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Sunil Patidar
College of Horticulture, Department of Fruit Science and PSMA, Mandsaur (M.P.), Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

Ashok Kumar Bajya
College of Horticulture, Department of Fruit Science and PSMA, Mandsaur (M.P.), Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

Toran Singh Daangi
College of Horticulture, Department of Fruit Science and PSMA, Mandsaur (M.P.), Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

Anil chouhan
College of Horticulture, Department of Fruit Science and PSMA, Mandsaur (M.P.), Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

Corresponding Author:
Sunil Patidar
College of Horticulture, Department of Fruit Science and PSMA, Mandsaur (M.P.), Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

Cultivation of Aonla in Malwa region (*Emblica officinalis* Gaertn.) fruits cv. NA-7

Sunil Patidar, Ashok Kumar Bajya, Toran Singh Daangi and Anil chouhan

Abstract
The experiment was conducted at the College of Horticulture, Department of Fruit Science, Mandsaur (M.P.), Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.). The Mandsaur is situated at 23.45^0 to 24.13^0 N latitude and 74.44^0 to 75.18^0 E longitudes at an altitude of 435 m Mean Sea Level. Geographically, the experimental site is lines at the border of M.P. The location of the experimental farm/plot is situated in the main campus of college. The main campus of college was located on the Mandsaur- Sitamau road adjacent to the Sitamau railway crossing phatak. It is also well connected by the Indore, Ratlam road. The experiment variety NA-7, comprised chemical (calcium nitrate) and two oil coating (seasamum oil & castor oil) with two concentrations of Ca(NO3)2e.g. 1.0% and 1.5% and also withtwo dipping times (5 minutes and 10 minutes), ultimately mixes 15 treatment.

Keywords: Ca (NO3)2, seasamum oil & castor oil, Mandsaur(MP)

Introduction
Aonla (*Emblica officinalis* Gaertn syn. *Phyllanthus emblica* Linn.) is an important fruit crop of commercial significance. It is quite hardy, prolific bearer and remunerative even without much care. It is also known as 'Indian Gooseberry' belongs to the family Euphorbiaceae with the chromosome number of 2n= 28. It is indigenous to tropical south-eastern Asia, particularly in central and southern India. It can be grown under wider edapho-climatic situations. However, well-drained fertile loamy soil is the best. It can also do well even in moderately alkaline soils. Aonla is drought hardy fruit crop which is characterized by deep root system and exhibits deciduous nature.

The success of aonla cultivation under arid ecosystem is largely based on efficient management of available natural resources.

India ranks first in the world in area and production of this crop. In India aonla is wildly grown in Uttar Pradesh, Gujarat, Rajasthan, Madhya Pradesh and Tamil Nadu etc. (Shukla, 2010) [12]. The total cultivated area under aonla in India is 95,000 hectares with annual production of 1173,000 MT (NHB, 2015). Madhya Pradesh forests have rich diversity of aonla. Major aonla producing areas in Madhya Pradesh are Sheopur, Betul, Balaghat, Satna, Sidhi, Panna, Ratlam, Mandsaur and Neemuch districts. The total cultivated area under aonla in Madhya Pradesh is 13.98,000 hectares with annual production of 373,000 MT (NHB, 2015).

Indian gooseberry is an under-utilized fruit tree with medicinal and herbal qualities. Its fruit is tonic for diuretic, laxative, antibiotic and act as cooling refrigerant. It is the richest source of vitamin C (500 mg/100 g) among all fruits except Barbados cherry and rich in pectin, iron, calcium and phosphorus. It is also known as amritphal. Fruit pulp of Indian gooseberry is an important ingredient of chavanprash and triphala powder which is used for curing different abnormalities. The fruit contains a chemical substance gallic acid and leuco-anthocyanin that has antioxidant property.

However, it is not consumed much as fresh fruit as it is highly acidic and astringent in taste. Several value added products like RTS, nectar murabba, pickle and candy, herbal squash, herbal jam and sauce (Singh, 2014) [8] are prepared. Aonla fruit is non- climacteric and does ripen on the tree.

In general during storage losses occurs in fruit weight, decay and nutritional quality. The pathological losses in fruits start soon after the harvesting which requires systematic study on shelf- life and stability of aonla fruits. A wide variation in physico-chemical composition has

been recorded in different cultivars of aonla which affects the losses during storage different cultivars of aonla. In recent days Calcium compounds like (calcium nitrate, calcium chloride, etc.) plays an important role in maintaining the quality of fruits. Post-harvest calcium compounds (calcium nitrate, calcium chloride, etc.) application have been used to delay aging or ripening to reduce post-harvest decay and to control the development of physiological disorders in fruits. Firming and resistance to softening resulting from addition of calcium have been attributed to the stabilization of membrane systems & the formation of Ca-pectate, which increase rigidity of the middle portion & cell wall of the fruit.

The use of growth regulators, edible coating, wax emulsion, use of fungicide, oil coating have received attention worldwide as these coating help in maintaining quality even under ordinary storage conditions.

Edible coatings have a high potential to carry active ingredients such as anti-browning agents, colorants, flavors, nutrients, spices, and antimicrobial compounds that can extend product shelf life and reduce the risk of pathogen growth on food surface (Dhall, 2013) [10]. Moreover, another important advantage of edible coating is the reduction of synthetic packaging waste because these coatings are composed of biodegradable raw material. Indeed, over the last two decades the development and use of edible coatings to prolong the shelf life and improve the quality of fresh products has been receiving increased attention.

Castor oil is a vegetable oil obtained by pressing the seeds of the castor oil plant (*Ricinus communis*). The common name "castor oil", from which the plant gets its name, probably comes from its use as a replacement for castoreum, a perfume base made from the dried perineal glands of the beaver. Castor oil has also a property of microbial activity (Bisen *et al*., 2012) [6], however, Sesame oil is a source of vitamin E. Vitamin E is an anti-oxidant. (Mohebbi*et et al*., 2015).

An attempt has been made in the present study to prolong the shelf life of aonla fruit with calcium nitrate and oil coating. Being a minor fruit crop, scanty research work has been carried out so far in M.P. on Indian gooseberry. However, in Malwa plateau conditions, there is little information available on prolonged shelf-life of aonla by post-harvest dip treatment as well as oil coating, So this experiment will be beneficial for the farmers of Malwa plateau.

Materials and Methods

The experiment entitled Cultivation of aonla in Malwa region (*Emblica officinalis* Gaertn.) fruits cv. NA-7was conducted during 2015-2016 at the Department of Fruit Science, K.N.K. College of Horticulture, Mandsaur (M.P.).

The methods employed during the course of investigation and material utilized has great significance in the research programme. The details of material used and techniques employed in carrying out the investigation are described under the following heads:

Location

The experiment was conducted at the College of Horticulture, Department of Fruit Science, Mandsaur (M.P.), Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.). The Mandsaur is situated at 23.45^0 to 24.13^0 N latitude and 74.44^0 to 75.18^0 E longitudes at an altitude of 435 m Mean Sea Level. Geographically, the experimental site is lines at the border of M.P. The location of the experimental farm/plot is situated in the main campus of college. The main campus of college was located on the Mandsaur- Sitamau road adjacent to the Sitamau railway crossing phatak. It is also well connected by the Indore, Ratlam road.

Climatic Conditions

Mandsaur has a subtropical climate with hot summer and cool winter. The temperature rises up to 46 ^{0}C during summer and falls to 3.6 ^{0}C during winter with an occasional occurrence of frost. The average annual rainfall is 744.8 mm, most of which occurred during July to September, winter and summer rains are uncommon.

The meteorological data such as maximum and minimum temperature (33.9 ^{0}C and 8.7 ^{0}C), relative humidity (74.4% and 63.8%) were recorded during the experimental period. The concerned data are presented in Table-3.1 and Figure-3.1

Table 3.1: Weekly meteorological observations during the storage period (January 2016)

Week	Temperature		Relative humidity %
	Minimum ^{0}C	Maximum ^{0}C	
14/1/16 to 20/1/16	10.6	27.9	74.4
21/1/16 to 27/1/16	8.7	26.0	73.5
28/1/16 to 3/2/16	11.9	28.8	65.0
4/2/16 to 10/2/16	12.8	29.9	68.4
11/2/16 to17/2/16	14.1	30.1	72.1
18/2/16 to 24/2/16	17.0	31.7	71.8
25/2/16 to 2/3/16	17.0	32.1	66.2
3/3/16 to 9/3/16	18.1	33.9	63.8

***Source*:** Meteorological observatory at Bahadari Farm of the College of Horticulture, Mandsaur (M.P.).

Experimental materials

Aonla fruits cv. NA-7 was procured from the Instructional cum Research Fruit Orchard, Department of Fruit Science, College of Horticulture, Mandsaur for this study.

Preparation of chemical solution

For preparation of 1% and 1.5% Calcium Nitrate Ca(NO3)2 solution, 10g and 15g, respectively weighed and dissolved in 1 liter of water.

Experimental details

The experiment variety NA-7, comprised chemical (calcium nitrate) and two oil coating (seasamum oil & castor oil) with two concentrations of Ca(NO3)2e.g. 1.0% and 1.5% and also withtwo dipping times (5 minutes and 10 minutes), ultimately mixes 15 treatment combinations of post-harvest.

dip. Post-harvest dipping of aonla fruits was done on 21 January 2016. The following treatment of experiment is given in the Table-3.2

Table 3.2 Experimental details
Name of crop: Aonla (Emblica officinalis Gaertn)
Variety: NA-7
Design: CRD
Number of treatments: 15
No. of fruits per treatment: 33
Number of replications: 03
Chemical Concentrations: Calcium Nitrate (Control, 1.0% and 1.5%)
Oil coatings: Seasamum oil (CSO), Castor oil (CCO)

Table-3.3 Treatments Treatment Combinations
T0:Control
T1:Calcium nitrate (1% dipping for 05 min)
T2:Calcium nitrate (1.5% dipping for 05 min)
T3:Calcium nitrate (1% dipping for 10 min)
T4:Calcium nitrate (1.5% dipping for 10 min)
T5:Coating with Seasamum oil (CSO)
T6:Coating with Castor oil (CCO)
T7:Calcium nitrate (1% dipping for 05 min)+ CSO
T8:Calcium nitrate (1.5% dipping for 05 min) + CSO
T9:Calcium nitrate (1% dipping for 10 min)+ CSO
T10:Calcium nitrate (1.5% dipping for 10 min) + CSO
T11:Calcium nitrate (1% dipping for 05 min)+ CCO
T12:Calcium nitrate (1.5% dipping for 05 min) + CCO
T13:Calcium nitrate (1% dipping for 10 min)+ CCO
T14:Calcium nitrate (1.5% dipping for 10 min) + CCO

Selection of fruits
Fresh, fully mature, uniform size and free form any infection/injury fruits of aonla were selected from nine year old trees of aonla (*Emblica officinalis Gaertn*) cv.NA-7 for the investigation.

Storage
After harvesting fruits were kept in plastic trays and stored at ambient temperature and relative humidity. The details of room temperature and relative humidity fluctuations during the course of investigation are given in Table-3.1. The treated fruits were subjected to various physico-chemical observations as per details given below at 5 days interval upto 45 days of storage.

Observations recorded at 5 days interval upto 45 days
Observations on physico-chemical characters and sensory evaluation of aonla fruits with different treatments application were recorded as per the methods given under different characters:

A. Physico-chemical parameters
1. Physiological Loss in Weight (PLW) in percent
2. Fruit Length (cm)
3. Fruit Diameter (cm)
4. Fruit Volume (ml)

Methodology Used For Observations
Physiological Loss in Weight (%)
For determination of physiological loss in weight (PLW), 3 fruits from each treatment were marked and labeled. The marked and labeled fruits in each treatment were weighed prior to storage. Their weight was determined on 5 days interval up to 45 days of storage. PLW in weight was expressed on percent basis (on the basis of original weight of fruit).

$$\text{Physiological Loss in Weight (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \text{ X } 100$$

Fruit Spoilage (%)
Spoiled fruits were visually counted out from total number of fruits in each treatment at an interval on 5 days interval upto 45 days of storage. Spoiled was expressed on percentage basis.

$$\text{Spoilage (\%)} = \frac{\text{Spoiled fruits}}{\text{Total fruits}} \text{ X } 100$$

Fruit Length (cm)
The length of fruits was measured from stem end to calyx end in centimetres at 5 days interval upto 45 daysand at harvest with the help of digital Vernier calliper.

Fruit Diameter (cm)
The diameter of the fruits was measured from the centre of the fruits in centimetres at 5 days interval upto 45 daysand at harvest with the help of digital Vernier calliper.

Chapter- IV
Results
Results of the present investigation entitled "Effect of different post-harvest treatments on shelf life and quality of aonla (*Emblica officinalis* Gaertn.) fruits cv. NA-7" during the period 2015-16 are presented under the following appropriate headings. The analysed data pertaining to the effect of calcium nitrate and oil coating (seasamum and castor oil) are storage period on physico-chemical changes of aonla cv. NA-7 during storage.
Under the present study the observations recorded on physico-chemical parameters and sensory evaluation characteristics at initial day, 5th, 10th, 15th, 20th, 25th, 30th, 35th, 40th and 45th days are presented in Tables- 4.1 to 4.16 and Figs. 4.1 to 4.16. The Analysis of Variances for these characters are presented in the Appendices from I to XIII.

Physiological Loss in Weight (%)
The analysed data indicating the physiological loss in weight (%) is presented in the Table- 4.1 and graphically in Fig. 4.1.
Indicating the Table-4.1, a increasing trend in values of physiological loss in weight (%) were recorded with the increases doses of the post-harvest treatments of storage aonla fruits (Calcium nitrate, Castor oil and Seasamum oil)alone or in combination. It was noticed that the significantly higher physiological loss in weight (%) was recorded in the treatment T_0 (Control) initial day (0), 5th day (2.42), 10th day (6.05), 15th day (12.10), 20th Day (18.14), 25th Day (25.40), 30th Day (33.87), 35th Day (44.76), 40th Day (56.85) and 45th Day (71.37) it was superior over rest of the treatments. Although, the treatment T_2 were *at par* with T_0 at initial day (0), 5th day (1.27), 10th day (2.53), 15th day (6.33), 20th Day (11.39), 25th Day (17.72), 30th Day (24.05), 35th Day (32.91), 40th Day (43.04) likewise upto 45th Day (54.43) and the treatment T_5, T_3 and T_1 followed the treatment T_0. The Lowest physiological loss in weight initial day (0), 5th day (1.09), 10th day (1.26), 15th day (3.77), 20th Day (8.16), 25th Day (11.21), 30th Day (17.07), 35th Day (24.39), 40th Day (30.49) and 45th Day (41.46) was recorded in T_{11}

Table 4.1: Effect of different post-harvest treatments on physiological loss in weight (%) in aonla fruits cv. NA-7 during storage

	Changes in PLW (%) during different storage interval (Days)										
Treatments	**Initial day**	**5th**	**10th**	**15th**	**20th**	**25th**	**30th**	**35th**	**40th**	**45th**	**Mean**
T_0(Control)	0.00	2.42	6.05	12.10	18.14	25.40	33.87	44.76	56.85	71.37	27.10
T_1Calcium nitrate (1% dipping for 05 min)	0.00	1.22	2.45	6.12	11.02	15.92	22.04	30.61	41.63	55.10	18.61
T_2Calcium nitrate (1.5% dipping for 05 min)	0.00	1.27	2.53	6.33	11.39	17.72	24.05	32.91	43.04	54.43	19.37
T_3Calcium nitrate (1% dipping for 10 min)	0.00	1.23	2.46	6.15	11.07	17.21	23.36	31.97	41.80	51.64	18.69
T_4Calcium nitrate (1.5% dipping for 10 min)	0.00	1.19	2.38	5.95	10.71	16.67	22.62	30.95	40.48	52.38	18.33
T_5Coating with Seasamum oil (CSO)	0.00	1.29	2.57	6.44	11.59	18.02	24.46	33.47	43.77	51.50	19.31
T_6Coating with Castor oil (CCO)	0.00	1.25	2.50	6.25	11.25	17.50	23.75	32.50	41.25	47.30	18.36
T_7Calcium nitrate (1% dipping for 05 min)+CSO	0.00	1.16	2.33	5.81	9.30	13.95	19.77	25.58	33.72	40.70	15.23
T_8Calcium nitrate (1.5% dipping for 05 min) +CSO	0.00	1.17	2.33	5.84	9.34	14.01	19.84	25.68	39.68	46.68	16.46
T_9Calcium nitrate (1% dipping for 10 min)+CSO	0.00	1.15	2.29	5.73	9.16	13.74	19.47	25.19	33.21	40.08	15.00
T_{10}Calcium nitrate (1.5% dipping for 10 min) +CSO	0.00	1.31	2.62	6.55	10.48	15.72	22.27	30.13	39.30	47.16	17.56
T_{11}Calcium nitrate (1% dipping for 05 min)+ CCO	0.00	1.09	1.26	3.77	8.16	11.21	17.07	24.39	30.49	41.46	13.89
T_{12}Calcium nitrate (1.5% dipping for 05 min)+ CCO	0.00	1.09	2.18	5.45	7.64	12.00	17.45	27.27	36.00	45.82	15.49
T_{13}Calcium nitrate (1% dipping for 10 min)+ CCO	0.00	1.28	2.56	6.41	8.97	14.10	20.51	30.77	38.46	63.24	18.63
T_{14}Calcium nitrate (1.5% dipping for 10 min)+ CCO	0.00	1.13	2.26	5.66	7.92	12.45	18.11	29.81	40.94	49.43	16.77
S. Em. ±	0.00	0.08	0.06	0.24	0.44	0.65	1.01	1.20	1.41	1.42	
CD (5%)	0.00	0.22	0.16	0.70	1.27	1.87	2.90	3.46	4.06	4.10	

Fruit Length Reduction (%)

The results indicating that the fruit length decreased with the increase in storage period up to 45th days. However, the reduction in length of aonla fruits was significantly affected by various treatments. Data regarding fruit length depicted in Table- 4.2 and graphically represented in Fig. 4.2.

The data presented in Table- 4.2 indicating that the minimum reduction in fruit length with the treatment T_{11} after initial day (3.71), 5th day (3.70), 10th day (3.68), 15th day (3.66), 20th Day (3.64), 25th Day (3.61), 30th Day (3.58), 35th Day (2.53), 40th Day (3.47) and 45th Day (3.40) respectively 8.36% reduction. Although, the treatment T_{13} at initial day (3.41) 5th day (3.40), 10th day (3.39), 15th day (3.36), 20th Day (3.33), 25th Day (3.30), 30th Day (3.26), 35th Day (3.20), 40th Day (3.13) and 45th Day (3.05) i.e. 10.56% decrease in fruit length which are *at par with* T_{11} (1.0 percent Calcium nitrate dipping for 5 minutes with coating Castor oil) and the treatment T_7 (1.0 percent Calcium nitrate dipping for 5 minutes with coating Seasamum oil), T_9 (1.0 percent Calcium nitrate dipping for 10 minutes with coating Seasamum oil) and T_1 (1.0 percent Calcium nitrate dipping for 5 minutes)followed the treatment T_{11} (1.0 percent Calcium nitrate dipping for 5 minutes with coating Castor oil) within the single doses of treatment T_1 (1.0 percent Calcium nitrate dipping for 5 minutes)gave the minimum decreased initial day (3.38) 5th day (3.37), 10th day (3.35), 15th day (3.32), 20th Day (3.29), 25th Day (3.26), 30th Day (3.21), 35th Day (3.15), 40th Day (3.07) and 45th Day (2.98) fruit length. The maximum fruit length decrease than initial day (3.43), 5th day (3.42), 10th day (3.40), 15th day (3.37), 20th Day (3.34), 25th Day (3.30), 30th Day (3.25), 35th Day (3.19), 40th Day (2.11) and 45th Day (2.00) was recorded in treatment T_0 (Control) i.e. 41.69%.

Table 4.2: Effect of different post harvest treatments on fruit length (cm) in aonla fruits cv. NA-7 during storage

		Changes in fruit length (cm) during different storage interval (Days)										
Treatments	**Initial day**	**5th**	**10th**	**15th**	**20th**	**25th**	**30th**	**35th**	**40th**	**45th**	**Decrease in fruit length (%)**	**Mean**
T_0(Control)	3.43	3.42	3.40	3.37	3.34	3.30	3.25	3.19	2.11	2.00	41.69	3.08
T_1Calcium nitrate (1% dipping for 05 min)	3.38	3.37	3.35	3.32	3.29	3.26	3.21	3.15	3.07	2.98	11.83	3.24
T_2Calcium nitrate (1.5% dipping for 05 min)	3.53	3.51	3.49	3.46	3.42	3.38	3.31	3.24	3.14	3.03	14.16	3.35
T_3Calcium nitrate (1% dipping for 10 min)	3.44	3.43	3.41	3.39	3.36	3.31	3.25	3.20	3.11	3.01	12.50	3.29
T_4Calcium nitrate (1.5% dipping for 10 min)	3.25	3.23	3.21	3.19	3.15	3.12	3.05	2.98	2.89	2.77	14.77	3.08
T_5Coating with Seasamum oil (CSO)	3.45	3.43	3.40	3.36	3.31	3.24	3.16	3.06	2.94	2.80	18.84	3.22
T_6Coating with Castor oil (CCO)	3.29	3.28	3.26	3.23	3.19	3.16	3.10	3.04	2.95	2.85	13.37	3.14
T_7Calcium nitrate (1% dipping for 05 min)+CSO	3.40	3.39	3.38	3.35	3.33	3.29	3.24	3.18	3.10	3.01	11.47	3.27
T_8Calcium nitrate (1.5% dipping for 05 min) +CSO	3.59	3.58	3.56	3.53	3.50	3.46	3.41	3.35	3.27	3.17	11.70	3.44
T_9Calcium nitrate (1% dipping for 10 min)+CSO	3.37	3.36	3.34	3.32	3.29	3.25	3.20	3.14	3.06	2.97	11.87	3.23
T_{10}Calcium nitrate (1.5% dipping for 10 min) +CSO	3.57	3.56	3.54	3.51	3.47	3.43	3.37	3.30	3.21	3.10	13.17	3.41
T_{11}Calcium nitrate (1% dipping for 05 min)+ CCO	3.71	3.70	3.68	3.66	3.64	3.61	3.58	3.53	3.47	3.40	8.36	3.60
T_{12}Calcium nitrate (1.5% dipping for 05 min)+ CCO	3.54	3.52	3.50	3.47	3.44	3.39	3.35	3.29	3.21	3.12	11.86	3.38
T_{13}Calcium nitrate (1% dipping for 10 min)+ CCO	3.41	3.40	3.39	3.36	3.33	3.30	3.26	3.20	3.13	3.05	10.56	3.28
T_{14}Calcium nitrate (1.5% dipping for 10 min)+ CCO	3.53	3.51	3.49	3.46	3.43	3.38	3.32	3.26	3.17	3.07	13.03	3.36
S. Em. ±	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-	-
CD (5%)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	-	-

Fruit Diameter (cm)

The analysed data regarding to the fruit diameter is presented in the Table- 4.3 and represented graphically in Fig. 4.3.

Indicating Table-4.3, a decreasing trend of values in fruit diameter were recorded with the increases doses of the post-harvest treatments of storage fruits (Calcium nitrate, Castor oil and Seasamum oil)alone or in combination. It was noticed that the significantly minimum reduction in fruit diameter with treatment T_{11} at initial day (3.68) 5th day (3.67), 10th day (3.66), 15th day (3.65), 20th Day (3.63), 25th Day (3.60), 30th Day (3.56), 35th Day (3.51), 40th Day (3.45) and 45th Day (3.38). In terms of percent reduction in diameter, the

minimum reduction (8.15%) was recorded under T_{11} treatment while it was found maximum (28.95%) with T_0. 8.15% than the initial value over the rest of the treatments. However, the treatment T_{13} at initial day (3.59),5th day (3.58), 10th day (3.57), 15th day (3.56), 20th Day (3.53), 25th Day (3.50), 30th Day (3.46), 35th Day (3.41), 40th Day (3.34) and 45th Day (3.25) i.e. 9.47% decrease in fruit diameter which are *at par with* T_{11} (1.0 percent Calcium nitrate dipping for 5 minutes with coating Castor oil) and the treatment T_7 (1.0 percent Calcium nitrate dipping for 5 minutes with coating Seasamum oil), T_6 (coating Castor oil) and T_{12} (1.5 percent Calcium nitrate dipping for 5 minutes with Castor oil coating)followed the treatment T_{11} (1.0 percent Calcium nitrate dipping for 5 minutes with coating Castor oil) within the single doses of treatment T_6 (coating Castor oil) gave the minimum decrements in initial day (3.44), 5th day (3.43), 10th day (3.42), 15th day (3.39), 20th Day (3.35), 25th Day (3.31), 30th Day (3.26), 35th Day (3.20), 40th Day (3.13) and 45th Day (3.05) fruit diameter. The maximum fruit diameter decreased than initial day (3.73), 5th day (3.69), 10th day (3.63), 15th day (3.55), 20th Day (3.45), 25th Day (3.33), 30th Day (3.19), 35th Day (3.03), 40th Day (2.85) and 45th Day (2.65) was recorded in treatment T_0 (Control) i.e.28.95%.

Table 4.3: Effect of different post-harvest treatments on fruit diameter (cm) in aonla fruits cv. NA-7 during storage

Treatments	Initial day	Changes in fruit diameter (cm) during different storage interval (Days)										
		5th	10th	15th	20th	25th	30th	35th	40th	45th	Decrease in fruit diameter (%)	Mean
T_0(Control)	3.73	3.69	3.63	3.55	3.45	3.33	3.19	3.03	2.85	2.65	28.95	3.31
T_1Calcium nitrate (1% dipping for 05 min)	3.43	3.42	3.42	3.39	3.36	3.32	3.27	3.20	3.12	3.03	11.66	3.30
T_2Calcium nitrate (1.5% dipping for 05 min)	3.78	3.77	3.75	3.72	3.68	3.62	3.55	3.46	3.36	3.26	13.76	3.60
T_3Calcium nitrate (1% dipping for 10 min)	3.66	3.65	3.63	3.60	3.57	3.52	3.48	3.40	3.31	3.21	12.30	3.50
T_4Calcium nitrate (1.5% dipping for 10 min)	3.72	3.71	3.69	3.66	3.61	3.55	3.48	3.39	3.29	3.18	14.52	3.53
T_5Coating with Seasamum oil (CSO)	3.65	3.64	3.63	3.60	3.55	3.50	3.44	3.37	3.29	3.20	12.33	3.49
T_6Coating with Castor oil (CCO)	3.44	3.43	3.42	3.39	3.35	3.31	3.26	3.20	3.13	3.05	11.34	3.30
T_7Calcium nitrate (1% dipping for 05 min)+CSO	3.51	3.50	3.49	3.47	3.43	3.39	3.34	3.28	3.21	3.13	10.83	3.38
T_8Calcium nitrate (1.5% dipping for 05 min) +CSO	3.70	3.69	3.68	3.65	3.61	3.56	3.50	3.43	3.35	3.26	11.89	3.54
T_9Calcium nitrate (1% dipping for 10 min)+CSO	3.77	3.76	3.75	3.72	3.68	3.63	3.57	3.50	3.42	3.33	11.67	3.61
T_{10}Calcium nitrate (1.5% dipping for 10 min) +CSO	3.85	3.84	3.82	3.79	3.74	3.68	3.61	3.53	3.44	3.34	13.25	3.66
T_{11}Calcium nitrate (1% dipping for 05 min)+ CCO	3.68	3.67	3.66	3.65	3.63	3.60	3.56	3.51	3.45	3.38	8.15	3.58
T_{12}Calcium nitrate (1.5% dipping for 05 min)+ CCO	3.81	3.80	3.79	3.77	3.74	3.70	3.65	3.59	3.51	3.42	10.24	3.68
T_{13}Calcium nitrate (1% dipping for 10 min)+ CCO	3.59	3.58	3.57	3.56	3.53	3.50	3.46	3.41	3.34	3.25	9.47	3.48
T_{14}Calcium nitrate (1.5% dipping for 10 min)+ CCO	3.66	3.65	3.64	3.62	3.58	3.53	3.47	3.40	3.31	3.20	12.57	3.51
S. Em. ±	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	-	-
CD (5%)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	-	-

Fruit Volume (ml)

The analysed data indicating the fruit volume is showed in the Table- 4.4 and Fig. 4.4.

It is depicted in the Table-4.4, was noticed that the significantly minimum fruit volume was decreased in the treatment T_{11} (1.0 percent Calcium nitrate dipping for 5 minutes with coating Castor oil)after initial day (82), 5th day (81), 10th day (80), 15th day (78), 20th Day (76), 25th Day (73), 30th Day (69), 35th Day (64), 40th Day (59) and 45th Day (37) i.e. 13.70% than the initial value, over the rest of the treatments. Although, the treatment T_7 which in treated with 1.0 percent Calcium nitrate dipping for 5 minutes with coating Seasamum oil, initial day (87), 5th day (86), 10th day (85), 15th day (83), 20th Day (80), 25th Day (76), 30th Day (71), 35th Day (67), 40th Day (60) and 45th Day (54) i.e. 13.91% decrease in fruit volume which are *at par* with T_{11} (1.0 percent Calcium nitrate dipping for 5 minutes with coating Castor oil) and the treatment T_9 (1.0 percent Calcium nitrate dipping for 10 minutes with coating Seasamum oil), T_{10} (1.5 percent Calcium nitrate dipping for 10 minutes with coating Seasamum oil) and T_8 (1.5 percent Calcium nitrate dipping for 5 minutes with coating Seasamum oil) followed the treatment T_{11} (1.0 percent Calcium nitrate dipping for 5 minutes with coating Castor oil)within the single doses of treatment T_6 (coating with Castor oil) gave the minimum decreases initial day (81), 5th day (80), 10th day (79), 15th day (77), 20th Day (73), 25th Day (68), 30th Day (63), 35th Day (57), 40th Day (50) and 45th Day (45.16) fruit volume. The maximum fruit volume decreased than initial day (83.67), 5th day (81.67), 10th day (78.67), 15th day (74.67), 20th Day (69.67), 25th Day (63.67), 30th Day (56.67), 35th Day (48.67), 40th Day (38.67) and 45th Day (26.67) was recorded in treatment T_0 (Control) i.e.25.58%

Specific Gravity

The result indicating that the data on specific gravity vary according to the various chemical treatments. Data on specific gravity of aonla fruits gradually decreases up to the 45th day of storage. However, the specific gravity of aonla fruits was not significantly affected by various treatments in aonla fruits.

Table 4.4: Effect of different post-harvest treatments on fruit volume (ml) in aonla fruits cv. NA-7 during storage

Treatments	Initial day	Changes in fruit volume (ml) during different storage interval (Days)										
		5th	10th	15th	20th	25th	30th	35th	40th	45th	Decrease in fruit volume (%)	Mean
T_0(Control)	83.67	81.67	78.67	74.67	69.67	63.67	56.67	48.67	38.67	26.67	25.58	62.27
T_1Calcium nitrate (1% dipping for 05 min)	82.67	81.67	80.67	78.67	74.67	70.67	65.67	59.67	50.67	39.67	17.18	68.47
T_2Calcium nitrate (1.5% dipping for 05 min)	80.00	79.00	78.00	76.00	72.00	67.00	62.00	56.00	48.00	39.00	17.88	65.70
T_3Calcium nitrate (1% dipping for 10 min)	82.33	81.33	80.33	78.33	74.33	69.33	64.33	58.33	50.33	42.33	17.25	68.13
T_4Calcium nitrate (1.5% dipping for 10 min)	85.00	84.00	83.00	81.00	77.00	72.00	67.00	61.00	53.00	43.00	16.94	70.60
T_5Coating with Seasamum oil (CSO)	78.67	77.67	76.67	74.67	70.67	65.67	60.67	54.67	46.67	40.67	17.80	64.67
T_6Coating with Castor oil (CCO)	81.00	80.00	79.00	77.00	73.00	68.00	63.00	57.00	50.00	45.16	16.89	67.32
T_7Calcium nitrate (1% dipping for 05 min)+CSO	87.00	86.00	85.00	83.00	80.00	76.00	71.00	67.00	60.00	54.00	13.91	74.90
T_8Calcium nitrate (1.5% dipping for 05 min) +CSO	86.67	85.67	84.67	82.67	79.67	75.67	70.67	66.67	54.68	48.68	15.11	73.57
T_9Calcium nitrate (1% dipping for 10 min)+CSO	88.33	87.33	86.33	84.33	81.33	77.33	72.33	68.33	61.33	55.33	14.76	76.23
T_{10}Calcium nitrate (1.5% dipping for 10 min) +CSO	77.33	76.33	75.33	73.33	70.33	66.33	61.33	56.33	49.33	43.33	16.04	64.93
T_{11}Calcium nitrate (1% dipping for 05 min)+ CCO	82.00	81.00	80.00	78.00	76.00	73.00	69.00	64.00	59.00	37.00	13.70	69.90
T_{12}Calcium nitrate (1.5% dipping for 05 min)+ CCO	92.67	91.67	90.67	88.67	86.67	82.67	77.67	69.67	61.67	52.67	14.24	79.47
T_{13}Calcium nitrate (1% dipping for 10 min)+ CCO	79.00	78.00	77.00	75.00	73.00	69.00	64.00	57.00	51.00	31.67	17.13	65.47
T_{14}Calcium nitrate (1.5% dipping for 10 min)+ CCO	89.33	88.33	87.33	85.33	83.33	79.33	74.33	65.00	55.17	47.67	15.46	75.52
S. Em. ±	1.03	1.02	1.02	0.98	0.97	1.07	1.09	1.19	1.88	1.33	-	-
CD (5%)	2.94	2.94	2.94	2.83	2.79	3.09	3.15	3.42	5.43	3.85	-	-

Discussion

Result of the experiment entitled cultivation of aonla in Malwa region (*Emblica officinalis* Gaertn.) fruits cv. NA-7" presented in the preceding chapter revealed that the treatment with calcium nitrate and oil coating (seasmum and castor oil) significantly affected various physico-chemical parameters of aonla fruits during the storage up to (45th days). The salient features of the result obtained are discussed in this chapter.

Physical Parameters

PLW during storage is characterized by reduction in fruit weight by the way of loss of moisture through evaporation and/or transpiration. It is the most important parameter because it governs the post-harvest quality of the aonla fruits. Any loss in weight of fruit is likely to reduce the quality of product drastically. Therefore, one of the main objectives of post-harvest treatment should be to reduce the PLW. It is evident from the present study that loss in weight was significantly affected by Calcium nitrate and oil coating throughout the storage period up to 45th day.

In general physiological loss in weight increases with the advancement of storage period**.** In the present investigation, the minimum percentage of PLW during storage was recorded with the application of 1.0% calcium nitrate dipping for 5 minutes with castor oil coating (T_{11}) form 0 to 41.46% followed by the application calcium nitrate 1% dipping for 10 minutes with seasamum oil coating and calcium nitrate 1% dipping for 5 minutes with seasamum oil coating while it was maximum (0 to 71.37%) under control.

Calcium nitrate and castor oil reduced the weight loss extends the shelf life of aonla fruit, this might be due to by maintaining their firmness and minimizing transpiration, evaporation and respiration rate, proteolysis and tissue breakdown and also due to microbial activity, which increase retention of moisture in fruit. It also acts as an anti-senescence agent by preventing cellular disorganization by maintaining protein and nucleic acid synthesis, (Gangwar*et al*., 2012 and Bisen *et al.*, 2012) [12, 6], reported that the highest weight loss of untreated fruits is due to increased storage breakdown associated with higher respiratory rate as compared to calcium nitrate and castor oil treated aonla fruits. Similar finding had been reported by Yadav and Shukla (2009) [12] in aonla, Das and Medhi, (1996) [9], Pandey *et al.* (2010) [6] and Jagadeesh *et al.* (2001) in guava fruits.

The fruit size (length and diameter), volume and pulp weight decreases in storage period. However, the treated fruits maintained minimum decrements of fruit size, volume and pulp weight as compared to control. At the end of the storage the minimum reduction in fruit size (length and diameter), volume and pulp weight observed when fruits were treated with in calcium nitrate 1.0% dipping for 5 minutes with castor oil coating (3.71 to 3.40 cm fruit length, 3.68 to 3.38 cm fruit diameter, 82 to 37 ml fruit volume and pulp weight 72.41 to 38.55 g) and maximum losses was noticed in untreated fruits. The reduction in fruit size, volume and pulp weight during storage period might be due to shrinking of fruits caused by transpiration. Application of calcium nitrate and castor oil might have decreased the rate of transpiration and PLW resulting in retention of better size fruits during storage. The results were supported by Kumar *et al.* (2005) [18] and Gangwar*et al.* (2012) [12].

Seed weight of the aonla fruit was found non-significant in all the treatments this might be due to the presence of stone (capsule) as a barrier in between the seeds and different application of the post-harvest treatments on aonla fruits, as these treatments might be not able to penetrate the stone wall, as the the seeds are present inside the stone. Stone in aonla fruit also helps in protecting the moisture level of the seeds throughout the storage period.

Specific gravity of aonla fruits gradually decreases up to the 45th day of storage. However, the specific gravity of aonla fruits was not significantly affected by various treatments in aonla fruits. At the end of 45th days storage, the optimum specific gravity was recorded with the application of 1.0% calcium nitrate dipping for 5 minutes with coating castor oil at initial day (1.00), 5th day (1.001), 10th day (1.012), 15th day (1.012), 20th Day (0.991), 25th Day (0.997), 30th Day (0.986), 35th Day (0.969), 40th Day (0.966) and 45th Day (1.297).Whereas, minimum was under control.

Calcium and castor oil treated fruits could possibly be due to slow reduction in weight and volume of the fruit because of the retarding effect of calcium on ripening process, (Bisen *et al.*, 2014 and Bisen *et al.*, 2012) [5, 6]. The present observation by Chundawat*et al.* (1978) [8], Singh (1980) [8] and Kher*et al.* (2005) in Guava fruits.

The losses due to decay were observed from the 20th days of storage and onwards increased significantly up to 45th days of storage. However, the result showed that all treatments gave a

longer storage life than the control, since instance decayed fruits were about 11.11, 14.81, 18.52, 22.22, 34.57 and 43.21% for the control fruits after 20th, 25th, 30th, 35th, 40th and 45th days. Minimum decayed fruits were observed treatments T_{11} (1.0% Calcium nitrate dipping for 5 minutes with Castor oil coating) at the end of storage period (45 Days). Decaying of the fruit is another important fruit quality parameter and occurrence of rotting adversely affects the shelf-life of fruits. Rotting caused due to infection by *Aspergillus Niger*, *Fusarium spp*. and fruit rot makes the fruit soft and affected fruits as they develop bad odour, (Dhumal*et al*., 2008) [11]. The dipping aonla fruits in calcium nitrate and oil coating (Seasamum and Castor oil) decreased fruit rot and preserved storage quality also treated fruits received significantly higher quality ratings than untreated fruits (Control). The current study demonstrated that application of calcium nitrate and castor oil has merit in reducing spoilage in aonla fruits which may integrity, microbial activity and thus lowering the spoilage were responsible for rotting of aonla fruits beneficial effects of calcium against post-harvest decay have been shown for various fruit species, (Bisen *et al*., 2012 and Cheour*et et al.,* 1990) [6, 7]. The role of post-harvest calcium application decreased decay incidence has been reported in aonla by Gangwar*et al*. (2012) [12] and Yadav *et al*. (2009). The result is in close proximity with findings of Yadav and Shukla (2009) [12] in aonla and Kaur and Kanwar (2004) in peach.

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