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RESEARCH PAPER

Influence of postharvest application of *Nigella sativa* oil and starch on the physiological, biochemical and quality parameters of pomegranate arils cv. 'BHAGWA'

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Abstract : Pomegranate (*Punica granatum* L.) is a tropical fruit and grown in many parts of the world predominantly in the Mediterranean region. Fresh seeds (arils) are consumed. Arils contain around 80 per cent of juice and 20 per cent of seed. However, quick browning and desiccation are the important concerns of quality during postharvest storage. To prevent quick moisture loss and browning of arils, applied different concentrations of black cumin seed oil and starch as a coating to improve the shelf life and quality of arils. Results showed that pomegranate arils coated with *Nigella sativa* oil at 200 ppm concentration recorded significantly lowest total sugars content and titrable acidity during the initial stages, whereas at later stages recorded significantly highest total sugars (14.408 and 13.687, respectively on days 12 and 16) and titrable acidity (0.382 and 0.358 on day 12 and 16). Further, arils treated with *Nigella sativa* oil at 200 ppm concentration recorded significantly lowest per cent of spoilage, physiological loss in weight and recorded significantly highest antioxidant activity, ascorbic acid and anthocyanins content. At the end, it was noticed that edible coating did not affect the natural flavour of pomegranate arils.

Key Words : Antioxidant activity, Anthocyanins, Ascorbic acid, *Nigella sativa* oil, Pomegranate arils, Starch

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INTRODUCTION

Pomegranate (*Punica granatum* L.) popularly known as Anar belongs to the family Punicaceae. It is an important fruit of tropical and sub-tropical regions of the world and is considered one of the hardiest fruit crops grown and thrives well under arid and semi-arid climatic conditions due to its wider adaptability because of its resistance to drought and salinity conditions without impairing yield. Aril (seed) is the economical part of the fruit which possess many medicinal properties and is sweet and acidic in taste. In the recent times, minimally processed ready-to-eat pomegranate arils have become most popular in the market particularly in the fresh malls. However, browning of arils is the major problem associated with quick desiccation. Edible coatings act as barriers during processing, handling and storage. In

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addition to reducing respiration rate, edible coatings prevent water loss from arils thereby act as a hydrophobic barrier. *Nigella sativa* oil is an essential oil obtained from the cold-pressed seeds of black cumin, used mainly for culinary and medicinal purposes was observed to possess anti-carcinogenic, anti-ulcer, anti-bacterial, anti-fungal and anti-inflammatory activities. Keeping all these useful activities in view, *Nigella sativa* oil and starch have been selected as edible coatings at different concentrations to find out their efficacy in reducing the browning and microbial spoilage thereby increasing the shelf life of arils.

MATERIAL AND METHODS

The present study was carried out at College of Horticulture, Venkataramannagudem, West Godavari district, Andhra Pradesh during the year 2015-16 to elucidate the information with regard to influence of edible oil (*Nigella sativa*) and starch in reducing the browning and spoilage of arils. The experiment was carried out with seven treatments *viz.*, T_1: Pomegranate arils treated with *Nigella sativa* oil 200 ppm (NS 200), T_2: Pomegranate arils treated with *Nigella sativa* oil 400 ppm (NS 400), T_3: Pomegranate arils treated with *Nigella sativa* oil 600 ppm (NS 600), T_4: Pomegranate arils treated with Starch 10 per cent, T_5: Pomegranate arils treated with Starch 20 per cent, T_6: Pomegranate arils treated with Starch 30 per cent, T_7: Control (no coating) with three replications in Completely Randomized Design. Fruits of pomegranate cv. 'BHAGWA' procured from farmer's field located at Dharmavaram village in Ananthapuram district of Andhra Pradesh were used in the study. Uniformly matured, well developed and good looking fruits with uniformity in size and free from pest and disease attack were harvested and brought to the laboratory with proper packing in cardboard fibre board boxes. After unpacking, the fruits were kept overnight under open conditions in the laboratory. On the next day morning, fruits were washed thoroughly under tap water and cleaned with dry cotton cloth. The arils were extracted manually after splitting the fruits with the help of sterilized knife. The entire process of aril extraction and packing were completed under total hygienic conditions in the laboratory. The spoilage was determined based on the visual observation as shrivelling of arils which led to fungal infection and subsequent rotting. The total soluble solids content of pomegranate arils was determined by using ERMA hand refractometer. A drop of juice obtained from arils was placed on the prism of the refractometer and observed the coincidence of shadow of sample by reading on the scale and expressed as °Brix (Ranganna, 1986). The percentage of reducing sugars content in the pomegranate aril juice was determined by Lane and Eyon method (AOAC, 1965). Ascorbic acid content in the pomegranate arils was determined as per the procedure outlined by Ranganna (1986). Total anthocyanins content in the pomegranate aril juice was determined by adopting the procedure outlined by Harborne (1973). Antioxidant activity in the pomegranate arils was assessed by using the free radical DPPH method (Bond and Michel, 1997). The data arrived were subjected to statistical analysis as per the procedure outlined by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Significant changes were observed in the physiological loss in weight (PLW) of arils treated with *Nigella sativa* oil and starch at different concentrations during storage at a temperature of 4°C (Table 1). Among the treatments, *Nigella sativa* oil coatings were found the best in retaining physiological loss in weight (PLW) compared to starch coatings. Significantly lowest PLW of pomegranate arils was recorded with *Nigella sativa* oil at 200 ppm concentration (1.932, 2.222, 2.333 and 2.527, respectively on day 4, 8, 12 and 16), whereas, control recorded significantly highest PLW (4.057, 7.100, 8.520 and 11.076, respectively on day 4, 8, 12 and 16). All the starch coatings were found intermediate between *Nigella sativa* oil and control treatments. Based on the results obtained it may be concluded that arils coated with *Nigella sativa* oil at 200 ppm concentration reduced the percentage of physiological loss in weight compared to other coatings during storage at a low temperature of 4°C. The weight loss in control arils revealed a continuous increase in PLW from the day of beginning to the end of storage. Generally in the postharvest treatment of fruits or arils cutting, slicing, dissecting and peeling increase water loss through transpiration due to continuous exposure of aril tissue following removal of natural epidermal layer on the arils and a further increase in the surface area of exposure. Consequently, the loss of water from the aril tissue severely impact the produce quality which initiates the visible sign of deformations in the fruit thus, leading to wrinkling of the surface of most fruit commodities (Bico *et al*., 2009 and Olivas and Canovas,

2009). Application of edible coating was found efficient in reducing the moisture loss from arils thereby reduced physiological loss in weight. Starch coating will form a thin film layer over the surface of arils thus, reducing oxygen permeability into the arils (Kramer, 2009). Han *et al*. (2004) and Vina *et al*. (2007) reported lowering of weight loss in arils coated with starch and *N. sativa* oil which might be attributed to improved water vapour barrier on the fruit surface by increasing the hydrophobicity thereby making the film resistant to water transmission.

Significant differences were observed in the spoilage per cent of arils by application of *Nigella sativa* oil and starch during storage at a low temperature of 4°C (Table 1). *Nigella sativa* oil coatings were found the best in minimizing spoilage per cent of arils compared to starch coatings. Significant differences were observed among the treatments at different concentrations with respect to spoilage per cent of arils. Significantly lowest spoilage per cent of arils was observed by coating with *Nigella sativa* oil at 200 ppm concentration (2.292, 2.636, 2.768 and 2.997, respectively on day 4, 8, 12 and 16). Control recorded significantly highest spoilage per cent (4.787, 8.377, 10.053 and 13.069, respectively on day 4, 8, 12 and 16) on all the days of observation recorded. Starch coatings recorded intermediate values between control and *Nigella sativa* oil treatments. The result obtained clearly indicated that pomegranate arils coated with *Nigella sativa* oil at 200 ppm concentration reduced spoilage per cent of pomegranate arils compared to other coatings. Essential oils have the affinity to conjugate with phenolic compounds in the plant cell and have shown a positive effect in controlling the pathogens (Plooto *et al.*, 2003). The result obtained indicated reduced spoilage of arils due to coating with black cumin seed oil and was found in harmony with Atia (2011) who reported a significant delay in the decay of date fruits by application of Arabic gum and black cumin seed oil. By applying films or coatings on the surface of fruits or arils, the colour can be improved during preservation thus, reduction observed in the browning of arils (Olivas and Canovas, 2009). The result obtained in the present study is in well consistent with the findings of Fortuny and Belloso (2003) and Mirdehghan *et al*. (2007) who reported that edible coating of fresh-cut fruits retarded an increase in the browning of fresh-cut fruits during storage.

Significant differences were observed in the data pertaining to TSS content of arils of pomegranate by coating with *Nigella sativa* oil and starch (Table 1). *Nigella sativa* oil coatings were found the best in maintaining TSS (°Brix) content of arils compared to starch coatings based on the data analyzed. Arils treated with *Nigella sativa* oil at 200 ppm concentration recorded significantly lowest values of total soluble solids (16.083 and 16.365, respectively on days 4 and 8) during the initial period of storage whereas at the later stage of storage significantly highest TSS content was observed (16.774 and 15.935, respectively on days 12 and 16) due to slower rate of respiration when compared with all other treatments. Control recorded significantly lowest TSS (16.328 and16.614 respectively on days 4 and 8) during the initial period of storage, whereas, due to rapid increase in the rate of respiration led to a decrease in the TSS content (14.122 and 12.851 respectively on day 12 and 16) of arils. Total soluble solids content coated

Table 1: Effect of *Nigella sativa* and starch coatings on physiological loss in weight, spoilage and TSS content during storage of pomegranate arils cv. 'BHAGWA'

Treatments	Physiological loss in weight (%)				Spoilage (%)				TSS (°Brix)			
	Day 4	Day 8	Day 12	Day 16	Day 4	Day 8	Day 12	Day 16	Day 4	Day 8	Day 12	Day 16
Nigella sativa 200 ppm	1.932	2.222	2.333	2.527	2.292	2.636	2.768	2.997	16.083	16.405	16.774	15.935
Nigella sativa 400 ppm	2.458	2.925	3.159	3.459	2.900	3.451	3.727	4.081	16.132	16.414	16.086	15.282
Nigella sativa 600 ppm	2.744	4.802	5.762	7.490	3.237	5.666	6.799	8.838	16.165	16.448	15.625	14.844
Starch 10%	2.926	5.120	6.144	7.988	3.452	6.042	7.250	9.425	16.214	16.497	15.178	14.419
Starch 20%	3.355	5.871	7.045	9.158	3.958	6.927	8.313	10.806	16.246	16.497	14.878	14.134
Starch 30%	3.628	6.349	7.618	9.904	4.281	7.491	8.989	11.686	16.295	16.581	14.259	13.546
Control	4.057	7.100	8.520	11.076	4.787	8.377	10.053	13.069	16.328	16.614	14.122	12.851
Mean	3.015	4.913	5.797	7.372	3.558	5.798	6.843	8.700	16.209	16.493	15.274	14.430
S.E. ±	0.048	0.119	0.152	0.215	0.057	0.140	0.180	0.254	0.006	0.006	0.015	0.012
LSD (P=0.05)	0.149	0.366	0.470	0.663	0.175	0.431	0.553	0.781	0.018	0.018	0.046	0.038

with *Nigella sativa* oil at 200 ppm concentration increased steadily with passage of time upto day 12 and since then onwards decreased gradually. The trend was found same with other treatments too, but increase in the rate of TSS content was observed only up to day 8 and then onwards a continuous decline noticed in the TSS content till the end of storage period. The change in TSS content by application of *Nigella sativa* oil at 200 ppm concentration was observed much less with the passage of time when compared with other treatments. The result obtained indicated that arils coated with *Nigella sativa* oil at 200 ppm concentration maintained a stable TSS content compared to other coatings on all the days of storage at 4°C temperature. In general, when edible coatings were applied on the fruits, it may cause slowing down of respiration and other metabolic activities which finally retard the ripening process. In the present study, edible soluble starch and *Nigella sativa* oil coatings significantly influenced the TSS content of arils. Arils treated with *Nigella sativa* oil showed significantly highest TSS content compared to starch coatings or control treatment. These findings were in similar line with those of Tulin and Ulukanil (2012) in pomegranate by application of 600 ppm *Nigella sativa* oil in combination with starch coating, where a decrease was observed in the TSS content. The present finding was found in parallel with the result obtained by Koksal (1989) in pomegranate.

Significant differences were observed in the titrable acidity of arils coated with *Nigella sativa* oil and starch stored at a low temperature of 4°C (Table 2). A gradual decrease was noticed in the titrable acidity of pomegranate arils coated with black cumin seed oil and starch with passage of time during storage. Arils treated with *Nigella sativa* oil at 200 ppm concentration recorded significantly lowest titrable acidity (0.554 and 0.562, respectively on day 4 and 8) during the initial period of storage, whereas, significantly highest titrable acidity (0.573 and 0.550, respectively on day 12 and 16) was observed during the later part of storage which might be due to slow and steady conversion of organic acids to sugars during storage when compared with other treatments. Control recorded significantly highest values of titrable acidity (0.561 and 0.569, respectively on day 4 and 8) during initial period of storage, whereas, with passage of time significantly lowest titrable acidity (0.498 and 0.463 respectively on day 12 and 16) was noticed. Rapid conversion of organic acids to sugars and spoilage of arils might have led to a reduction in the acidity of arils. Titrable acidity increased steadily in the arils coated with *Nigella sativa* oil at 200 ppm concentration with passage of time upto day 12 and since then onwards decreased gradually. The trend was the same with other treatments, but increase in the titrable acidity was only upto day 8 and then onwards a continuous decline was observed till the end of storage period. The changes in titrable acidity were found much less with *Nigella sativa* oil applied at 200 ppm concentration with passage of time when compared with other treatments. Bico *et al*. (2009) reported lower rate of respiration, thus, lower use of organic acids in the enzymatic reactions of respiration with particular reference to postharvest application treatments. Arils treated with *Nigella sativa* oil showed significantly highest titrable acidity compared to other

Table 2: Effect of *Nigella sativa* and starch coatings on titrable acidity, total sugars and ascorbic acid content during storage of pomegranate arils cv. 'BHAGWA'

Treatments	Titrable acidity (%)				Total sugars (%)				Ascorbic acid content (mg/100g)			
	Day 4	Day 8	Day 12	Day 16	Day 4	Day 8	Day 12	Day 16	Day 4	Day 8	Day 12	Day 16
Nigella sativa 200 ppm	0.554	0.562	0.573	0.550	13.815	14.056	14.408	13.687	13.045	12.393	11.401	10.033
Nigella sativa 400 ppm	0.555	0.563	0.554	0.531	13.857	14.099	13.817	13.126	13.025	12.374	11.384	10.018
Nigella sativa 600 ppm	0.556	0.564	0.541	0.519	13.885	14.128	13.421	12.750	12.663	12.030	11.067	9.739
Starch 10%	0.557	0.565	0.528	0.507	13.927	14.171	13.037	12.385	11.759	11.171	10.277	9.044
Starch 20%	0.558	0.565	0.520	0.499	13.955	14.199	12.779	12.140	11.306	10.741	9.882	8.696
Starch 30%	0.560	0.568	0.502	0.482	13.997	14.242	12.248	11.636	10.492	9.968	9.170	8.070
Control	0.561	0.569	0.498	0.463	14.025	14.270	12.130	11.038	9.045	8.593	7.905	6.957
Mean	0.557	0.565	0.531	0.507	13.923	14.166	13.120	12.395	11.619	11.038	10.155	8.936
S.E. ±	0.002	0.002	0.006	0.007	0.005	0.005	0.013	0.011	0.099	0.194	0.194	0.222
LSD (P=0.05)	0.005	0.005	0.019	0.023	0.016	0.016	0.039	0.032	0.304	0.063	0.063	0.072

treatments including control. Results of the present study were in confirmation of the results obtained earlier by Zhou *et al*. (2008) in pears by coating with starch and Tulin and Ulukanil (2012) in pomegranate by application of *Nigella* oil at the rate of 600 ppm in combination with starch.

The data presented in Table 2 has revealed significant changes in the total sugars content of arils stored at low temperature by treating with *Nigella sativa* oil and starch. Arils treated with *Nigella sativa* oil at 200 ppm concentration recorded significantly lowest total sugars (13.815 and 14.056, respectively on day 4 and 8) during the initial period of storage whereas, significantly highest total sugars (14.408 and 13.687, respectively on days 12 and 16) were observed during the later part of the storage which might be due to slower rate of respiration during the storage. Control recorded significantly highest total sugars (14.025 and 14.270, respectively on day 4 and 8) during the initial period of storage, whereas, during the later part of the storage total sugars content decreased very rapidly (12.130 and 11.038, respectively on day 12 and 16) due to a rapid rate of respiration thereby recorded spoilage of arils. Total sugars content of arils coated with *Nigella sativa* oil at 200 ppm concentration increased steadily with passage of time upto day 12 and since then onwards decreased gradually. The trend with other treatments was observed the same, but increase in the total sugars content was only upto day 8 and then onwards a continuous decline was observed in the totals sugars content till the end of storage period. The changes in total sugars content of *Nigella sativa* oil treated at 200 ppm concentration was found much less even with passage of time when compared with other treatments. The results obtained indicate that pomegranate arils coated with *Nigella sativa* oil at 200 ppm concentration was found the best coating in maintaining total sugars content compared to other coatings on all the days of storage at 4°C temperature. Mahajan *et al*. (2011) reported maximum average TSS and total sugars concentrations (12.37 and 8.90%) in pear cultivar 'Patarnakh' coated with citrashine which might be due to the slower rate of metabolic activity upto 21 days of storage.

Significant changes were observed in the data pertaining to ascorbic acid content of arils influenced by *Nigella sativa* oil and starch coating (Table 2). From the data it is evident that ascorbic acid content of pomegranate arils decreased gradually with each successive interval of observation during storage period. Significantly highest ascorbic acid content of pomegranate arils was observed with *Nigella sativa* oil at 200 ppm concentration (13.045, 12.393, 11.401 and 10.033, respectively on day 4, 8, 12 and 16). Control recorded significantly lowest ascorbic acid content (9.045, 8.593, 7.905 and 6.957, respectively on day 4, 8, 12 and 16). Result indicated that arils coated with *Nigella sativa* oil at 200 ppm concentration maintained optimum range of ascorbic acid content compared to other coating treatments. Rapid perishable nature of ascorbic acid content observed in control treatment which might be due to excessive loss of water recorded during storage period in turn led to cell wall damage. Arils coated with *Nigella sativa* oil at 200 ppm concentration recorded significantly highest ascorbic acid content throughout the storage period. These results followed a similar trend with those findings reported earlier by Tulin and Ulukanil (2012) in pomegranate arils. Oms-Oliu *et al*. (2008) reported a significant reduction in the loss of vitamin C content in several fruits including those of fresh-cut pears by use of poly saccharides as edible coating. Zhou *et al*. (2008) reported similar kind of observation in pears by using shellac coating.

Significant differences were observed in the anthocyanins content of arils of pomegranate by application of *Nigella sativa* oil and starch as coating and stored at a low temperature of 4°C (Fig. 1). From the data analyzed, it is very clear that a significant reduction was observed in the total anthocyanins content of pomegranate arils at each successive interval of observation recorded during storage. Arils coated with *Nigella sativa* oil at 200 ppm concentration recorded significantly highest anthocyanins content (2.703, 2.568, 2.362 and 2.079, respectively on day 4, 8, 12 and 16) without any significant differences with other *Nigella sativa* oil concentrations. Control recorded significantly lowest anthocyanins content (1.802, 1.712, 1.575 and 1.386, respectively on day 4, 8, 12 and 16) on all the days of observation recorded. Coating of arils with *Nigella sativa* oil significantly influenced anthocyanins content by reducing the physiological loss in weight which is considered to be related with moisture loss. These results were in similar trend with those findings of Tulin and Ulukanil (2012) who stated that total anthocyanins content of pomegranate arils was found highest with the treatment of 300 ppm *Nigella sativa* oil in combination

with starch coating.

Significant differences were observed in the antioxidant activity of pomegranate arils treated with *Nigella sativa* oil and starch coatings (Fig. 2). From the data it is evident that antioxidant activity of pomegranate arils decreased at each successive interval of observation recorded during storage. Significantly highest antioxidant activity of pomegranate arils was observed with *Nigella sativa* oil at 200 ppm concentration (75.435, 71.663, 65.930 and 58.019, respectively on day 4, 8, 12 and 16). Control recorded significantly lowest antioxidant activity (50.290, 47.776, 43.953 and 38.679, respectively on day 4, 8, 12 and 16). The present result has clearly indicated that pomegranate arils treated with *Nigella sativa* oil at 200 ppm concentration recorded significantly highest antioxidant activity. Moghadam and Kiaeshkevarian (2013) reported a decline in the antioxidant activity of different varieties of citrus fruits during storage. A decrease in the antioxidant activity was found associated with a decrease in the quantity of phenolic substances (Shen *et al*., 2013). Sepheri *et al*. (2015) reported significantly highest antioxidant activity in kiwi fruit slices coated with a combination of 60 per cent chitosan and 40 per cent *Aloe vera* compared to control.

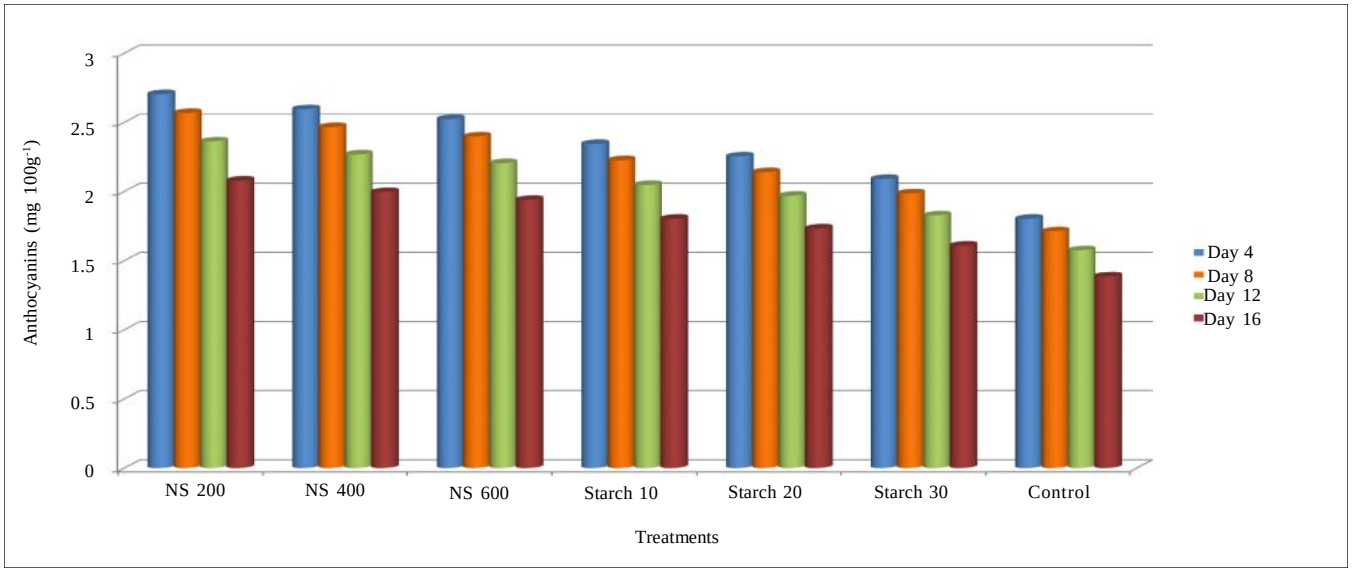

Fig. 1 : Effect of *Nigella sativa* oil and starch coatings on anthocyanins content of arils of pomegranate cv. 'BHAGWA'

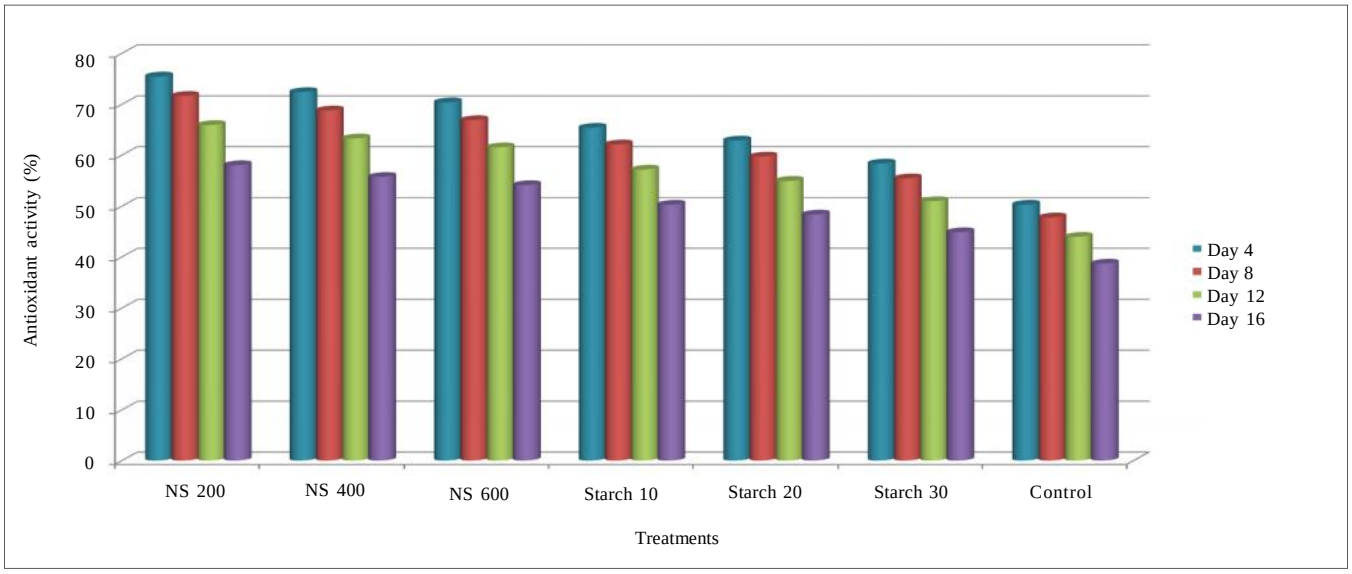

Fig. 2 : Effect of *Nigella sativa* oil and starch coatings on antioxidant activity of arils of pomegranate cv. 'BHAGWA'

Based on the result obtained, it is evident that application of *Nigella sativa* oil at 200 ppm concentration positively influenced several of the aril quality parameters which include physiological loss in weight, spoilage per cent, titrable acidity, total soluble solids, total sugars, ascorbic acid, anthocyanins and antioxidant activity thereby a reduction observed in the browning of arils which in turn increased quality of pomegranate arils.

REFERENCES

A.O.A.C. (1965). *Official methods of analysis*, Association of Official Analytical Chemists, Washington, D.C., U.S.A.

Atia, M.M.M. (2011). Efficiency of physical treatments and essential oils in controlling fungi associated with some stored date palm fruits. *Australian J. Basic & Appl.Sci.*, **5** (6): 1572-1580.

Bico, S.L.S., Raposo, M.F.J., Morais, R.M.S.C. and Morais, A.M.M.B. (2009). Combined effects of chemical dip and/or carrageenan coating and/or controlled atmosphere on quality of fresh cut banana. *Food Cont.*, **20** : 508–514.

Bond, S. and Michel, R. (1997). Antioxidant activity analysis in various fruit crops, *J. Postharvest Biol. & Technol*., **52** : 654-658.

Fortuny, S.R.C. and Belloso, M.O. (2003). New advances in extending the shelf-life of fresh cut fruits: A review. *Trends Food Sci. & Technol*., **14**: 341–353.

Han, C., Zhao, Y., Leonard, S.W. and Traber, M.G. (2004). Edible coatings to improve storability and enhance nutritionalvalue of fresh and frozen strawberries (*Fragaria ananasa*) and rasp berries (*Rubus ideaus*). *Postharvest Biol. &Technol*., **33**: 67–78.

Harborne, J.B. (1973). *Phytochemical methods*. Chapman and Hall International Ed. Toppan Co. Ltd., Tokyo, Japan.

Koksal, A.I. (1989). Research on the storage of pomegranate (cv. GOK BAHCE) under different conditions. *Acta Horticulturae*. **258** : 295–302.

Kramer, M.E. (2009). Structure and function of starch based edible films and coating. In: *Edible films and coatings for food applications.* M.E. Embuscado and K.C. Huber, eds.). Springer, New York, NY. pp.113–135.

Mahajan, B.V.C., Singh, J. and Dhillon, W.S. (2011). Effect of different edible coatings on quality and shelf-life of pears under supermarket and ordinary market conditions. ISSN:1553-8621(Online) *J. homepage*:*http://www.tandfonline.com/loi/wsfr20*.

Mirdehgan, S.H., Rahemi, M., Castillo, S., Romero, D., Serrano, M. and Valero, D. (2007). Pre-storage application of polyamines by pressure or immersion improves shelf-life of pomegranate stored at chilling temperatures by increasing endogenous polyamine levels. *Postharvest Biol. & Technol*., **44**: 26–33.

Moghadam, F.J. and Kiaeshkevarian, M. (2013). Response of bioactive compounds in citrus fruits to wax coating during storage. *J. Plant Prod.,* **20**: 59-72.

Olivas, G.I. and Canovas, B.G. (2009). Edible films and coatings for fruits and vegetables. Embuscado and K.C. Huber (eds.). *Edible films and coatings for food application.* pp. 211–238.

Oms-Oliu, G., Fortuny, S.R. and Belloso, M. (2008). Edible coatings with anti-browning agents to maintain sensory quality and antioxidant properties of fresh-cut pears. *Postharvest Biol. & Technol*., **50**(1): 87–94.

Panse, V.G. and Sukhtame, P.V. (1985). *Statistical methods for agricultural workers*. Indian Council of Agricultural Research, New Delhi, India. pp. 186.

Plooto, A., Roberts, R.G. and Roberts, D.D. (2003). Evaluation of plant essential oils as natural postharvest disease control of tomato (*Lycopersicon esculentum*). *Acta Horticulturae.*, **628** : 737-745.

Ranganna, S. (1986). *Hand book of analysis and quality control for fruits and vegetable products.* Tata McGraw Hill Publishing Company Limited, NEW DELHI, INDIA.

Sepheri, N., Elhamirad, A. and Armin, M. (2015). Effects of chitosan and *Aloe vera* coating treatments on antioxidant activity and colour changes of Kiwi slices. *J. Renewable Nat. Resour. Bhutan,* **3** (1): 226-234.

Shen, Y., Yang, H., Chen, J., Liu, D. and Ye, X. (2013). Effect of waxing and wrapping on phenolic content and antioxidant activity of citrus during storage. *J. Food Process.& Preservat.*, **37**: 222-231.

Tulin, A. and Ulukanil, Z. (2012). Application of edible starch based coating including glycerol plus *Oleum Nigella* on arils from long stored whole pomegranate fruits. *J.Food Process. & Preservat.*,**36**: 81–95.

Vina, S.Z., Mugridge, A., Garcia, M.A., Ferreyra, R.M., Martino, M.N., Chaves, A.R. and Zaritzky, N.E. (2007). Effects of polyvinyl chloride films and edible starch coatings on quality aspects of refrigerated Brussels sprouts. *J. Food Chem.,***103**: 701–709.

Zhou, R., Mo, Y., Li, Y., Zhou, Y., Zhang, G. and Hu, Y. (2008). Quality and internal characteristics of Huanha pears (*Pyrus pyrifolia Nakai*, cv. HUANHUA) treated with different kinds of coating during storage. *J.Postharvest Biol.&Technol.,* **40**: 171–179.