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POST HARVEST QUALITY ANALYSIS OF 'EMBUL' BANANA FOLLOWING ARTIFICIAL RIPENING TECHNIQUES

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Abstract: Banana (*Musa* spp.) is an important source of nutrients. 'Embul' is a popular banana variety in Sri Lanka. Banana ripening is practiced naturally and artificially. But artificial ripening could have negative effects on human and the nutrient content of such banana could be altered. Therefore, the investigation was based on the evaluation of postharvest quality of Embul banana following the artificial ripening treatments with respect to physico-chemical and sensory quality evaluation. Three samples of Embul banana at same maturity stage were treated with 0.25g/ L Calcium Carbide, 1 mL/ L Ethephon with Calcium hydroxide in airtight separate containers and the other sample was allowed to ripe naturally. Total sugar content, vitamin C, total titratable acidity, pH, total soluble solids, moisture content in pulp and peel and brix/total titratable acidity ratio were the assessed physico-chemical quality parameters, for each banana sample during the six days period of ripening with two days intervals. Aroma, taste, colour, texture and overall acceptability were recorded as five sensory quality assessing attributes. The best physico-chemical quality was observed for naturally ripened banana and the least quality was recorded for Calcium Carbide treated sample for almost all the quality parameters. Quality of Ethephon treated sample was in between the other two samples. The highest sensory scores were recorded for naturally ripened banana. Therefore, the results revealed that the chemically treated Embul banana had low level of nutritional and organoleptic quality than naturally ripened banana.
Keywords: Embul banana, Artificial ripening, Fruit quality, Calcium Carbide, Ethephon.

I. INTRODUCTION

Banana (*Musa* spp.) is one of the major crops which are cultivated in all over the world. Banana is grown in more than 120 countries throughout the tropical and subtropical regions [1]. Banana is considered as popular staple food for more than 400 million people [2]. India is the largest producer of banana with 23.205 millions mt of annual productions [3]. Approximately 100,000 Sri Lankans engage with banana cultivation. Banana fruits are wholesome and fairly well balanced source of nutrients containing various mineral salts, high amount of carbohydrates with a little oil and protein [4]. It gives high content of vitamins A

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and C but less in vitamins B [5]. Banana has significant health benefits. It reduces risk of high blood pressure, reduces risk of stroke, cholesterol-lowering effect, great support to kidney health and has potential as a remedy for heart born and important to healthy teeth and bones, giving better contribution to body's immune system, promoting brain health and heart health [6]. Ripening is the final stage of development of a fruit. Series of physiological and biochemical changes are occurred during ripening process. Ripening results numerous changes in quality characteristics like color, taste, aroma, texture. This natural process allows fruit to become more edible, sweeter and attractive to consumption [7]. Ripening agents hasten the ripening process. It can be natural or artificial. Ethylene is a natural ripening agent and its action is controlled by the responsible genes [8]. Artificial ripening can be mainly considered as a commercial strategy to cut down the detrimental losses in transportation. Ethephone, arificial ethylene, Ethylene glycol, Ethral and Calcium carbide are major commercially popular artificial ripening agents [9]. But Calcium carbide is prohibited to practice according to international rule of the prevention of Food Adulteration Rules [10]. Because Calcium carbide is extremely hazardous to human as it contains traces Arsenic and Phosphorus [11]. Not only that but also ethylene gas has bad effects for health [12] and artificial ripening techniques may have potential to quality degradation of fruits. Simply the quality is the degree of excellence or superiority. Fruit Quality may have two distinct aspects, quantitative and qualitative quality. Physico-chemical parameters including Vitamin C, Total Sugar, Total Titratable Acidity, Total Soluble Solids, Moisture content and Pulp and peel weights can be analyzed quantitatively. Qualitative evaluation can be practiced with five sensory attributes. Those are aroma, color, taste, texture and overall acceptability.

II. MATERIALS AND METHODS

The research was conducted at the Advanced Laboratory, Department of Botany, University of Ruhuna, Matara, Sri Lanka. The fruit quality of 'Embul' banana was analyzed from two separate experimental aspects after artificial ripening. Those aspects are quantitative quality analysis from physicochemical parameters and the qualitative quality analysis from sensory evaluation. Calcium carbide and Ethephon were used as the artificial ripening agents. Five bunches of banana were harvested at optimum stage of maturity from same field and immediately transported to the laboratory. Banana hands were separated from bunches and allowed to delatex. Debris and dust on selected banana hands were removed from washing and blotted from piece of cloth. Three banana hands were selected from one bunch of banana which were in the middle of the bunch. Thirty banana fruits were picked out from each bunch

of banana. Three samples were selected for the two treatments with Calciun carbide, Ethephon and the control sample which was facilitated for natural ripening. Each sample has nine replicates and they were packed in ventilated plastic baskets. 1 mL/L of Ethephon and 0.25mol/dm^3 of Calcium hydroxide mixture, 0.25gL^{-1} of Calcium carbide [13] were put in the containers. The initial physico-chemical and sensory analysis were analyzed at the beginning and the analysis were done periodically on 2^{nd}, 4^{th} and 6^{th} days during the ripening period for each three samples. pH value, Moisture of peel and pulp [14], Pulp/Peel ratio, Titratable acidity [14], Total Soluble Solids, Vitamin C content and Total sugar [15] were the determined physico-chemical parameters. Three samples were evaluated according to five attributes.

Five attributes were taste, aroma, color, texture and overall acceptability. The sensory evaluation was done by semi-trained panel of thirty judges.

Physico-chemical, nutritional quantitative experimental results were subjected to analysis of variance with 95% confidence level from SPSS17.0 software. Qualitative sensory quality results were subjected to Kruskal-wallis one way nonparametric test from Statistix 10.0 software.

III. RESULTS AND DISCUSSION

Table 1: Changes in Total sugar content during ripening

Treated Condition	Ripening Period/ Days		
	2	4	6
Total Sugar,%(2.03±0.02)			
Calcium carbide	6.58 ± 0.28^{a}	8.09 ± 0.10^{p}	13.59 ± 0.37^{w}
Ethephon	7.92 ± 0.25^{a}	14.14 ± 0.94^{q}	19.42 ± 0.48^{x}
Untreated	11.89 ± 0.90^{b}	20.68 ± 1.34^{r}	22.25 ± 0.88^{y}

Means with different superscripts (a,b,c) for analysis of 2^{nd} day, (p,q,r) for analysis 0f 4^{th} day and (w,x,y) for analysis of 6^{th} day. Different letters indicates significant difference ($p\leq0.05$). Initial values are given in parenthesis

The higher values of total sugar were observed on 6^{th} day of ripening period for all three samples. The highest total sugar value was recorded from untreated banana sample. Lower values were observed for Calcium carbide treated sample. The observed values of total sugar for Ethephon treated banana sample were in between the values of other two samples. Total sugar variation was in trend of increment during ripening period of all three samples [16].

Table 2: Changes in total titratable acidity during ripening

Treated Condition	Ripening Period/Days		
	2	4	6
Total Titratable Acidity,%(0.26±0.02)			
Calcium carbide	0.34 ± 0.01^{b}	0.58 ± 0.02^{q}	0.64 ± 0.02^{x}
Ethephon	0.32 ± 0.01^{b}	0.53 ± 0.02^{q}	0.52 ± 0.01^{w}
Untreated	0.28 ± 0.02^{a}	0.47 ± 0.02^{p}	0.68 ± 0.02^{x}

Means with different superscripts (a,b,c) for analysis of 2nd day, (p,q,r) for analysis 0f 4th day and (w,x,y) for analysis of 6th day. Different letters indicates significant difference ($p\leq0.05$). Initial values are given in parenthesis

Total titratable acidity was increased during ripening period for all three samples. On 4th day, the acid amount was very low in untreated sample with respect to other two. Calcium carbide treated banana sample had higher values on 4th and 6th days. However during ripening process, sweetness is increased & sourness is reduced.

Table 3: Changes in Vitamin C content during ripening

Treated Condition	Ripening period/Days		
	2	4	6
Vitamin C/mg per 100g (4.23±0.00)			
Calcium carbide	4.44 ± 0.21^{a}	6.62 ± 0.24^{q}	7.33 ± 0.24^{x}
Ethephon	5.08 ± 0.00^{b}	5.08 ± 0.00^{p}	5.78 ± 0.24^{w}
Untreated	5.36 ± 0.24^{b}	8.03 ± 0.42^{r}	7.96 ± 0.12^{y}

Means with different superscripts (a,b,c) for analysis of 2nd day, (p,q,r) for analysis 0f 4th day and (w,x,y) for analysis of 6th day. Different letters indicates significant difference ($p\leq0.05$). Initial values are given in parenthesis

Vitamin C is a crucial nutritious character of fruits. Vitamin C also had a trend of increment during ripening. The highest vitamin C amount of 8.03mg % was observed in untreated sample. But after that it was inclined. Ethephon treated sample had low level of vitamin C amount than calcium carbide treated and untreated samples. But the least vitamin C value was 4.44mg% detected from calcium carbide treated sample.

Table 4: Changes in Total soluble solids during ripening period

Treated Condition	Ripening Period/Days		
	2	4	6
Total Soluble Solids, ^{o}Brix (4.00±0.00)			
Calcium carbide	7.17 ± 0.29^{a}	9.50 ± 0.50^{p}	11.00 ± 0.00^{w}
Ethephon	9.50 ± 0.50^{b}	11.83 ± 0.29^{q}	15.50 ± 0.50^{x}
Untreated	13.00 ± 0.00^{c}	15.33 ± 0.58^{r}	18.67 ± 0.58^{y}

Means with different superscripts (a,b,c) for analysis of 2nd day, (p,q,r) for analysis 0f 4th day and (w,x,y) for analysis of 6th day. Different letters indicates significant difference ($p \leq 0.05$). Initial values are given in parenthesis

Highest Total soluble solid value was observed in untreated banana sample. The less brix values were recorded in calcium carbide treated sample. Brix values were increased during the ripening in all the three samples of banana. Ethephon treated sample had a trend of increment but is in between the values of other two samples.

Table 5: Changes in pH value during ripening period

Treated Condition	Ripening Period/Days		
	2	4	6
pH (5.70±0.00)			
Calcium carbide	4.82 ± 0.22^{a}	4.45 ± 0.08^{p}	4.95 ± 0.07^{w}
Ethephon	5.42 ± 0.07^{b}	5.32 ± 0.11^{q}	5.19 ± 0.13^{x}
Untreated	5.64 ± 0.13^{b}	5.22 ± 0.08^{q}	4.22 ± 0.13^{x}

Means with different superscripts (a,b,c) for analysis of 2nd day, (p,q,r) for analysis 0f 4th day and (w,x,y) for analysis of 6th day. Different letters indicates significant difference ($p \leq 0.05$). Initial values are given in parenthesis

Higher pH values were observed in both Ethephon treated and naturally ripened samples. There was a significant difference between calcium carbide treated sample and the other two samples with respect to the 0.05 level of significance.

Table 6: Changes in moisture content of pulp during ripening

Treated Conditions	Ripening Period		
	2	4	6
Moisture(%), pulp (64.00±0.00)			
Calcium carbide	62.93 ± 0.99^{a}	64.67 ± 0.42^{p}	64.60 ± 0.87^{w}
Ethephon	65.80 ± 0.72^{b}	66.07 ± 1.10^{pq}	66.27 ± 0.87^{w}
Untreated	67.00 ± 1.31^{b}	68.33 ± 1.70^{q}	69.40 ± 6.64^{w}

Means with different superscripts (a,b,c) for analysis of 2nd day, (p,q,r) for analysis 0f 4th day and (w,x,y) for analysis of 6th day. Different letters indicates significant difference ($p \leq 0.05$). Initial values are given in parenthesis

Table 7: Changes in Moisture content in peel during ripening

Treated Condition	Ripening Period/Days		
	2	4	6
Moisture(%), Peel (88.17±0.76)			
Calcium carbide	80.93 ± 3.21^{a}	80.67 ± 2.41^{p}	79.73 ± 3.33^{w}
Ethephon	84.80 ± 1.74^{ab}	82.13 ± 3.63^{p}	79.73 ± 1.89^{w}
Untreated	87.87 ± 0.61^{b}	84.67 ± 4.46^{p}	84.27 ± 0.61^{w}

Means with different superscripts (a,b,c) for analysis of 2nd day, (p,q,r) for analysis 0f 4th day and (w,x,y) for analysis of 6th day. Different letters indicates significant difference ($p \leq 0.05$). Initial values are given in parenthesis

The moisture contents of pulp in all samples were increased during the ripening. The least moisture content of 62.93% was observed for calcium carbide treated sample with a significant difference among others. But in that case had similar low values for moisture content for Ethephon treated sample too. The moisture content of peel had trend of decrement during the period of ripening. The situation around calcium carbide treated sample had considerable variation with Ethephon treated and naturally ripened samples for moisture content of pulp and peel. Ethephon showed just one significantly differences situation with calcium carbide treated banana.

Table 8: Changes in ^{0}Brix/ Total titratable acidity during ripening

Treated Condition	Ripening Period		
	2	4	6
^{0}Brix/Total Titratable Acidity (15.65±0.97)			
Calcium carbide	21.01 ± 0.83^{a}	16.45 ± 1.45^{p}	17.07 ± 0.40^{w}
Ethephon	29.49 ± 2.17^{b}	22.22 ± 0.91^{q}	30.00 ± 0.89^{y}
Untreated	46.08 ± 2.57^{c}	32.48 ± 1.64^{r}	27.46 ± 1.28^{x}

Means with different superscripts (a,b,c) for analysis of 2nd day, (p,q,r) for analysis 0f 4th day and (w,x,y) for analysis of 6th day. Different letters indicates significant difference ($p \leq 0.05$). Initial values are given in parenthesis

Three samples were shown significance different ($p \leq 0.05$) for ^{0}Brix/Titratable acidity. The highest ^{0}Brix/Ttratable acidity values were obtained for untreated sample and lowest values were observed Calcium carbide treated banana sample.

Table 9: Sensory score results

Treated Condition	Aroma	Color	Taste	Texture	Overall Acceptability
Calcium carbide	34.47^{b}	34.43^{b}	33.40^{b}	38.57^{b}	29.30^{c}
Ethephon	45.23^{ab}	43.23^{b}	47.90^{ab}	44.03^{ab}	45.97^{b}
Untreated	56.80^{a}	58.83^{a}	55.20^{a}	53.90^{a}	61.23^{a}

a,b,c superscripts are assigned separately for different quality attributes with separate analysis, Different letters indicates significant difference ($p \leq 0.05$),(n=30).

Sensory evaluation was conducted on 4th day of ripening period. Five different sensory attributes were evaluated separately. Overall acceptability can be considered as a summary of qualitative sensory evaluation. The analyzed results for all the attributes were in higher

preference level for naturally ripened sample and least scores were recorded for Calcium carbide treated sample with respect to 0.05% significant level. But Ethephon didn't have any significant difference with other two samples. So there was not any significant ($p \leq 0.05$) difference among artificially ripened samples whereas with naturally ripened sample.

IV. CONCLUSIONS

Artificially ripened banana had significantly low level of physico-chemical, nutritional quantitative quality than naturally ripened 'Embul' banana. Calcium carbide treated banana sample had comparatively low level of nutritious factors than Ethephon treated sample. The optimum quality aspects were fulfilled with respect to most of quality parameters in 4^{th} day of ripening period and that should be important for consumers.

According to the results of sensory evaluation, it can be concluded that the significantly excellent sensory quality was in naturally treated set of 'Embul' banana with relative to artificially ripened banana. The least quality was recorded for calcium carbide treated sample. The quality of Ethephon treated sample was in between the quality of naturally ripened banana and calcium carbide treated 'Embul' banana.

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