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Extension of Shelf life of Khasi Mandarin (*Citrus reticulata Blanco*) with some Bio-extracts and other Treatments

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Abstract

The present investigation was conducted during 2020-2021 in the laboratory of Department of Horticulture, School of Agricultural Sciences, Medziphema Campus, Nagaland University. Fully matured fruits at colour break stage were harvested from farmers field at Wokha at random representing all sides and canopy of the trees and subjected to treatments under CRD with three replications. The treatments comprised of cold water dip (control), Melia seed extract (5%), garlic extract (10%), waxing (4%), hot water dip (50 ±2 °C), Melia seed extract (5%) + waxing, garlic extract (10%) + waxing. The PLW (%) at 52 days of storage was found least with MSE 5% + waxing followed by waxing (4%) and garlic extract (10%) + waxing. The juice content was found to be significantly highest (34.00 ml) with the treatment of hot water dip (50 ±2 °C) while the lowest resulted with control treatment (27.67 ml). The control treatment was found to exhibit the highest TSS content (10.97 °Brix) at 49 DAS (days after storage) which were statistically at par with the treatments MSE 5 % and GE 10% (10.80 °Brix). The titrable acidity did not vary significantly amongst treatments. The highest reducing sugar content (3.92 %) was observed in fruits treated with GE 10% on 49 DAS while the least (3.07 %) was with waxing treatment. Total sugar content was found to be highest with the treatment MSE 5% on all days of observation. This shows that waxing treatment with or without MSE 5% and GE 10% maintained quality of fruits during its storage life.

Keywords: Khasi Mandarin; Bio-Extracts; Waxing, Hot Water; Storage Life

Abbreviations

MSE: Melia Seed Extract; GE; Garlic Extract; PLW: Physiological Loss in Weight; TSS: Total Soluble Solids.

Introduction

Citrus is the collective generic term comprising a number of species and varieties of fruits, known over the world for their characteristic flavour and attractive range of colours. The citrus fruits belong to the family Rutaceae and occupy a prominent place among popular and extensively grown tropical and sub-tropical fruits of the world covering an estimated area of 2.9 million ha. [1]. Citrus is native to a large area, which extends from Himalayan foot hills of northeast India to north central China, the Philippines, Myanmar, Thailand, Indonesia and New Caledonia. Citrus industry in India is the third largest fruit industry of the country after mango and banana. The high demand for oranges on both national and international level has been attributed to the appreciation of its nutritional importance and as a rich source of vitamins C. In India, citrus is grown in 0.62 million ha area with the total production of 4.79 million tones and most important commercial citrus species in India are mandarin orange (*Citrus reticulata*), sweet orange (*Citrus sinensis*) and acid lime (*Citrus aurantifolia*) sharing 41, 23 and 23 % respectively of all citrus fruits produced in the country [2].

A large number of citrus species or progenitors of many citrus fruits are believed to have originated in India. The north eastern states of India are a repository of a number of citrus species. As early as 1956, Bhattacharya and Dutta described 17 citrus species, 52 cultivars and a few probable natural hybrids from this region. post-harvest management in Khasi mandarin has not been given much importance mainly due to lack of awareness as well as insufficient infrastructure for its proper management. Bulk quantities of the produce gets damaged during the process of handling, transportation and marketing. A recent study conducted by Assam Agricultural University, Jorhat revealed that post-harvest loss of Khasi mandarin is about 13.955 per cent. This loss is due to improper harvesting, rough handling, absence of packaging systems and inadequate storage facilities. Moreover the fruits are harvested either in immature or improper stage which reduces the shelf-life of mandarin and lowers its edible quality [3]. In order to reduce post-harvest losses, synthetic fungicides are applied either pre- or post-harvest. However, the application of synthetic chemical compounds to control post-harvest diseases often result in chemical residues on fruit that may affect human health. Biological controls of post-harvest fruits like banana [4] and vegetable diseases have been investigated by many scientists during the past several decades. Other approaches have also been tried to identify the effective natural chemicals (*i.e*., those present in plant extracts), which may be more acceptable to consumers than those that are synthetically produced. Grainge, et al. [5] have documented and classified a number of plants belonging to various families having growth regulating, fungicidal properties and plants like neem, melia (Ghora or wild neem), mentha, commercial lantana are under active investigation for use as plant protection agents. Already neem based formulations are available in the market. Owing to its various effects, azadirachtin is considered as active principal substance in neem, which has growth regulating, fungicidal and insecticidal properties [6].

Garlic oleoresins are obtained by the solvent extraction of crushed bulbs and cloves of garlic, *Allium sativum* L. The product has characteristic aroma of fresh garlic, is extremely pungent and highly concentrated. It is a viscous liquid that is light orange to amber in colour. Some post-harvest bio control agents using antagonistic isolates of fungi and bacteria have also been developed to reduce post-harvest diseases of citrus. Therefore, the development and use of alternative post-harvest control options, involving biological agents or natural plant extracts, have become important since it is perceived as being environmentally safer and more acceptable to the general public in the light of organic food [7]. Moreover, instead of using chemicals, bio-extracts can be easily prepared at field level which are low cost and locally available and can be very beneficial to farmers in enhancing the storage life of produce. This paper highlights the results in the study of some botanicals from locally available plants and can be prepared at farmers field.

Materials and Methods

Mandarin orange trees of 12-15 years were selected for fruit collection at a private orchard located in Wokha District, Nagaland, India. Fully matured fruits were harvested at colour break stage representing all sides and canopy of the trees. The fruits were harvested with the help of secateurs keeping a small portion of the stalk intact. Fruits thus collected were kept in shade to remove field heat. Then the fruits were wiped clean of dust particles with clean cotton cloth and packed in corrugated boxes lined with paddy straw as cushioning material to avoid bruising during transportation. The boxes were then loaded in a vehicle and transported to the Laboratory, Department of Horticulture, Nagaland University, Medziphema covering a distance of 124 Km. In the Laboratory the fruits were sorted out and placed in trays at ambient condition after administering various treatments for further analyses. Each treatment was replicated three times with 120 fruits in each unit. The experiment was laid in completely randomised design (CRD) with 7 treatments *viz*., T1-Cold water dip, T2-*Melia* seed extract (5 %), T3-Garlic extract (10 %), T4-Waxing (0.2%), T5-Hot water (50 ± 1) T6-*Melia* seed extract (5 %) + waxing (0.2 %), T7-Garlic extract at 10 %) + waxing at 0.2 %).

Preparation of bio-extracts and other treatments used in the experiments were as follows:

Garlic extract (10%)

Approximately 10 g of garlic was chopped into small pieces, added to 100 ml of deionized water, and allowed to sit at room temperature for 24 hours. The resulting solution was decanted to collect a pale white transparent garlic extract solution, and the solid garlic pieces were removed [8]. This extract solution of 10% was used for dipping the oranges and allowed to dry on the skin.

Melia seed extract (5%) - 50 g of seeds of the plant *Melia azedarach* L. was soaked in 1 litre of water. The kernel was pounded gently so that no oil comes out. The outer coat was removed before pounding. The pounded Melia seeds powder was gathered in a muslin pouch and soaked for 24 hours in the water. The pouch was squeezed and the extract filtered. To the filtrate, an emulsifier - labolene (1 ml) was added

[9]. The emulsifier helps the extract to stick well to the fruit surface.

Wax (1:4) **-** The wax emulsion was prepared in the laboratory by adding 200 mg of Waxol into 800 ml of water heated to 80 °C to readily mix the wax. The fruits were dipped into this emulsion while it was still in liquid form.

Cold and Hot water treatment (50 ±1°C) **-** The control treated fruits were dipped in cold water for 5 minutes and exposed to light breeze from a fan to remove excess surface water. While for the Hot water treatment, the oranges were immersed for 5 minutes in water heated to 50 °C, followed by a gentle breeze from a fan to remove the surface water.
Physiological loss in weight (PLW %) of fruits was estimated at two days interval upto 52 days of storage. Three fruits at random (average weight of 92.25 g) were used as a sample. The physiological losses in weight (PLW) of fruits were calculated by following the formula of Kaur [10] as follows

$$\text{Percentage of weight loss (\%WL)} = \frac{IW - FW}{IW} \times 100$$

Where,
%WL = percentage of total weight loss; IW = initial weight; FW = final weight
Total soluble solids (°Brix) and titrable acidity (%) were estimated following procedures given in AOAC [11]. Total and reducing sugar content (%) were determined by Lane, et al. method [12]. The data thus obtained were computed, analyzed and inferred for significant test in accordance with the procedure outlined by Panse and Sukhatme [13]. The significance of different sources of variation were tested by error mean square using Fisher Snedecor ` F' test of probability at 5% level of significance.

Results

Physical parameters

There was least physiological loss in weight (PLW) of fruits (0.22 to 6.83 %) during storage in fruits treated with Wax from D1 (day 1) upto D27 (day 54) followed closely by MSE 5%+waxing (0.32 to 4.75%) and GE 10%+waxing (0.55 to 9.61%) upto 54 days of observation (Fig 1). There was comparatively more loss in physiological weight in MSE 5% (2.27 to 38.76%) treated fruits even compared with control (2.12 to 30.32%). There was gradual decrease in the juice content with progress in days of storage with all treatments (Table 1). At 49 days of storage, the juice content was found to be highest (34.00 ml) with the treatment of Hot water while the lowest resulted with control treatment (27.67 ml).

Qualitative parameters

There was an initial decrease in the TSS of fruits and thereafter increased with progress in storage days (Table 2). The treatment MSE 1% was found to exhibit the highest TSS content (9.73 °Brix) while control fruits resulted with the lowest (9.00 °Brix). However, at 49 DAS the control fruits were observed with the highest content (10.97 °Brix) which were statistically at par with the treatments MSE 1%+waxing, MSE 1% and GE 1% (10.90 and 10.80 °Brix, respectively). There was significant variations in the acidity content only on day 7 of storage while on all other days of observations the various treatments did not result in any significant differences (Table 3). At 7 DAS, the least acidity (0.43 %) was observed in the treatment MSE 5%+waxing closely followed by control, GE 10% and Hot water (0.45, 0.47 % respectively) which were found to be statistically at par. The TSS-acid ratio more or less increased with increase in days of storage but did not follow any definite trend amongst the treatments (Table 4).

The reducing sugar content showed gradual increase with storage days although there were some variations on the different days of observations with the exception of waxing which more or less contained similar reducing sugar in fruits on all days of observations (Table 5). The highest reducing sugar content (4.49 %) was observed in fruits treated with GE 10%+waxing on 49 DAS followed closely by GE 10% (3.92%), Hot water (3.73 %), MSE 5%+waxing (3.65 %) and MSE 5% (3.57 %) which were all found to be statistically same. The least (2.38 %) content was with Hot water treatment at 7 DAS. Table 6 depicts non-reducing sugar content which also followed a similar trend as the reducing sugar content which were significantly different with the various treatments. The total sugar content in fruits during storage was found to vary significantly due to different treatments barring 14 DAS where the greatest content was found with the treatment MSE 5% on all days of observation (Tables 7-9). On further scrutiny of the data the total sugar content in fruits showed an increasing trend with days of storage in all treatments.

Discussion

The decrease in PLW (%) on wax treated fruits could be due to reduction in respiration and transpiration loss due to coating on the fruit surface [14]. Transpiration or evaporation of water from the plant tissues, is one of the major causes of deterioration in fresh horticultural crops after harvest. Water loss through transpiration not only results in direct quantitative losses (loss of saleable weight), but also causes losses in appearance (wilting, shriveling), textural quality (softening, flaccidity, limpness, loss of crispness and juiciness) and nutritional quality. Transpiration can be controlled either through the direct application of post-harvest treatments to the produce (surface coatings and other moisture barriers) or through manipulation of the environment (maintenance of high relative humidity). The increase in TSS and sugar contents during early part of storage may be due to the hydrolysis of insoluble polysaccharides into simple sugar. Such changes are expected to be slower and more gradual when the metabolism of the commodity is slowed down by the application of various treatments. With the decrease in metabolism the rate of utilization of stored metabolites is also slowed down thereby resulting in retention of higher levels of these constituents [9].

Conclusions

Among the different bio-extracts and other treatments, MSE 5% gave better results in terms of TSS (°brix), titrable acidity (%), TSS-acid ratio, sugar content (%), while wax coating of fruits alone or in combination with the bio extracts were found to maintain the fruit weight (g) and juice content (ml) and slowing down the ripening (aging) process of fruits. Formulation of bio-extract namely MSE 5% may be recommended for treatment of harvested fruits for prolonging the storage life of Khasi mandarin for about 3 weeks, however, for longer duration wax coating (wax:water 1:4) may be preferred. Thus, it was evident that various plant extracts and simple dipping of fruits in hot water as post-harvest treatments could bring about the desired effect on maintaining quality of citrus fruits during storage (Figure 1).

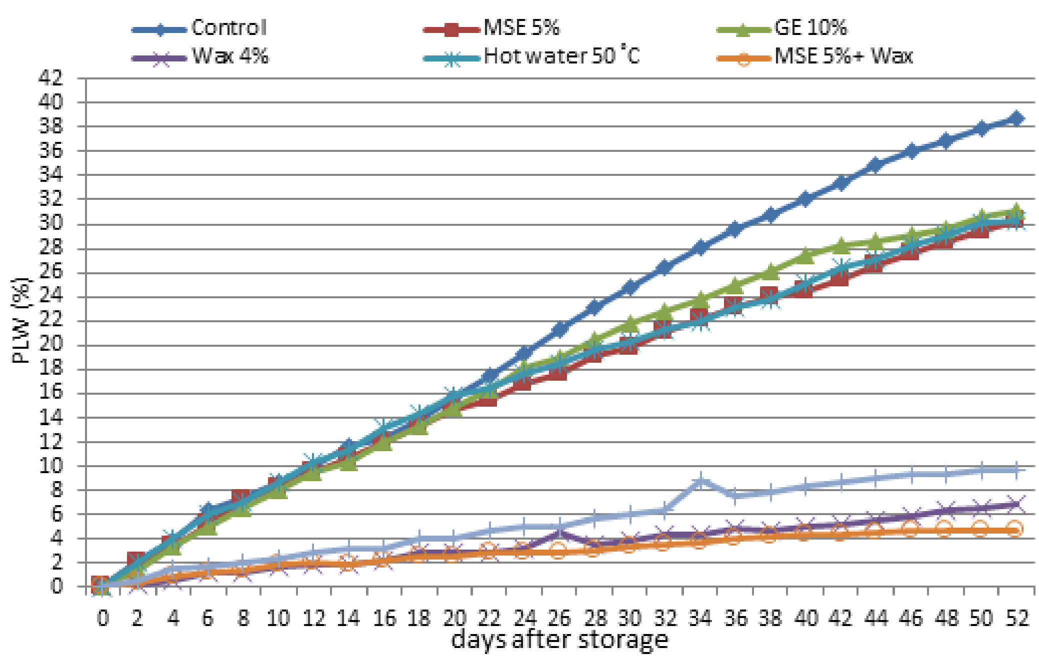

Figure 1: Physiological loss in weight (%) in Khasi mandarin during storage.

Treatment		Days after storage						
	0	7	14	21	28	35	42	49
Control	35.9	36.7	40.7	43.7	45	32.7	30.7	27.7
MSE 5%		37.2	39.3	37	35.3	32.3	30.3	29
GE 10%		42.8	39.7	39.7	40.3	35.3	32	30
Waxing		35.3	37.7	41.3	42	38.3	34.3	32
Hot water		37	46.7	36.7	39.7	35	30.3	34
MSE 5%+waxing		35.7	30.3	33.3	39	36	31.7	32.7
GE 10%+ waxing		34.3	42	36.3	36.3	34	34	30
S Em ±		3.71	2.56	2.12	3.66	1.86	1.14	1.02
LSD (p=0.05)		NS	5.5	4.54	NS	NS	2.45	2.2

Table 1: Juice content in fruits as influenced by various treatments in shelf life of Khasi mandarin.

Treatment		Days after storage						
	0	7	14	21	28	35	42	49
Control	9	9	9.4	9.6	10.8	10.8	10.9	11
MSE 5%		9.3	9.3	9.6	10.2	10.4	10.4	10.8
GE 10%		9.3	9.3	9.5	10.3	10.4	10.6	10.8
Waxing		9.3	9.3	9.2	10.2	10.3	10.4	10.5
Hot water		8.8	9.3	9.4	10	10.1	10.1	10.3
MSE 5%+waxing		8.8	8.4	9.5	10.3	10.6	10.4	10.9
GE 10%+ waxing		9.2	9.4	9.5	9.9	10.2	10.3	10.4
S Em ±		0.4	0.1	0.2	0.2	0.13	0.11	0.16
LSD (p=0.05)		NS	0.2	NS	0.43	0.28	0.24	0.35

Table 2: Influence of different treatments on the fruit TSS (^{0} Brix) of fruits during storage

Treatment		Days after storage						
	0	7	14	21	28	35	42	49
Control	0.6	0.5	0.5	0.5	0.4	0.4	0	0.4
MSE 5%		0.6	0.5	0.5	0.5	0.4	0	0.4
GE 10%		0.5	0.5	0.5	0.5	0.5	0	0.4
Waxing		0.5	0.5	0.5	0.4	0.4	0	0.4
Hot water		0.5	0.5	0.5	0.4	0.5	0	0.4
MSE 5%+waxing		0.4	0.4	0.4	0.4	0.4	0	0.4
GE 10%+ waxing		0.6	0.5	0.5	0.4	0.4	0	0.4
S Em ±		0	0	0.1	0	0	0	0
LSD (p=0.05)		0.1	NS	NS	NS	NS	NS	NS

Table 3: Effect of post-harvest treatments on titrable acidity (%) in Khasi mandarin.

Treatment		Days after storage						
	0	7	14	21	28	35	42	49
Control	15.4	20	20.1	20.2	25.9	25.5	29	29.4
MSE 5%		16.7	19.6	19.7	23.1	24.6	24.5	26.8
GE 10%		18.2	18.4	18.7	22.1	23.7	24.4	24.5
Waxing		19.1	21.1	20.9	23	23.5	24.1	23.5
Hot water		18.9	19.9	20.1	24.4	21.6	23	22.8
MSE 5%+waxing		21.7	21	23.6	27.3	28.2	26.3	26.1
GE 10%+ waxing		16.3	19.2	21.5	26.4	25.5	25.6	24.6
S Em ±		1.27	1.87	2.24	2.59	2.36	2.85	1.19
LSD (p=0.05)		2.72	NS	NS	NS	NS	NS	2.56

Table 4: TSS-acid ratio as influenced by the application of various treatments during storage life of Khasi mandarin

Treatment		Days after storage						
	0	7	14	21	28	35	42	49
Control	2.5	3	3.1	3.1	3.1	3.1	3.2	3.3
MSE 5%		3	2.9	3	3.2	3.2	3.4	3.6
GE 10%		3	3.4	3.5	3.6	3.7	3.7	3.9
Waxing		3	2.9	3	2.9	3	3.1	3.1
Hot water		2	3.6	3.3	3.2	3.5	3.6	3.7
MSE 5%+waxing		3	3	3.1	3.2	3.3	3.5	3.7
GE 10%+ waxing		3	3.5	3.6	3.6	3.6	3.7	4.5
S Em ±		0	0.2	0.1	0.2	0.2	0.1	0.4
LSD (p=0.05)		0	0.3	0.3	0.3	0.3	0.3	0.8

Table 5: Effect of different treatments on the reducing sugar content (%) of Khasi mandarin during storage.

Treatment		Days after storage						
	0	7	14	21	28	35	42	49
Control	3.4	4	4	4.4	4.3	3.9	4	3.9
MSE 5%		4	4.2	5	5.7	4.6	6	6
GE 10%		3	3.2	3.4	3.8	3.8	4.1	4.3
Waxing		2	2.7	3.4	3	3.3	3.4	3.9
Hot water		4	3.1	3.7	3.8	3.6	4.3	4.4
MSE 5%+waxing		4	3.8	3.9	3.2	3.2	3.4	3.8
GE 10%+ waxing		3	2.7	2.6	2.7	2.9	2.9	2.3
S Em ±		1	0.4	0.5	0.4	0.3	0.4	0.5
LSD (p=0.05)		1	0.9	1	0.9	0.7	0.8	1.1

Table 6: Influence of various treatments on Khasi mandarin during storage on non-reducing sugar content (%).

Treatment		Days after storage						
	0	7	14	21	28	35	42	49
Control	6.2	7.2	6.9	7.7	7.6	7.51	7.41	7.41
MSE 5%		6.9	6.9	8.3	9.1	8.73	9.68	9.84
GE 10%		6.8	6.8	7.1	7.6	7.61	8.01	8.46
Waxing		5.8	5.8	6.5	6.1	6.46	6.67	7.17
Hot water		6.5	6.5	7.3	7.3	7.27	8.03	8.34
MSE 5%+waxing		6.9	6.9	7.2	6.6	6.93	7.07	7.61
GE 10%+ waxing		6.3	6.3	6.3	6.5	6.67	6.67	6.9
S Em ±		0.6	0.5	0.5	0.4	0.4	0.29	0.3
LSD (p=0.05)		1.2	NS	1	0.9	0.86	0.62	0.64

Table 7: Total sugar content (%) of fruits as affected by the different treatments during storage.

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