Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(2): 3100-3103
Received: 01-01-2018
Accepted: 02-02-2018

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Effect of washing treatments on quality of banana fruits

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Abstract
A study was conducted to check the efficacy of different washing treatments using sanitizers on the quality of banana fruits. Being a climacteric fruit crop, it suffers with shorter shelf life with loss of appearance under ambient conditions. The fruits were subjected to washing treatments for 5 minutes using aqueous ozone, hydrogen peroxide, Sodium hypochlorite and calcium hypochlorite solutions and then stored under ambient condition for 6 days. The fruits treated with sodium hypochlorite and aqueous ozone showed significantly minimum physiological loss in weight (14.23 and 14.28 per cent), minimum (22.38 and 22.63ºB) total soluble solids, respiration rate (62.23 and 60.40ml CO_2/kg/hr) and titratable acidity (0.63 and 0.62 per cent) was seen in sodium and calcium hypochlorite treated fruits as compared to untreated fruits. Highest sensory scores (7.00) were observed in the fruits treated with aqueous ozone. This experiment shows that there is immense scope for using ozone by the small holders to ensure quality banana fruits even in the local markets.

Keywords: banana, ozone, calcium hypochlorite, shelf life

1. Introduction
Banana is one of the economically important fruit crops and is popular all over the world because of the high nutritive value. Banana is a rich source of carbohydrate, potassium, phosphorus, calcium, magnesium and Vitamin-B. Fruit is free from fat with high calorific value. The low-fat and high sugar bananas are uses as dessert food and staple foods (Aurore *et al.*, 2009) [1]. It is the cheapest fruit among all other fruits in India. Banana is a climacteric fruit and its biochemical changes continue after harvest till senescence. Unlike many other fruits, banana is not a seasonal fruit and the availability of fruits can be seen in large quantities round the year. The benefits of increased production will not be realized unless it is duly accompanied by careful handling, advanced storage, packaging and transport techniques (Tapas *et al.*, 2016) [2].

Chlorine is a very potent disinfectant with powerful oxidizing properties. Chlorine kills pathogens such as bacteria and viruses by breaking the chemical bonds in their molecules. Chlorine compounds containing disinfectants can exchange atoms with other compounds, such as enzymes in bacteria and other cells. When enzymes come in contact with chlorine, one or more of the hydrogen atoms in the molecule are replaced by chlorine. This causes the entire molecule to change shape or fall apart. When enzymes do not function properly, a cell or bacterium will die. Calcium hypochlorite and sodium hypochlorite are the common sources of chlorine used for disinfecting produce and produce process water. Hydrogen peroxide (H_2O_2) is a well-studied oxidizing agent, directly toxic to pathogens. It has both bacteriostatic and bactericidal activity, due to its capacity to generate other cytotoxic oxidizing species, such as hydroxyl radicals (Alexandre *et al*., 2012) [3]. Ozone is a very pungent, naturally occurring gas with strong oxidizing properties and is highly reactive with a half-life ranging from 15 to 30 minutes, degraded into O_2 which presents no residual activity (Cullen *et al*., 2009) [4]. Ozonization has been suggested as an effective antimicrobial sanitizer for water, food, and food processing surfaces and equipment (Novak and Yuan, 2007) [5].

In India, soon after harvesting the fruits are transported to the ripening unit, the fruits are ripened and then there are marketed by the local vendors. For the local markets no step is taken for reducing the microbial load over the fruits which is going to cause some post harvest diseases like anthracnose, crown rot *etc*. In this context, if an additional step of washing the fruits before ripening is introduced then the post harvest diseases can be reduced to some extent. With this hypothesis, this study was conducted to check the efficacy of sanitizers/disinfectants to reduce the microbial contamination which in turn will be checking the post harvest quality of banana fruits.

2. Materials and Methods

This study was performed in the Department of Post Harvest Technology laboratory, Bagalkot. The healthy banana hands were pre-cooled and then the washing treatments were imposed for duration of five minutes *viz.*, T_1: Ozonated water (0.2-0.35mg/lit.), T_2: Hydrogen peroxide (40mM), T_3: Sodium hypochlorite (30ppm), T_4: Calcium hypochlorite (30ppm), T_5: Normal tap water, T_6: Control (untreated fruits). After washing, the fruits were air dried, wrapped in paper and stored under ambient condition. The observations were recorded on every second day.

2.1 Physiological loss in weight (PLW %)

In each replication, 4 fruits were ear marked to record the PLW. The marked fruits in each replication of the respective treatment were weighed individually at the beginning of storage to record the initial weight. On subsequent days of observation, the fruits were weighed again. The cumulative losses in weight of fruits were calculated and expressed as per cent physiological loss in weight.

2.2 Respiration rate (ml CO_2/kg/h)

Respiration rate was measured with a CO_2 gas analyzer (Make: PBI Dansensor, CheckMate - II) in static method. The fruit was weighed and placed in a hermetically sealed container of 1250 ml capacity for 60 minutes. At the end of incubation period, gas sample was drawn from the container head space using gas tight syringe and injected into the CO_2 analyzer. The change in CO_2 gel concentration in the head space and time was read in the instrument was recorded. The respiration rate of the fruit was expressed as ml CO_2/kg/h.

2.3 TSS (°B)

The juice extracted by squeezing the homogenized fruit pulp through muslin cloth was used to measure the TSS. It was determined by using ERMA hand refractometer, replicated three times and the mean was expressed in °B.

2.4 Titratable acidity (%)

A known volume of juice sample (10 ml) was taken and titrated against standard NaOH using phenolphthalein indicator. The appearance of light pink colour was marked as the end point. The value was expressed in terms of citric acid as per cent titratable acidity of juice (AOAC, 1984) [6].

2.5 Visual colour change

Mainly colour changes in banana during ripening are based on the peel colour rather than the pulp colour and hence colour of banana peel has been used in the assessment of the stages of ripeness of banana. Commercial standard colour charts are available in which 7 stages of peel color were reproduced and translated to a numerical scale where Stage 1=all green, 2= green with trace of yellow, 3= more green than yellow, 4= more yellow than green, 5= yellow with trace of green, 6= full yellow, 7= full yellow with brown spots. According to colour chart, in terms of peel colour slight difference occurs among the advanced stages of maturity *i.e.* stage 5, 6 and 7 as compared to initial stages (Tapre and Jain, 2012) [7].

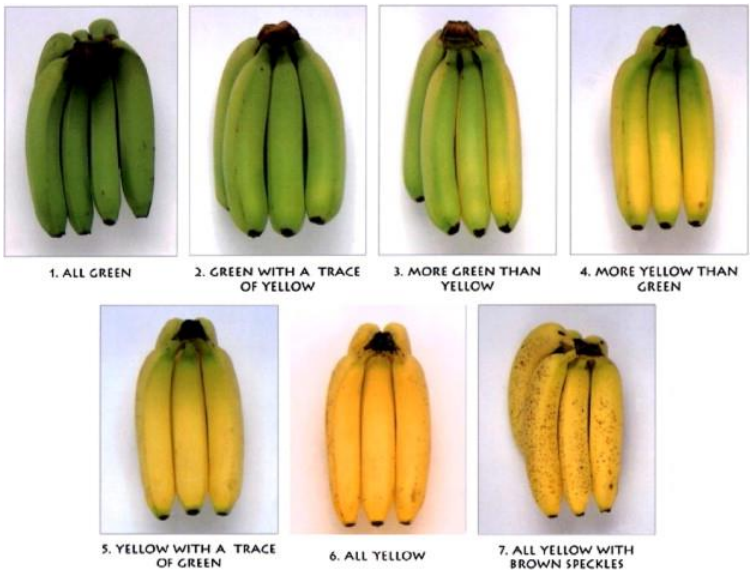

Fig 1

2.6 Organoleptic evaluation of fruits

Organoleptic evaluation of fruits was carried out by a panel of 5 semi-trained judges on 6th day. The sensory characters like skin colour and appearance, texture, taste and flavour, and overall acceptability were evaluated on a 9 point Hedonic scale.

2.7 Statistical analysis

Statistical analysis was performed using Web Agri Stat Package (WASP) Version 2.0 (Jangam and Thali, 2010) [8]. All data the collected were analysed by one-way analysis of variance (ANOVA). Significant differences among means at $P \leq 0.05$ were determined by post hoc tests using Duncan's multiple range test.

3. Results and discussion

The surface washing treatments had shown significant effect on the quality of the fresh banana fruits stored at an ambient temperature. The results with respect to physiological loss in weight showed significant difference between the treatments. Maximum physiological weight in loss was observed in untreated fruits whereas minimum was noticed in ozone and sodium hypochlorite treated fruits (Table 1). It was observed that the respiration rate differed significantly among the treatments, highest being in untreated fruits and minimum in sodium and calcium hypochlorite treated fruits (Table 1). Higher physiological loss in weight and respiration rate in the untreated fruits is may be due the normal accelerated metabolic activities of the fruits. The weight loss in fruits may

be due to the breakdown of reserved carbohydrates during respiration, water loss and changes in the internal and external factors. The reduced weight loss was may be due to the effect of ozone which might have retained the moisture content in the fruits against transpiration process. And also might have slowed down the respiration rate thus reducing the quantitative deterioration.

There was increase in the TSS and titratable acidity of the fruits in all the treatments as the storage days increased because of ripening of the fruits (Table 2). Significantly lower total soluble solids was observed in the sodium hypochlorite and calcium hypochlorite treated fruits followed by ozone treated fruits. The increase in the total soluble solids during ripening was due to breakdown of starch and polysaccharides into simple sugars. Increased TSS during maturation and ripening could also have been due to partial breakdown of pectins and celluloses (De Lima *et al.*, 2001) [9]. Organic acids normally decrease in several fruits except in banana as they are respired or converted to sugar (Seymour, 1993) [10]. However, the increase in titratable acidity during ripening may be due to the increase in malic acid (John and Marchal, 1995) [11]. Several enzymes can have an influence on the level of organic acids in banana; malate synthase, activity of which decreases during ripening; malic enzyme, which is involved in the decarboxylation of malic acid and phosphoenol pyruvate carboxylase, which plays a part in the formation of malic acid (John and Marchal, 1995) [11], decrease of which may play a pivotal role in increase in fruit acidity during storage. These treatments caused decrease in the rate of respiration and delayed the climacteric peak, which may be the reason for lower value of acidity of fruits.

From the present study, it is evident that the fruits which have undergone washing treatments retained quality and showed good visual appearance. The data with respect to visual colour change is depicted in Table 3. The change in colour was first noticed in the untreated fruits and then in the treated fruits but at the end of storage period there was no significant difference in between the treated and untreated fruits. Colour development is closely associated with a climacteric peak in all the treatments including untreated fruits (Tapas *et al.*, 2016) [2]. The colour development which started prior to the onset of climacteric was completed at the peak climacteric (Leoseck, 1950) [12]. Sensory evaluation of the fruits was done at the end of 6th day. No significant difference was observed between the treatments. However, ozone treated fruits recorded maximum scores with respect to all the parameters.

Table 1: Effect of washing treatments on PLW (%) and respiration rate (mg CO_2/kg/hr) on banana fruits

	PLW (%)			Respiration rate (ml CO_2/kg/hr.)		
Trts.	**2nd day**	**4th day**	**6th day**	**2nd day**	**4th day**	**6th day**
T_1	5.16	9.44^{c}	14.28^{c}	34.33^{c}	54.05^{d}	64.75^{d}
T_2	5.37	11.13^{ab}	15.06^{bc}	40.50^{ab}	56.43^{b}	71.88^{b}
T_3	5.06	10.35^{bc}	14.23^{c}	27.80^{c}	53.23^{e}	62.23^{e}
T_4	6.03	11.22^{ab}	15.90^{abc}	25.23^{c}	52.20^{f}	60.40^{e}
T_5	6.69	11.94^{ab}	17.07^{ab}	39.55b^{c}	55.33^{c}	67.88^{c}
T_6	6.34	12.32^{a}	17.62^{a}	46.85^{a}	58.17^{a}	77.01^{a}
S.Em±	0.27	0.37	0.56	1.26	0.18	0.49
CD (5%)	NS	1.62	2.51	5.60	0.79	2.18
CD (1%)	NS	NS	NS	7.67	1.09	3.00

Table 2: Effect of washing treatments on TSS (ºB) and TA (%) on banana fruits

	TSS (ºB)			TA (%)		
Trts.	**2nd day**	**4th day**	**6th day**	**2nd day**	**4th day**	**6th day**
T_1	14.62^{bc}	19.50^{bc}	23.55^{bc}	0.23^{d}	0.33^{c}	0.66^{d}
T_2	15.54^{b}	20.73^{b}	24.45^{b}	0.34^{b}	0.46^{ab}	0.76^{b}
T_3	13.42^{bc}	18.23^{c}	22.38^{c}	0.15^{e}	0.24^{d}	0.63^{de}
T_4	12.61^{c}	18.19^{c}	22.63^{c}	0.13^{e}	0.22^{d}	0.62^{e}
T_5	12.54^{c}	18.36^{c}	24.63^{b}	0.31^{c}	0.43^{b}	0.72^{c}
T_6	18.91^{a}	23.18^{a}	26.00^{a}	0.38^{a}	0.52^{a}	0.80^{a}
S.Em±	0.62	0.48	0.29	0.02	0.03	0.03
CD (5%)	2.76	2.14	1.30	0.03	0.06	0.03
CD (1%)	3.78	2.92	1.77	0.04	0.10	0.06

Table 3: Effect of washing treatments on visual colour change and sensory evaluation on banana fruits

	Visual colour change			Sensory evaluation			
Trts.	**2nd day**	**4th day**	**6th day**	**Colour and appearance**	**Taste and flavour**	**Texture**	**Overall acceptability**
T_1	2.50	4.25	7.00	6.00	7.75	7.75	7.75
T_2	2.50	4.25	7.00	6.38	7.50	7.75	7.50
T_3	2.50	4.25	6.75	7.50	7.50	8.00	7.50
T_4	2.50	4.25	6.50	7.00	7.75	7.75	7.50
T_5	2.50	4.25	6.75	7.00	7.25	6.75	7.00
T_6	2.50	4.25	7.00	6.75	7.50	7.50	7.25

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