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ORIGINAL ARTICLE

Effect of various ripening agents on physico- chemical properties of banana cv. Grand Naine

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ABSTRACT
The present investigation entitled Effect of various ripening agents on physico-chemical properties of banana cv. Grand Naine was conducted in the laboratory of the Department of Horticulture, Khalsa College, Amritsar during 2019-2020. The experiment comprised of ten postharvest treatments viz., control, ethrel 300 ppm, ethrel 400 ppm, ethrel 600 ppm, cold water + ethrel 200 ppm, hot water + ethrel 200 ppm, perforated polythene bags, unperforated polythene bags, unperforated polythene bags with $KMnO_4$ and newspaper wrap. Changes in different physico – chemical characteristics of banana were studied at 2 days interval during storage for 8 days. The two-factor experiment was laid out in Completely Randomized Design (CRD) with three replications. Results of the study revealed that marked variations were recorded among the post harvest treatments on ripening of banana. Among all the treatments, $KMnO_4$ treated banana showed minimum (2.3 %) total weight loss at 8^{th} day of storage. The highest fruit color (7), pulp to peel ratio (2.41%), fruit taste (9.10), moisture content in pulp (76.60 %), total soluble solids (21.97 %), total sugars (18.09 %) and reducing sugars (12.10 %) was observed in the treatment of ethrel 600 ppm.
Keywords : *Banana, Ethrel, Grand Naine, $KMnO_4$, Moisture, Physico-chemical, Ripening,*

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INTRODUCTION

Banana (*Musa* sp.) is also known as apple of the paradise and is the tallest of the herbaceous plants with pseudostem [1].It belongs to the family Musaceae. It is evolved by natural hybridization between the two species *Musa acuminate* and *Musa balbisiana.* Out of which the most edible fruited bananas, usually seedless belong to the species *Musaacuminata*colla [2]. It is one of the most traded tropical fruits of the world [3].Banana is deeply interwoven in cultural heritage of India that its plants, leaves and fruits are considered very auspicious in all the festive occasions and used in social functions or worship of god [4].It is equally liked by all age group of people because of its digestibility and palatability. It contains carbohydrates, crude fiber, proteins, fat, ash, phosphorous, iron, β- carotene, riboflavin, niacin and ascorbic acid [5]. The banana fruit can be eaten raw, cooked, processed into flour and can be fermented for the production of beverages such as banana juice, vinegar and wine [6].Grand Naine is a superior selection of Giant Cavendish variety which was introduced in India in 1990. Due to several desirable traits like excellent fruit quality and resistance to *Fusarium wilt* it has proved a better variety with high productivity [7].Banana is a climacteric fruit showing an increase in respiration rate resulting in development of color, flavor and aroma. Banana is harvested mature but in unripe condition and is subsequently allowed to ripen further. In natural conditions, they ripen slowly, leading to high weight loss, desiccation, uneven ripening and failure to develop good color and aroma. Hence marketable quality gets deteriorated. Therefore to reduce the post harvest losses bananas are harvested green and are normally artificially ripened with the use of ripening agents which hastens the ripening process [8]. These include ethylene gas, ethephon, ethrel which helps in early and uniform ripening of banana fruits with good color development and taste. Ethrel treatment of fruits results in high marketable fruit, minimum spoilage percentage and higher peel : pulp ratio . However, to further boost the production of this crop,

adequate ripening technology needs a great attention [9]. Bananas are generally ripened in the markets by calcium carbide and use of this chemical is prohibited due to health reasons. Therefore, alternative measures need to be investigated for improving the ripening of banana fruits, so that uniformly ripened and quality fruits are made available to consumers in the market.

MATERIAL AND METHODS

The investigation was conducted at the laboratory of department of Horticulture Khalsa College, Amritsar, during the year 2019-2020. The material used for the present experiment were freshly harvested mature banana bunches of cv. Grand Naine. The bananas used in the experiment were collected from the private orchard of Mewa Singh of village Kulaar, Ludhiana. The experiment was conducted in Completely Randomized Design with three replications and 7 treatments viz. T_1 :Control (banana fingers were washed simply with tap water only). $T_{2:}$ Ethrel 300 ppm (3 minutes dip), $T_{3:}$ Ethrel 400 ppm (3 minutes dip), T_4: Ethrel 600 ppm (3 minutes dip), T_5: Cold water+ Ethrel 200 ppm $T_{6:}$ Hot water (50+-2^{o}C)+ Ethrel 200 ppm, $T_{7:}$ Perforated transparent polyethylene bags T_8 : Unperforated transparent polyethylene bags, T_9: Unperforated plastic bags with $KMnO_4$,T_{10} : Newspaper wrap. After the application of treatments, the fruits were kept on newspapers on the laboratory table at room temperature. Each treatment comprised of 20 fingers. Detailed observations were recorded at 2nd, 4th, 6th and 8th days for physical and bio-chemical parameters. For determination of Physiological loss in weight banana hands used in the study were weighed using an analytical balance and kept for storage. Per cent total weight was calculated at the interval of 2 days using the following formula:

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

Where %WL = percentage of total weight loss
IW = Initial fruit weight
FW = Final fruit weight

The panel of five judges scored the quality characteristics in terms of fruit taste of each sample on nine point hedonic scale. Pulp to peel ratio was measured by dividing the pulp weight with peel weight. Fruit color was determined by comparing the pericarp color with Munsell′s color chart.Total soluble solids of strained pulp extract were determined with the help of Bausch and Lomb hand refractrometer and subsequent corrections were made with the help of temperature correction chart at 20° C room temperature .Titratable acidity and sugars were determined by the method of [10].

RESULTS AND DISCUSSION

Physiological loss in weight (%)

The highest physiological loss in weight was observed with ethrel 600 ppm (5.9 %) on the 8th day of storage which resulted in shrivelling, softening and over-ripening of fruits. Minimum loss in weight (2.3%) was recorded in unperforated bags with $KMnO_4$ treated fruits and these were hard in texture. The results corresponds with the weight loss values reported by [11] for fruits stored under open ambient condition for the same period.Thelower weight loss obtained from fruits placed in polythene bags with perforation compared to those in non-perforated ones could be due to the removal of ethylene which has a catalytic role in increasing respiration, and maintaining RH in the package thus reducing water loss [12]. In all treatments the percentage weight loss increased with the storage time and ripening progressed, which possibly resulted from transpiration and respiration of the fruits. Energy produced from the respiration process in the form of heat is released from the fruit by evaporation of water causing a weight loss [11] Loss in weight by various treatments also has also been reported by [9, 13, 14] and [14] in banana cv. Grande.

Table 1 : Effect of various ripening agents on physiological loss in weight (%) of banana cv. Grand Naine

Treatments	2nd day	4th day	6th day	8th day
T_1 : Control	1.21	1.96	2.40	2.90
T_2 : Ethrel 300 ppm	1.32	2.40	3.00	3.50
T_3 : Ethrel 400 ppm	1.60	2.80	3.50	3.90
T_4 : Ethrel 600 ppm	1.80	3.10	4.30	5.90
T_5 : Cold water + ethrel 200 ppm	1.30	2.30	3.00	3.30
T_6 : Hot water (50 ± 2°C)+ ethrel 200 ppm	1.28	2.20	2.90	3.00
T_7 : Perforated transparent polythene bag	1.20	1.91	2.20	2.60
T_8 : Un perforated transparent polythene bag	1.19	1.88	2.20	2.40
T_9 : Un perforated polythene bag with $KMnO_4$	0.90	1.10	2.00	2.30
T_{10} : Newspaper wrap	1.24	2.10	2.70	2.90
CD @ 5 % level	0.34	0.23	0.20	0.25

Fruit taste

It is evident that the maximum score of fruit taste was observed in the treatment of ethrel 600 ppm on 6th day of storage. Unperforated bags with $KMnO_4$ resulted in minimum fruit taste scores which might be due to the fact that the fruits under $KMnO_4$ were not ripened and their texture was hard. Also, $KMnO_4$ seems to be ethylene absorber. The increase in taste in all the treatments might be due to the reason that during ripening starch hydrolysis occurred due to enzymes and converted into glucose and fructose [14]. The increase in taste during ripening was due to the increase in certain volatile compounds which acted as a precursor for taste in the fruit cells. The findings of [15] in banana cv. Robusta, [9] in cv. Grand Naine are in support with the present results.

Table 2 : Effect of various ripening agents on fruit taste of banana cv. Grand Naine

Treatments	2nd day	4th day	6th day	8th day
T_1 : Control	0.00	6.72	8.75	8.83
T_2 : Ethrel 300 ppm	0.00	6.90	8.83	8.99
T_3 : Ethrel 400 ppm	0.00	7.32	9.00	9.10
T_4 : Ethrel 600 ppm	0.00	7.82	9.36	9.20
T_5 : Cold water + ethrel 200 ppm	0.00	6.86	8.81	8.99
T_6 : Hot water (50 ± 2°C)+ ethrel 200 ppm	0.00	6.84	8.80	8.95
T_7 : Perforated transparent polythene bag	0.00	6.61	8.62	8.58
T_8 : Un perforated transparent polythene bag	0.00	6.21	8.41	8.72
T_9 : Un perforated polythene bag with $KMnO_4$	0.00	4.60	7.79	8.31
T_{10} : Newspaper wrap	0.00	6.80	8.79	8.89
CD @ 5 % level	0.00	0.06	0.03	0.03

Pulp to peel ratio

Highest pulp to peel ratio (2.41) was recorded in the treatment of ethrel 600 ppm followed by ethrel 400 ppm (2.23). Lowest pulp to peel ratio was observed with the treatment of unperforated bags with $KMnO_4$ (1.49).The increase in the pulp to peel ratio might be due to the change in sugar concentration in the pulp compared to the peel thus contributing to different change in osmotic pressure. Water might be lost from the peel of banana both by transpiration and osmosis due to which the peel weight was reduced and pulp to peel ratio increased. The increase in pulp to peel ratio during ripening was observed by [16] and [17, 18] also reported the same in banana cvs. Amritsagar, Mehersagar and Genasundori.

Table 3 : Effect of various ripening agents on pulp to peel ratio of banana cv. Grand Naine

Treatments	2nd day	4th day	6th day	8th day
T_1 : Control	1.24	1.38	1.52	1.64
T_2 : Ethrel 300 ppm	1.33	1.62	1.83	2.17
T_3 : Ethrel 400 ppm	1.38	1.63	1.86	2.23
T_4 : Ethrel 600 ppm	1.43	1.84	1.98	2.41
T_5 : Cold water + ethrel 200 ppm	1.3	1.5	1.67	1.71
T_6 : Hot water (50 ± 2°C)+ ethrel 200 ppm	1.30	1.48	1.62	1.70
T_7 : Perforated transparent polythene bag	1.21	1.35	1.49	1.61
T_8 : Un perforated transparent polythene bag	1.20	1.32	1.45	1.56
T_9 : Un perforated polythene bag with $KMnO_4$	1.20	1.30	1.40	1.49
T_{10} : Newspaper wrap	1.26	1.40	1.59	1.69
CD @ 5 % level	0.15	0.15	0.16	0.17

Fruit color

It evident from the data that the fastest color change was observed in ethrel 600 ppm treatment and reached at full yellow color with brown spots over it on 8th day with scoring of (7.00). On the same day, fruits treated with ethrel 400 ppm scored (6.33) The least score (3.33)was in newspaper wrap.The conversion of green color of the peel into yellow might be as a result of chlorophyll degradation which acted as an indicator of senescence that was enhanced by high rate of respiration which in turn was regulated by temperature, ethylene, O_2, CO_2 gasses [19].

Table 4: Effect of various ripening agents on fruit color of banana cv. Grand Naine

Treatments	2nd day	4th day	6th day	8th day
T_1 : Control	1.00	2.00	2.67	4.33
T_2 : Ethrel 300 ppm	1.33	3.66	4.00	6.00
T_3 : Ethrel 400 ppm	1.66	3.33	4.33	6.33
T_4 : Ethrel 600 ppm	2.00	4.00	5.00	7.00
T_5 : Cold water + ethrel 200 ppm	1.00	2.66	3.67	5.66
T_6 : Hot water (50 ± 2°C)+ ethrel 200 ppm	1.00	2.33	3.33	5.33
T_7 : Perforated transparent polythene bag	1.00	2.00	3.00	4.00
T_8 : Un perforated transparent polythene bag	1.00	2.00	2.66	3.66
T_9 : Un perforated polythene bag with $KMnO_4$	1.00	1.33	2.33	3.33
T_{10} : Newspaper wrap	1.00	1.66	2.67	3.33
CD @ 5 % level	0.44	0.76	0.82	0.82

Total soluble solids of pulp (%)

The data indicated that the maximum TSS (21.68 %) was recorded in the treatment of ethrel 600 ppm while the minimum TSS (19.92 %) was in unperforated bags with $KMnO_4$which was due to the ethylene absorbing capacity of $KMnO_4$ which delayed the ripening of fruits [20]. The increase in TSS content of fruits might be an indication of high respiration rate and ripening stages, thereby resulting in quality deterioration with the onset of senescence. On the other hand, delay in the increment of TSS content of fruits stored in unperforated polythene bag with $KMnO_4$ could be due to the slowdown of ripening as a result of removal of ethylene as $KMnO_4$ is an ethylene removing agent. The results are in agreement with [15, 18, 21] in Grand Nainecv. of banana.

Table 5 : Effect of various ripening agents on total soluble solids (%) of pulp of banana cv. Grand Naine

Treatments	2nd day	4th day	6th day	8th day
T_1 : Control	11.98	18.64	20.55	20.61
T_2 : Ethrel 300 ppm	13.94	19.57	21.65	21.25
T_3 : Ethrel 400 ppm	14.17	20.78	21.97	21.58
T_4 : Ethrel 600 ppm	14.93	21.15	22.80	21.68
T_5 : Cold water + ethrel 200 ppm	12.95	19.50	21.90	21.18
T_6 : Hot water (50 ± 2°C)+ ethrel 200 ppm	12.48	19.24	21.00	20.78
T_7 : Perforated transparent polythene bag	11.69	18.02	20.45	20.72
T_8 : Un perforated transparent polythene bag	10.93	17.97	19.82	20.04
T_9 : Un perforated polythene bag with $KMnO_4$	9.92	15.00	16.82	19.92
T_{10} : Newspaper wrap	12.02	19.23	20.72	20.65
CD @ 5 % level	0.052	0.064	0.052	0.050

Titratable acidity (%)

The minimum acidity (0.36 %, 0.29 %, 0.23 % and 0.18 %) was observed in ethrel 600 ppm. Optimum range of acidity (0.26 %) was observed in the ethrel treatment 400 ppm after 6 days of storage.The decrease in titratable acidity during storage might be due to the utilization of organic acids in respiration process and other bio-degradable reactions, glycolytic pathways or might have been used in respiration or both. Earlier findings of [9] in banana cv. Grand Naine,[15] in Robusta banana and [13] in Grand Naine banana also obtained the similar results. The present studies are also in line with the findings of [21] in banana cv. Grand Naine and [18] in banana cultivars.

Table 6 : Effect of various ripening agents on titratable acidity (%) of banana cv. Grand Naine

Treatments	2nd day	4th day	6th day	8th day
T_1 : Control	0.50	0.42	0.39	0.30
T_2 : Ethrel 300 ppm	0.42	0.33	0.27	0.22
T_3 : Ethrel 400 ppm	0.39	0.31	0.26	0.21
T_4 : Ethrel 600 ppm	0.36	0.29	0.23	0.18
T_5 : Cold water + ethrel 200 ppm	0.42	0.34	0.28	0.24
T_6 : Hot water (50 ± 2°C)+ ethrel 200 ppm	0.46	0.35	0.29	0.25
T_7 : Perforated transparent polythene bag	0.53	0.46	0.42	0.34
T_8 : Un perforated transparent polythene bag	0.55	0.48	0.45	0.36
T_9 : Un perforated polythene bag with $KMnO_4$	0.56	0.50	0.47	0.39
T_{10} : Newspaper wrap	0.48	0.35	0.33	0.27
CD @ 5 % level	0.038	0.049	0.056	0.048

Total sugars (%)

The data on the total sugars of banana cv. Grand Naine depicted that significantly higher total sugars (18.09 %) were analysed from the fruits treated with ethrel 600 ppm .Unperforated polythene bags with $KMnO_4$ registered the lowest (10.99 %) total sugars.The observed increment in the amount of total sugars might be due to the conversion of starch into sugars due to respiratory metabolic pathways in starch hydrolysis. Similar observations were recorded by [15] in banana fruits.The increase in sugars in ethrel 600 ppm might be due to the faster ripening process which converted starch into sugar while the slower rate in the treatment could be due to the effects of them in delaying the ripening process. This is in accordance with the findings of [22], [23], and [24] in banana fruits with polythene bags having more control over the gas exchange with the surrounding air, the levels of CO_2, O_2 around the fruits slowed down the conversion of starch to sugars [20].The delay in the increase of the sugars by inclusion of $KMnO_4$ in polythene bags might be attributed to the ethylene removal effect of $KMnO_4$ [12]. The research findings of [9] and [21] in banana cv. Grand Naine are in line with the present findings.

Table 7 : Effect of various ripening agents on total sugars (%) of banana cv. Grand Naine

Treatments	2nd day	4th day	6th day	8th day
T_1 : Control	4.52	7.99	10.29	16.78
T_2 : Ethrel 300 ppm	5.21	9.35	10.72	17.79
T_3 : Ethrel 400 ppm	6.14	10.10	10.93	17.82
T_4 : Ethrel 600 ppm	6.25	10.69	11.12	18.09
T_5 : Cold water + ethrel 200 ppm	4.90	8.90	10.69	17.59
T_6 : Hot water (50 ± 2°C)+ ethrel 200 ppm	4.87	8.60	10.42	17.10
T_7 : Perforated transparent polythene bag	4.22	7.75	10.26	16.02
T_8 : Un perforated transparent polythene bag	4.21	7.10	10.05	14.89
T_9 : Un perforated polythene bag with $KMnO_4$	3.86	6.81	9.98	10.99
T_{10} : Newspaper wrap	4.82	8.00	10.39	16.98
CD @ 5 % level	0.015	0.02	0.02	0.03

Reducing sugars (%)

From the perusal of the data it is clear that the highest percentage of reducing sugars (12.10 %) was recorded in the fruits treated with ethrel 600 ppm. The minimum reducing sugars were recorded in the fruits treated with $KMnO_4$ because fruits were unripe even after 8 days and it was due to ripening inhibiting effect of $KMnO_4$. The observed lesser amount of reducing sugars at the early period of ripeness followed by an increment as ripening progresses could be due to the higher amount of sugars at later stage of ripeness which were in agreement with the report of [20].The fruits stored in polythene bags in combination with $KMnO_4$ showed decline in sugar content which could be related to delay in ripening as $KMnO_4$ reacts with ethylene and limit its catalytic role on respiration [25]. The findings of [23, 21] and [9] in banana cv. Grand Naine are in confirmation with the present studies.

Table 8 : Effect of various ripening agents on reducing sugars (%) of banana cv. Grand Naine

Treatments	2nd day	4th day	6th day	8th day
T_1 : Control	4.33	6.38	8.17	10.30
T_2 : Ethrel 300 ppm	4.91	6.84	8.39	11.35
T_3 : Ethrel 400 ppm	5.25	7.39	8.45	11.45
T_4 : Ethrel 600 ppm	5.96	7.82	9.15	12.10
T_5 : Cold water + ethrel 200 ppm	4.87	6.80	8.35	11.30
T_6 : Hot water (50 ± 2°C)+ ethrel 200 ppm	4.78	6.64	8.26	11.05
T_7 : Perforated transparent polythene bag	4.16	6.29	8.04	9.70
T_8 : Un perforated transparent polythene bag	4.02	6.17	7.02	9.13
T_9 : Un perforated polythene bag with $KMnO_4$	2.06	5.84	6.56	7.89
T_{10} : Newspaper wrap	4.68	6.64	8.18	10.91
CD @ 5 % level	0.15	0.15	0.16	0.17

Starch content (%)

According to the data decrease was more rapid with ethrel 600 ppm (3.01 %) while the maximum starch content (7.01 %) was found with the treatment of unperforated bags with $KMnO_4$.In this study starch levels decreased in all the treatments as the ripening advanced. Ripening resulted in decline of starch content which could be attributed to the increased activity of amylase and other enzymes resulting in gluconeogenesis [26, 27]**.** The findings of [13] in banana cv. Grand Naine are in line with the present results.

Table 9 : Effect of various ripening agents on starch content (%) of banana cv. Grand Naine

Treatments	2nd day	4th day	6th day	8th day
T_1 : Control	17.42	13.26	11.03	6.95
T_2 : Ethrel 300 ppm	16.26	12.73	9.43	6.01
T_3 : Ethrel 400 ppm	15.03	11.43	8.21	5.07
T_4 : Ethrel 600 ppm	14.56	10.03	6.99	3.01
T_5 : Cold water + ethrel 200 ppm	16.94	12.97	10.07	6.44
T_6 : Hot water (50 ± 2°C)+ ethrel 200 ppm	16.97	13.04	10.32	6.58
T_7 : Perforated transparent polythene bag	17.57	13.74	11.16	6.97
T_8 : Un perforated transparent polythene bag	18.06	14.12	11.24	7.00
T_9 : Un perforated polythene bag with $KMnO_4$	21.12	16.49	11.34	7.01
T_{10} : Newspaper wrap	19.19	13.06	10.84	6.86
CD @ 5 % level	0.14	0.22	0.16	0.21

CONCLUSION

It is concluded from the present study that ethrel 600ppm proved to be the most effective treatment in enhancing TSS, reducing sugars, total sugars, physiological loss in weight, pulp to peel ratio, fruit tasteand fruit color as compared to other treatments. Minimum acidity was also observed under the fruits treated with ethrel 600 ppm. By going through the results of the present study it may be concluded that ethrel 600 ppm can be successfully used for adequate ripening of banana fruits cv. Grand Naine.

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