The Pharma Innovation Journal 2023; 12(11): 1607-1613

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(11): 1607-1613

www.thepharmajournal.com
Received: 11-08-2023
Accepted: 18-10-2023

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Effect of pre-harvest bagging and fungicide application on mango (*Mangifera indica* L.) chemical characteristics

Sonam Sharma, Sunil Malik, Rakesh Kumar, Vivak Ujjwal, Gurdev Chand, Bhav Kumar Sinha and Rajesh Kumar

Abstract
The experiment to study the combined effect of bagging and fungicide application on chemical traits of Dasheri mango involving nine treatments in Randomized Block Design was conducted at Horticultural Research Centre and Post-Harvest Laboratory of Department of Horticulture, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut during the year 2015. In this inquiry, the chemical characteristics of mango were examined in terms of Total Soluble Solids (TSS), Total Sugars (%), Reducing Sugar (%), Non-reducing Sugar (%), and Acidity (%). The results indicate that among the pre-harvest treatments, fruits bagged in brown paper and treated with a foliar application of 0.05% carbendazim had the highest levels of total soluble solids (21.16 ^{o}brix). Fruits bagged with brown paper plus foliar treatment attained the highest amount of total sugars, reducing sugars, and non-reducing sugars. Fruits packaged in brown paper with foliar carbendazim application had the lowest amount of fruit acidity (0.11%), whereas fruit packaged in transparent polythene with or without carbendazim had a greater level of fruit acidity (0.23%).

Keywords: Dasheri, chemical traits, pre-harvest, carbendazim, bagging

Introduction
A significant commercial fruit crop, the mango (*Mangifera indica* L.), is a member of the dicotyledonous family Anacardiaceae. It is thought that this fruit originated in a tropical or subtropical region of south Asia, most likely India. The mango fruit, which is a big drupe, is regarded as the king of fruits. It is a significant tropical fruit that is grown in India and other countries. Because of their wide range of adaptability, great nutritional content, variety, wonderful taste, and outstanding flavour, mangoes are very well-liked by people. Both vitamin A and vitamin C are abundant in it. With a yield of 20.90 million tonnes and a productivity of 9.7 MT/ha, mango is grown on an area of 2.32 million hectares in India (Anonymous, 2021) [2]. Numerous studies have been done on the horticultural qualities of Indian mangoes (Singh and Bana, 1976) [21]. A variety of methods are being tried to improve and safeguard the mango's outer physical characteristics, including its size, colour, decay loss, shelf life, pulp colour, and skin shrivelling as well as its total soluble solid (brix), acidity (%), total sugar (%), reducing sugar (%), and non-reducing sugar (%). Bagging and application of fungicide especially carbondazim is an important practice to improve different parameter associated with mango quality. Individual fruit is bagged when it is placed within specially crafted paper or fabric bags. Bagging shields fruits from insects, fungi, diseases, and mechanical harm, decreases the need for insecticide treatment, and estimates the number of fruits per tree that may be harvested. An emerging agricultural practice called "on-tree fruit bagging" is covering fruit with a cloth or paper bag which is widely used for pear (Qian *et al*., 2013) [15], apple (Bai *et al*., 2016) [4], grape (Zheng *et al*., 2013) [27], and mango (Karanjalker *et al*.,2018 and Kanzaki *et al*., 2020) [10, 9]. The practice of bagging helps to reduce the impact of unfavourable environmental conditions (Nagaharshitha *et al*., 2017) [13]. Fruits that are bagged can also have better internal quality since it encourages coloration during harvest (Devalla *et al*., 2016) [6]. According to Sharma *et al*. (2014) [19], the pre-harvest fruit bagging technique has recently demonstrated good outcomes with fruits like banana, litchi, and apple. Sometimes, methods like applying carbendazim (Methyl 1H-benzimidazol-2-yl carbamate) together with physical treatments like bagging and picking fruits with a pedicle are employed to improve the post-harvest quality and fruit ripening propensity.

With the use of fungicides and fruit bagging, studies have been done to improve the post-harvest quality and decrease spoiling losses of mango fruits (Nair and Singh, 2003 and Mahajan *et al*., 1996) [11, 12]. Mango storage diseases caused by anthracnose and stem end rot can be effectively managed by pre-harvest spraying with a fungicide such carbendazim 0.1%. Captan fungicide was added to the hot water bath to further minimize fruit deterioration and enhance fruit quality (Subramanyam, 1969) [24]. Fungicides are employed in the majority of commercial mango production scenarios, according to research findings (Ploetz, 2004) [14]. According to Sharma *et al*.'s study from 2023, pre-harvest brown paper bagging of mangoes with or without application of 0.05% carbendazim was important in enhancing mango post-harvest quality. Mango fruit storage capacity and fruit consistency must be enhanced in order to successfully transport mango fruit to distant markets (Simmons *et al*., 1997) [20]. One of the biggest issues the mango business faces is postharvest handling of mango fruits (Amin *et al*., 2008) [1]. Given the significance of the mango crop for both the domestic and global markets, as well as the role that bagging and carbendiazim foliar treatment play in enhancing the overall quality of mango fruit, an analysis titled "Effect of Pre-harvest Bagging and Fungicide Application on Mango (*Mangifera Indica* L.) Chemical Characteristics" was undertaken at Horticultural Research Centre and Post-Harvest Technology Laboratory of Department of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh during the year 2015.

Materials and Methods

The goal of the current study was to ascertain the combined impact of bagging and fungicide application on chemical features of Dashehari mango under ambient conditions. It was carried out in an experimental orchard and post-harvest laboratory of the Department of Horticulture during the 2014–15 growing season. The chemical characteristics of mangoes examined in this study included Total Soluble Solids, Acidity (%), Sugars (%), and Total Solvable Solids. % reduction in sugar: Non-reducing sugar (%), total invert sugars (%), and total sugars (%) In a randomized block design, the experiment was set up. Mango trees that were at least 20 years old were chosen for the experiment. a typical sample of five fruits for nine treatments, each of which had three replications and 135 randomly chosen fruits. The morning hours saw the first harvest of the physiologically matured treated fruits with consistent size and specific gravity (1.00). There were a total of 15 fruits per treatment.

T1 - Control (Fresh water) + no bagging
T2 - Bagging with brown paper+ no foliar application of carbendazim (0.05%)
T3 -Bagging with brown paper + foliar application of carbendazim (0.05%)
T4 -Bagging with white paper+ no foliar application of carbendazim (0.05%)
T5 -Bagging with white paper + foliar application of carbendazim (0.05%)
T6 -Bagging with newspaper + no foliar application of carbendazim (0.05%)
T7 -Bagging with newspaper +foliar application of carbendazim (0.05%)
T8 -Bagging with transparent polythene+ no foliar application of carbendazim (0.05%)
T9 -Bagging with transparent polythene + foliar application of carbendazim (0.05%)

Analysis of chemical traits

With the use of a Digital Pocket Hand Refractometer by ATAGO Japan, the total soluble solids (TSS) in fruit were calculated. The results were reported in terms of degree Brix (°B). Estimates and percentages of the reducing sugar, non-reducing sugar, and total sugar were made. The sugars were calculated using the accepted method outlined in AOAC (1980) [3]. The method outlined by Lane and Eynon (1923) as detailed by Ranganna (1997) [16] was used to determine the sugar content in samples using Fehling's 'A' and 'B' solutions. Titration with 0.1N NaOH in the presence of the phenolphthalein indicator was used to calculate the total titratable acidity (TTA). Citric acid, which predominates among the organic acids in mango fruit, is used to express TTA (Ueda *et al*., 2000) [26].

The analysis of variance (ANOVA) technique was used to statistically analyze the data collected for each parameter (Fisher, 1958) [7].

Results and Discussion

Table 1: Effect of pre-harvest bagging and fungicide application on total soluble solids (TSS) in mango under ambient condition

S. No	Treatments	Mean	±SE
1	T1 - Control (Fresh water) + no bagging	17.433	0.088
2	T2 - Bagging with brown paper+ no foliar application of carbendazim (0.05%)	19.817	0.818
3	T3 -Bagging with brown paper + foliar application of carbendazim (0.05%)	21.167	1.135
4	T4 -Bagging with white paper+ no foliar application of carbendazim (0.05%)	19.767	1.084
5	T5 -Bagging with white paper + foliar application of carbendazim (0.05%)	20.333	0.751
6	T6 -Bagging with newspaper + no foliar application of carbendazim (0.05%)	19.187	1.399
7	T7 -Bagging with newspaper +foliar application of carbendazim (0.05%)	19.733	0.639
8	T8 -Bagging with transparent polythene+ no foliar application of carbendazim (0.05%)	18.310	0.537
9	T9 -Bagging with transparent polythene + foliar application of carbendazim (0.05%)	19.077	1.191
	C.D.	N.S.	
	SE(d)	1.307	

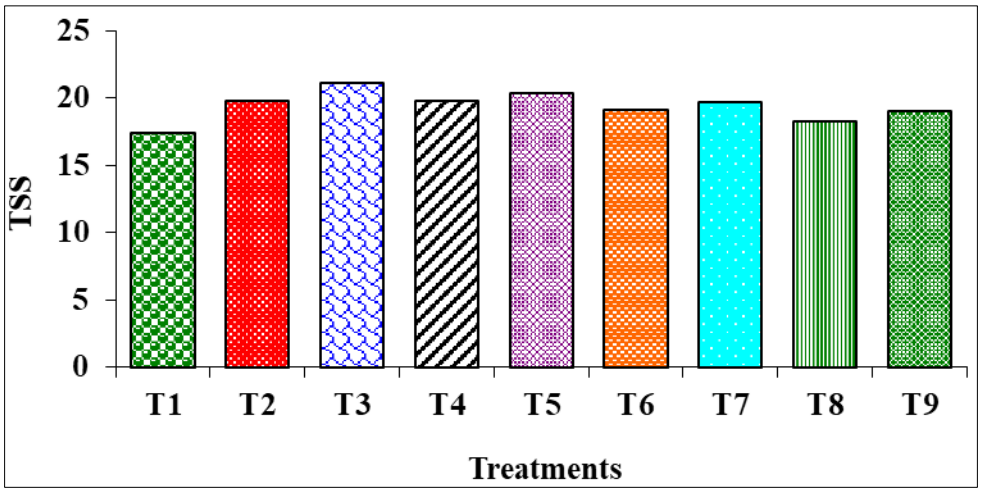


Fig 1: Effect of pre-harvest bagging and fungicide application on TSS (° brix) in mango under ambient condition

The effect of pre-harvest bagging and fungicide application on total soluble solids (TSS) in mango under ambient condition was studied and when compared to the control, all pre-harvest treatments significantly affected the content of soluble solids in mango fruits during ambient storage (Table: 1 & fig: 1). Total soluble solids in fruits that had been bagged or treated before to harvest ranged from 18.31 to 21.16 °brix. The fruits treated with bagging with brown paper + 0.05% carbendazim had the greatest amounts of soluble solids (21.16 °brix), followed by those treated with bagging with white paper + 0.05% carbendazim (20.33 °brix). However, control fruits (17.43 °brix) and bagging with polythene + no spray (18.31 °brix) had the lowest quantities of soluble solids. Comparing bagging with and without carbendazim, the addition of carbendazim considerably raised the amounts of total soluble solids in fruits. Comparing the effect of bagging with newspaper bags with or without spray on the levels of total soluble solids revealed that white paper bags with or without spray was more successful at increasing the content of total soluble solids. Bagging with brown paper + carbendazim (0.05%) significantly raised the level of total soluble solids in pre-harvested bagged/treated fruits, according to research on the combined effects of bagging and carbendazim spray on the content of total soluble solids in fruits. In a similar vein, Jakhar and Pathak (2014) [8] observed the highest TSS concentration in the Amrapali mango during both research years when mangoes were bagged after being treated with $CaCl_2$ at 2% and K_2SO_4 at 1% in brown paper. In pre-harvest treated fruits, also discovered greater concentrations of total soluble solids and sugars. When compared to treatments that didn't contain carbendazim, the current study's treatments had significantly higher amounts of soluble solids and total sugars in fruits. Sreejith Vijayan Ramakrishna *et al*. (2015) [23], who observed that carbendazim treated fruits contained higher levels of total sugars at the end of storage time, further supported the substantial significance of carbendazim in enhancing the chemical composition of fruits. When carbendazim and $CaCl_2$ were used together, Baneshan mango storage quality improved in terms of total soluble solids and sugars (Sudhavani and Sankar 2002) [25].

Table 2: Effect of pre-harvest bagging and fungicide application on total Sugar (%) in mango under ambient condition

S. No	Treatments	Mean	±SE
1	T1 - Control (Fresh water) + no bagging	13.223	0.110
2	T2 - Bagging with brown paper+ no foliar application of carbendazim (0.05%)	14.853	0.280
3	T3 -Bagging with brown paper + foliar application of carbendazim (0.05%)	15.030	0.327
4	T4 -Bagging with white paper+ no foliar application of carbendazim (0.05%)	14.207	0.081
5	T5 -Bagging with white paper + foliar application of carbendazim (0.05%)	14.423	0.169
6	T6 -Bagging with newspaper + no foliar application of carbendazim (0.05%)	13.450	0.139
7	T7 -Bagging with newspaper +foliar application of carbendazim (0.05%)	13.563	0.103
8	T8 -Bagging with transparent polythene+ no foliar application of carbendazim (0.05%)	13.283	0.110
9	T9 -Bagging with transparent polythene + foliar application of carbendazim (0.05%)	13.310	0.087
	C.D.	0.479	
	SE(d)	0.224	

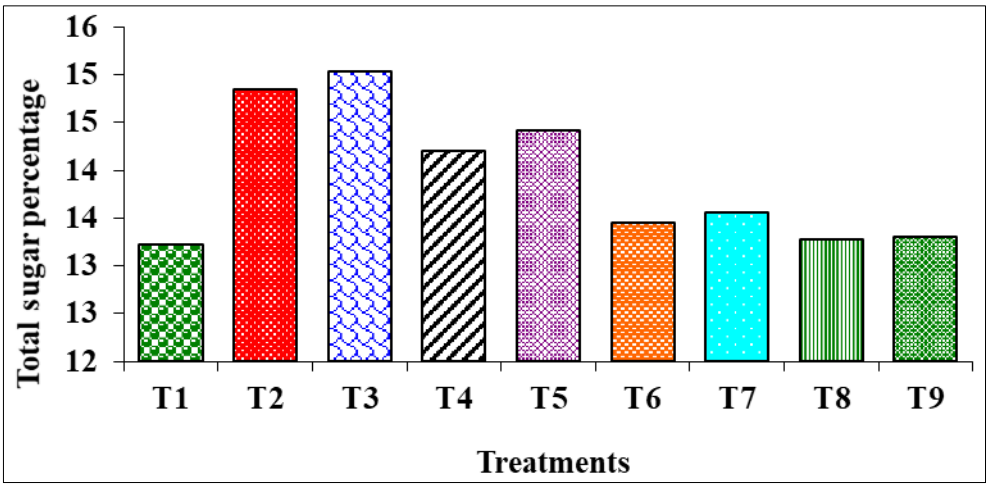


Fig 2: Effect of pre-harvest bagging and application of fungicide on Total sugar % in mango under ambient condition

In comparison to the sugar content of control fruits, the amounts of total sugars in pre-harvested bagged/treated fruits were dramatically impacted (Table 2 & fig 2). Fruits that had been packaged or treated before to harvest ranged in total sugar content from 13.28 to 15.03 percent. The fruits that had been packaged with brown paper plus 0.05% carbendazim had the highest amounts of total sugars (15.03%), followed by brown paper plus 0.05% carbendazim (14.42%), and white paper alone (14.20%). Control fruits had the lowest level of sugar during ripening (12.22%).When ripening time came around for the pre-harvested bagged fruits, brown paper bagging was comparatively more effective at raising the levels of sugars than other bagging materials, including white paper, newspaper, and transparent polythene. The amount of total sugars in pre-harvested bagged fruits was considerably impacted by carbendazim in the study. In comparison to treatments without carbendazim (13.28 to 14.85%), pre-harvested fruits with bagging containing carbendazim exhibited greater levels of sugars (13.31 to 15.03%). Similar findings were made in the Amrapali mango by Jakhar and Pathak (2014) [8] who found that pre-harvest bagging and foliar spraying with 2% $CaCl_2$ and K_2SO_4 improved fruit storage quality with regard to sugars. When compared to treatments that didn't contain carbendazim, the current study's treatments had significantly higher amounts of soluble solids and total sugars in fruits. Ramakrishna *et al*. (2015) [23] also observed that fruits treated with carbendazim had higher levels of total sugars at the conclusion of the storage period, confirming the substantial effect of carbendazim in enhancing the chemical composition of fruits.

Table 3: Effect of pre-harvest bagging and fungicide application on reducing sugar % in mango under ambient condition.

S. No	Treatments	Mean	±SE
1	T1 - Control (Fresh water) + no bagging	4.850	0.340
2	T2 - Bagging with brown paper+ no foliar application of carbendazim (0.05%)	6.117	0.434
3	T3 -Bagging with brown paper + foliar application of carbendazim (0.05%)	6.150	0.328
4	T4 -Bagging with white paper+ no foliar application of carbendazim (0.05%)	5.817	0.366
5	T5 -Bagging with white paper + foliar application of carbendazim (0.05%)	5.900	0.208
6	T6 -Bagging with newspaper + no foliar application of carbendazim (0.05%)	5.700	0.200
7	T7 -Bagging with newspaper +foliar application of carbendazim (0.05%)	5.800	0.115
8	T8 -Bagging with transparent polythene+ no foliar application of carbendazim (0.05%)	5.667	0.067
9	T9 -Bagging with transparent polythene + foliar application of carbendazim (0.05%)	5.667	0.203
	C.D.	N.S.	
	SE(d)	0.402	

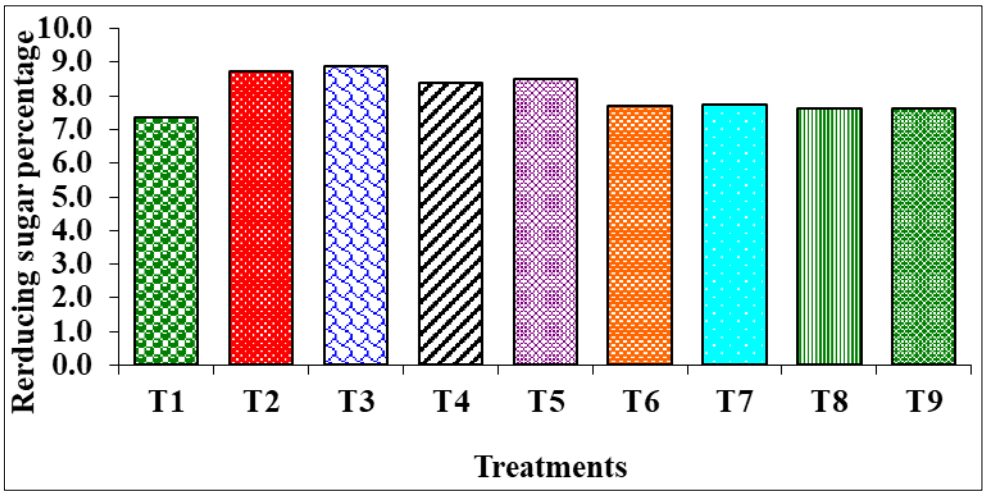


Fig 3: Effect of pre-harvest bagging and application of fungicide on reducing sugar % in mango under ambient condition

The information on how pre-harvest bagging and pesticide treatment throughout the ripening process under ambient conditions affects the reduction of sugar percent in mango fruits is compiled in Table 3 and Fig 3. Fruits that were bagged with brown paper and either 0.05% carbendazim or 0.05% carbendazim alone had the highest decreasing sugar contents, 6.14% and 6.12%, respectively. During the experiment, the lowest decreasing sugar content in the control was 4.85%, followed by 5.65% when bags made of transparent polythene were used. But compared to the control, other treatments also displayed higher decreasing sugar concentration.

It is clear from the statistics that pre-harvest bagging and pesticide application during ripening had an impact on the mango fruits' declining sugar content. Similar findings were made in the Amrapali mango by Jakhar and Pathak in 2014. They stated that pre-harvest bagging and foliar spraying with 2% $CaCl_2$ and K_2SO_4 improved the fruit's storage quality for sugars.

Table 4: Effect of pre-harvest bagging and fungicide application on non-reducing sugar % in mango under ambient condition

S. No	Treatments	Mean	±SE
1	T1 - Control (Fresh water) + no bagging	7.360	0.160
2	T2 - Bagging with brown paper+ no foliar application of carbendazim (0.05%)	8.737	0.157
3	T3 -Bagging with brown paper + foliar application of carbendazim (0.05%)	8.880	0.113
4	T4 -Bagging with white paper+ no foliar application of carbendazim (0.05%)	8.390	0.445
5	T5 -Bagging with white paper + foliar application of carbendazim (0.05%)	8.523	0.367
6	T6 -Bagging with newspaper + no foliar application of carbendazim (0.05%)	7.727	0.093
7	T7 -Bagging with newspaper +foliar application of carbendazim (0.05%)	7.763	0.023
8	T8 -Bagging with transparent polythene+ no foliar application of carbendazim (0.05%)	7.617	0.170
9	T9 -Bagging with transparent polythene + foliar application of carbendazim (0.05%)	7.643	0.116
	C.D.	0.669	
	SE(d)	0.313	

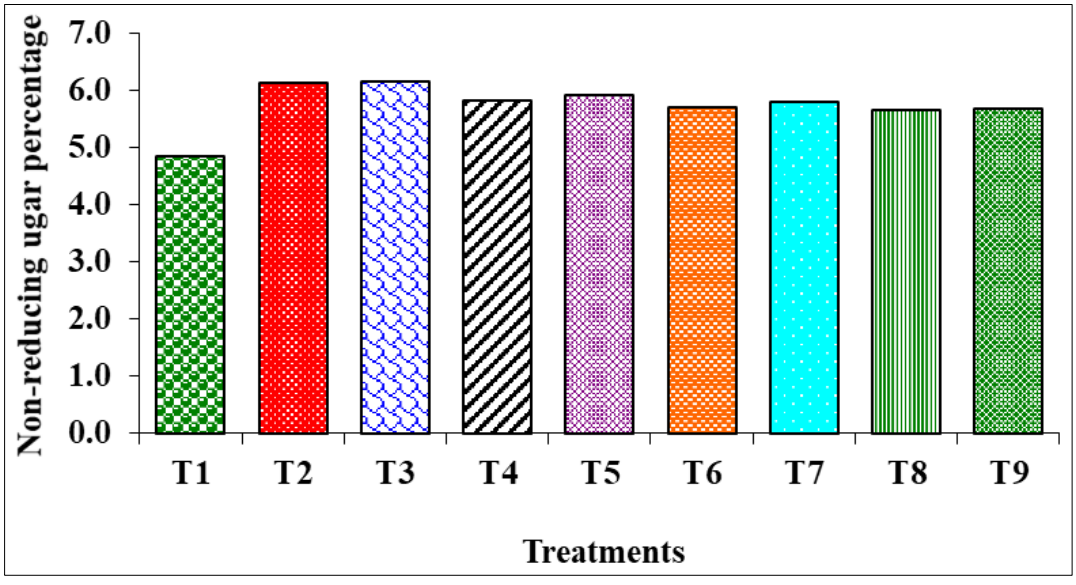
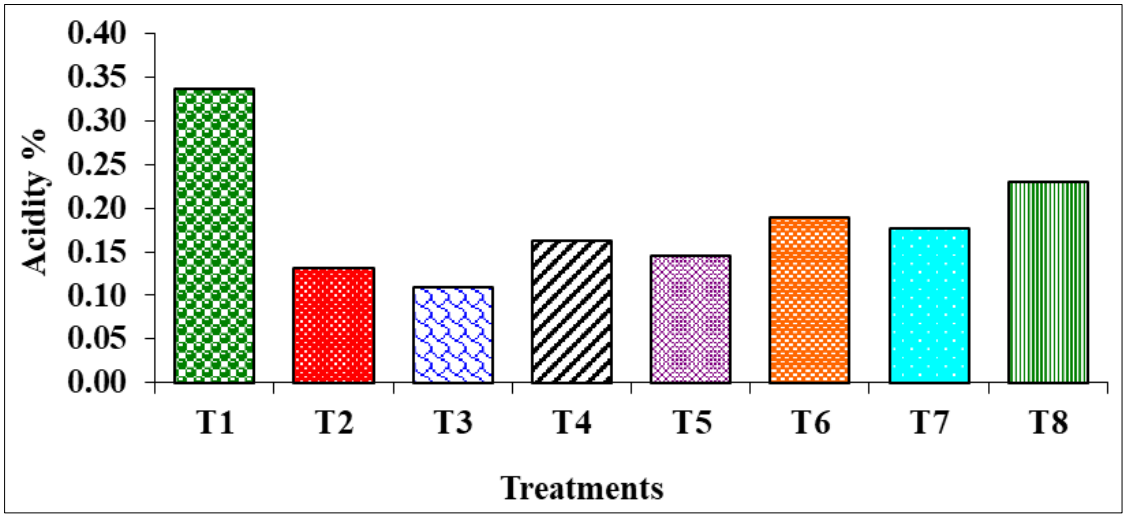


Fig 4: Effect of pre-harvest bagging and application of fungicide on non- reducing sugar % in mango under ambient condition

The data pertaining to the effect of pre harvest bagging and application of pesticide on non-reducing sugar per cent during the ripening under ambient condition presented in Table 4 & fig 4. The perusal of the data reflected that the non-reducing sugar content of mango fruits was significantly increased in pre-harvest bagged/treated fruits during the ripening. The maximum non-reducing sugar content 8.89% and 8.73% was recorded in fruits bagged with brown paper + 0.05% carbendazim and fruits bagged with brown paper + without 0.05% carbendazim and minimum 7.64% and 7.63% was recorded in fruits bagged with transparent polythene + 0.05% carbendazim and fruits bagged with transparent polythene without carbendazim, respectively. An examination of data revealed that the pre harvest treatments influenced the non-reducing sugar content of mango fruits.Other treatments also showed higher non-reducing sugar content in comparison to control. Similar effect of the pre harvest treatment of $CaCl_2$ @2% + K_2SO_4 @1% + bagging on non-reducing sugar content was also reported by Jakhar and Pathak, 2014 [8] in Amrapali mango.

Table 5: Effect of pre-harvest bagging and fungicide application on acidity in mango under ambient condition

S. No	Treatments	Mean	±SE
1	T1 - Control (Fresh water) + no bagging	0.337	0.009
2	T2 - Bagging with brown paper+ no foliar application of carbendazim (0.05%)	0.132	0.004
3	T3 -Bagging with brown paper + foliar application of carbendazim (0.05%)	0.110	0.006
4	T4 -Bagging with white paper+ no foliar application of carbendazim (0.05%)	0.163	0.007
5	T5 -Bagging with white paper + foliar application of carbendazim (0.05%)	0.146	0.011
6	T6 -Bagging with newspaper + no foliar application of carbendazim (0.05%)	0.190	0.006
7	T7 -Bagging with newspaper +foliar application of carbendazim (0.05%)	0.177	0.007
8	T8 -Bagging with transparent polythene+ no foliar application of carbendazim (0.05%)	0.230	0.015
9	T9 -Bagging with transparent polythene + foliar application of carbendazim (0.05%)	0.200	0.015
	C.D.	0.029	
	SE(d)	0.014	



Pre-harvest fruits that had been bagged or handled during ripening were tested for acidity, and the results are shown in Table 5 and Fig 5. The information shows that pre-harvest bagging and fungicide treatments had a considerable impact on the amount of acidity in apples. Fruits that had been pre-harvested treated ranged in acidity level from 0.11 to 0.23%. While control fruits had the highest amount of acidity (0.33%), fruits bagged with brown paper and carbendazim (0.05%) had the lowest level (0.110%) as they ripened. Bagging with clear polythene applied as pre-harvest stage was the least effective treatment for lowering fruit acidity levels when compared to bagging with brown paper, white paper, newspaper, and other materials. All of the treatments significantly lowered compared to the control. The amount of acidity was further decreased when carbendazim was added to these treatments. In terms of the combined impact of bagging and spray, pre-harvest bagging with brown paper + carbendazim 0.05% led to the greatest reduction in fruit acidity. When pre-harvest bagging (with brown paper) and applications of $CaCl_2$ at 2% and K_2SO_4 at 1% were made, Jakhar and Pathak (2014) [8] also observed a decrease in the degree of acidity in Amrapali Mango fruits. The aforementioned findings were very similar to those of Sharma *et al*., 2014 [19]; Singh *et al*., 1998 [22]; and Dhemre and Waskar, 2003 [5].

Conclusion

According to the results of the study, maximum level of total sugars, reducing sugars, and non-reducing sugars were obtained in fruits bagged by brown paper + foliar application of 0.05% carbendazim, followed by bagging of fruits by brown paper without foliar application of 0.05% carbendazim. White paper was comparatively more successful than newspaper and transparent polythene in raising the levels of total sugars in fruits when it came to fruit bagging. The total sugar content of fruits was dramatically increased by the addition of carbendazim to the treatments. Additionally, it was shown that fruits packaged in clear polythene with 0.05% carbendazim applied to the leaves had higher levels of acidity than those packaged in brown paper with this combination. Overall, it was discovered that pre-harvest brown paper bagging of fruits with or without the application of 0.05%

carbendazim was significant in improving the post-harvest quality of mango. Farmers, particularly leading mango growers, should be encouraged to adopt this practice to improve the quality of their produce and receive the greatest possible financial return from their produce.

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