{fg}	43.59^{fg}	**43.88^{gh}**	41.42^{fg}	42.18^{fgh}	**41.80^{fg}**
T_{12}	45.00	45.00	**45.00**	42.92^{ef}	42.03^{de}	**42.47^{ef}**	40.51^{efg}	40.68^{def}	**40.60^{ef}**
T_{13}	45.00	45.00	**45.00**	37.00^{a}	37.39^{a}	**37.19^{a}**	34.72^{a}	36.10^{a}	**35.41^{a}**
SE (m) ±				**0.46**	**0.40**	**0.43**	**0.76**	**0.62**	**0.69**
CD at 5%				**1.33**	**1.16**	**1.24**	**2.20**	**1.80**	**2.00**

Table 6. Continued.

Treatments	TSS: acid ratio in fortified squash of aonla								
	90 DAP			120 DAP			% decreased during storage		
	2022	2023	Pooled mean	2022	2023	Pooled mean	2022	2023	Pooled mean
T_1	35.63^{b}	35.97^{bc}	**35.80^{bc}**	33.54^{bc}	34.85^{b}	**34.19^{b}**	25.46	22.56	**24.01**
T_2	36.65^{bcd}	37.22^{bcd}	**36.93^{bcd}**	34.47^{bcd}	36.06^{bc}	**35.27^{bc}**	23.39	19.87	**21.63**
T_3	35.45^{b}	35.58^{bc}	**35.52^{bc}**	33.23^{b}	34.37^{b}	**33.80^{b}**	26.15	23.61	**24.88**
T_4	39.81^{fg}	40.89^{ef}	**40.35^{ef}**	37.65^{ef}	39.61^{cd}	**38.63^{de}**	16.33	11.98	**14.16**
T_5	39.77^{efg}	40.56^{ef}	**40.16^{ef}**	37.62^{ef}	39.28^{cd}	**38.45^{cde}**	16.40	12.70	**14.55**
T_6	38.07^{de}	38.94^{def}	**38.51^{de}**	35.99^{cde}	37.70^{bcd}	**36.85^{bcde}**	20.01	16.21	**18.11**
T_7	35.93^{bc}	35.26^{b}	**35.59^{bc}**	33.99^{bcd}	34.17^{b}	**34.08^{b}**	24.46	24.08	**24.27**
T_8	37.36^{cd}	37.36^{bcd}	**37.36^{cd}**	35.32^{bcde}	36.19^{bc}	**35.76^{bcd}**	21.50	19.57	**20.54**
T_9	35.32^{b}	34.82^{ab}	**35.07^{b}**	33.41^{bc}	33.73^{b}	**33.57^{b}**	25.75	25.05	**25.40**
T_{10}	40.62^{g}	41.31^{f}	**40.97^{f}**	38.83^{f}	40.50^{d}	**39.66^{e}**	13.72	9.99	**11.86**
T_{11}	39.45^{efg}	39.94^{def}	**39.69^{ef}**	37.56^{ef}	38.92^{cd}	**38.24^{cde}**	16.53	13.50	**15.02**
T_{12}	38.35^{def}	38.30^{cde}	**38.32^{de}**	36.28^{def}	37.11^{bcd}	**36.69^{bcde}**	19.38	17.54	**18.46**
T_{13}	31.63^{a}	32.13^{a}	**31.88^{a}**	25.63^{a}	24.20^{a}	**24.92^{a}**	43.05	46.21	**44.63**
SE (m) ±	**0.58**	**0.94**	**0.76**	**0.91**	**1.37**	**1.14**			
CD at 5%	**1.70**	**2.72**	**2.21**	**2.65**	**3.99**	**3.32**			

*DAP- Days after processing.

*The superscript letter indicates that the treatment means with same letters are at par at 5% level of significance, while the means with different letters are significantly different at 5% level of significance. These letters have been affixed based on CD- value comparison of treatment means.

50.71, 45.19, 40.47 and 34.58 and 51.32, 48.52, 42.61, 38.15 & 32.61 mg/100g) was documented under T_4 (25% Aonla + 75% Pomegranate) at 0, 30, 60, 90 and 120 days after processing (DAP). There was steady decrease in the ascorbic acid value in various treatments during the storage period at ambient condition, the major reason behind declining of ascorbic acid value with the advancement in storage period is due to the oxidation or irreversible of L ascorbic acid into dehydro ascorbic acid in the presence of enzyme ascorbic acid oxidase (ascorbinase) caused by trapped or residual oxygen in the glass bottles. These findings were in close agreement with the findings of Roopak *et al.* (2006), Rajesh *et al.* (2009), Choudhary *et al.*

(2013) and Vaishnavi (2016) in aonla blended squash.

TSS: acid ratio

The data pertaining to change in TSS: Acid ratio of fortified squash of aonla under different treatments at 0, 30, 60, 90 and 120 days after processing during both the years as well as pooled means are depicted in Table 6. Initially, the TSS: Acid ratio for all the treatments recorded 45.00, as the TSS and acidity of the fortified aonla squash was maintained at 45° Brix and 1 % respectively for all the treatments. It is evident from the experimental results of TSS: Acid ratio for aonla based fortified squash that the TSS: Acid ratio of the prepared squash varied significantly under different treatments and showed downtrend. Maximum TSS: Acid ratio (44.89, 42.08, 40.62 and 38.83 and 44.73, 43.19, 41.31 and 40.50 and 44.81, 42.63, 40.97 and 39.66) during both the years of investigation as well as pooled mean data respectively were recorded under the treatment T_{10} (25% Aonla + 73% Pomegranate + 2% Ginger), while the minimum TSS: Acid ratio (37.00, 34.72, 31.63 and 25.63 and 37.39, 36.10, 32.13 and 24.20 and 37.19, 35.41, 31.88 and 24.92) was documented under T_{13} (100% Aonla) at 30, 60, 90 and 120 days after processing (DAP). There was steady decline in the TSS: Acid ratio content in various treatments during the storage period at ambient condition, due to increase in acidity of prepared fortified squash with higher magnitude as compared to the increase in TSS. Similar findings were also reported by Choudhary *et al.* (2013), Vaishnavi (2016) in aonla blended squash and Chandrakar (2022) in aonla blended RTS.

CONCLUSION

Analysis of bio-chemical parameters under 13 treatments of fortified aonla squash during the experimental year 2021-2022 and 2022-2023 unveiled that the treatment T_{10} (25% Aonla + 73% Pomegranate + 2% Ginger) documented maximum total soluble solids content and TSS: Acid ratio among all the other treatments. Further, the treatment T_4 (25% Aonla + 75% Pomegranate) reported maximum pH value and minimum acidity and ascorbic acid content. However, the treatment T_{13} (100% Aonla) recorded maximum acidity and ascorbic acid content as well as minimum total soluble solids content, pH and TSS: Acid ratio.

ACKNOWLEDGMENT

The authors gratefully acknowledge the College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (CG) for providing research facilities to carry out the present investigation.

REFERENCES

Anonymous (2020) Final estimate of area and production of horticultural crops 2020-2021, by DAC&FW.

Chandrakar P (2022) Standardization of recipe and storage of Aonla (*Emblica officinalis* Gaertn) based fortified Ready-To-Serve beverage. MSc thesis. College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (CG), pp 492012.

Choudhary ML, Verma IM, Singh J, Chandra A, Godara SL (2013) Studies on biochemical changes in aonla (*Emblica officinalis* Gaertn.) squash under storage condition. *Progressive Horticulture* 45 (2): 281.

Das A, Bahadur V, Prasad VM, Mishra S (2021) Standardization, physico-chemical and organoleptic assessment during storage of ready to serve blended kinnow-aonla beverage. The Pharma Innovation Journal 10(12): 700-706.

Devra NS, Kaushik RA, Meena HR (2017) Standardization and storage study of aonla (*Emblica officinalis* Gaertn) based blended ready-to-serve beverages. Int J Curr Microbiol App Sci 6(5): 1275-1284.

Jain V, Singh P, Singh AK (2006) Screening of aonla cultivars for making squash. *Indian J Arid Hort* 1 (1): 44-46.

Purandar M, Sahoo BB, Das BK, Katiyar D (2013) Studies on processing and storage stability of aonla (*Emblica officinalis* Gaertn) nectar. *Hort Flora Research Spectrum* 2(3): 259-261.

Purewal SS, Kamboj R, Sandhu KS, Kaur P, Sharma K, Kaur M, Salar RK, Punia S, Siroha AK (2022) Unraveling the effect of storage duration on antioxidant properties, physico-chemical and sensorial parameters of ready to serve Kinnow-Amla beverages. *Applied Food Research* 2: 57.

Rajesh L, Sindhu SS, Jithender K, Sehrawat SK (2009) Storage studies of aonla blended squash with different fruit juices. *Haryana Journal of Horticultural Science* 38(3-4): 264-269.

Ranganna S (1986) Analytical methods and FPO specification in handbook of analysis and quality control for fruit and vegetable products. 2nd edn. Tata Mcgraw- Hill Pub. Co., New Delhi.

Ranganna S (2003) Handbook of Analysis and Quality Control for Fruits and Vegetable Products. Tata Mc Graw-Hill Publishing Company Limited. New Delhi, pp 11- 12.

Reddy HA, Chikkasubbunna V (2008) Standardization of recipe and storage behavior of lime blended Amla squash. *The Asian Journal of Horticulture* 2:203-207.

Roopak J, Singh G, Singh AK (2006) Evaluation of aonla (*Emblica officinalis* Gaertn) cultivars for squash making. *Progressive Agriculture* 8 (1): 29-31.

Sangeeta V, Anisa D (2014) Studies on preparation and shelf life of honey aonla squash. *International Journal of Engineering Research Sports Science* 1(5): 1-3.

Singh O, Sanjay P, Singh R (2013) Studies on suitable blending ratio for the preparation of aonla based quality beverages. *Annals of Horticulture* 6 (2): 198-204.

Vaishnavi S (2016) Standardization of nutritionally enriched aonla (*Emblica officinalis*) based unfermented blended beverages. MSc thesis. Horticultural College and Research Institute Dr. Ysrhu, Venkataramannagudem, West Godavari 534101, AP.