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Effect of Relative Humidity on the Ripening Behaviour and Quality of Ethylene Treated Banana Fruit

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ABSTRACT

This research was conducted to investigate the effect of different humidity levels in the ripening behavior and quality of ethylene treated and un-treated Banana fruits. The experiment was laid out according to Factorial Design with four replications. It was observed that low relative humidity accelerated the ripening of Banana fruit but when ripening was initiated with ethylene this factor was not dominant. Low humidity (60 - 65%) increased the water loss (6.95%), which reduced the quality of ripe fruit. Banana ripened at medium (80 - 85%) and high relative humidity (90 - 95%) showed the same quality but better than those at low humidity (60 - 65%). In order to attain the best quality ripe fruit banana fruits should be treated with ethylene and relative humidity during ripening must be 90 - 95%

Key Words: Humidity; Ripening; Ethylene; Banana

INTRODUCTION

The dessert Banana of international trade is botanically known as Musa *AAA*. It belongs to family correct the name of family Musaceae. Banana fruits have special place in human diets. They are chiefly eaten as dessert fruit, because in the ripe stage they are sweet and easily digestible (Robinson, 1996). They are useful for patients with peptic ulcers, for treatment of infant diarrhea (Koszles, 1995). They are low in fats, cholesterols and salts. They can make useful contribution in the human diet to make the vitamin A, C and B6 contents.

Humidity is an important environmental factor that influences the shelf life and quality of fresh fruits and vegetable in both long and short-term storage (Frith, 1991). Relative humidity is defined by sing and Heldman (1984) as the ration of the mole fraction of water vapor in a given moss of a moist air sample to the mole fraction in an air sample of the same mass when saturate at the same temperature and pressure.

Harvey (1978) claims that the control of relative humidity in the post harvest environment is relative humidity promotes fruit spoilage by after as important as the control of temperature.

Generally, there is an inverse relationship between the water loss by fruit and the relative humidity of the storage environment (Gac, 1956). Low relative humidity has been shown to increase the weight loss while high increasing diseases. There are conflicting observation in the effect of humidity on respiration, ethylene production and ripening of Banana fruits. Relative humidity can affect the occurrence of some physiological disorders and uniformity in ripening (Kader, 1985). This research was conducted to investigate the effect of different humidity levels in the ripening behavior and quality of ethylene treated and un-treated Banana fruits.

MATERIALS AND METHODS

This research was conducted in post harvest laboratory of Cranfield University at Silso College UK in 1999. Pre climacteric Cavendish Bananas were obtained from C.t. Wilkinson, Belford, UK.

The Bananas were cut into individual fingers and after treatment with thiabendazob fungicide; half of the Bananas were treated 1000-ppm ethylene for 24 h. Six fingers of ethylene treated Banana were then placed in each of three air tights plastic boxes with an air in let and out-let. The three levels of air at relative humidity (60 - 65%, 80 - 85% & 90 - 95%) were passed though the in-let into the Jars continuously. The 3 L glass Jar was connected to the in-let and out-let of each pump, to feed air into each box separately. For the first treatment the Jar was filled with silica gel to provide low (60 - 65%) humidity for second treatment the Jar was left empty to provide ambient air (80 - 85%) humidity, and for third treatment the Jar was filled with water to provide high (90 - 95%) humidity.

The experiment was conducted with four replications. Fruit were analyzed when they reached color score 6.

Assessment of fruit ripening. Ripening of banana fruit was assessed according to peel color change compared with a color chart as described by Stover and Simmond (1987).

Assessment of fruit quality. The quality of ripe fruit was assessed by the following two methods.

Objective methods. The peel color was measured by colorimeter (Minolta model CR - 200/ Cr - 2006). A

positive a values corresponding to the degree of red-ness, while a negative value corresponding to the degree of green ness. a* positive of values represents the degree of yellow ness and negative one represents the blue ness.

Peel firm-ness was measured using on instron universal tasting machine (model 2211) with an 8 mm cylindrical probe. Total soluble soils percentage was measured using refractometer. Starch percentage was measured by using the technique recommended by Blankenship *et al.* (1993).

Individual fruit was weighed using a digital balance (precise 60000 cumulative weight loss percentages was calculated as follows).

$$\text{Weight loss \%} = \frac{Wo - Wi}{Wo} \times 100$$

Where,

Wo = original weight

Wi = Weight at sampling (when Banana reached at color score 6)

Weight loss percentage per day was calculated as follows:

$$\text{Weight loss percentage per day} = \frac{TWP}{SC}$$

Where,

TWP = Total weight loss percentage at color stage 6

SC = Storage life (total days when Banana reached color store 6 from pre-climacteric stage)

Subjective Assessments (Sensory Evaluation). The fruits were removed from storage when they were at color score 6. Panel of eight assessors was selected from the college and the tests involved individual assessment in isolated testing condition under a standard light source.

The Judges were asked to assess pulp flavor, sweet-ness, and acceptance on life point's sale as follows:

1. Low
2. Moderate
3. Moderate high
4. Good/ high
5. Very good/ high

The scores marked by panelists were collected and an average was calculated for each parameter and sub parameter. There averages were used for statistical analysis. Means of treatments were calculated and persecuted in the formers of cables.

Statistical analysis. Data were processed and analysis of variance (ANOVA) was carried out based on completely randomized designs using MSTATC, a P.C based programming. LSD at P = 0.05 was used to test for significant difference of results where applicable.

RESULTS AND DISCUSSION

Storage Life (Speed of Ripening). The results regarding the effect of humidity and ethylene are given in (Table I & II). Statistical analysis showed significant different for ethylene treatment and humidity levels at the P = 0.001 level. Statistical analysis showed significant differences

Table I. Effect of relative humidity on the storage life and other quality parameters

Quality parameter	Relative humidity				
	Low-70 - 75%	Medium 80 - 85%	High 90 - 95%	LSD 0.05)	(P. C.V
Storage life (days)	9.3	10.5	11.3	0.99	9.11
Weight less %	6.95	2.08	1.13	0.48	14.2%
Weight less % per day	0.71	0.22	0.12	0.083	6.6%
a values (green ness)	-2.56	-2.70	-2.85	NS	14.7%
b values (yellowness)	+49.41	+48.80	+47.32	NS	5.5%
Peel firmness (Nmmt)	2.7	2.3	3.6	0.32	9.7%
TSS %	22.0	22.1	22.2	NS	4.0%
Starch %	18	18	18	NS	12.0%
Flavour	2.1	3.0	3.0	0.47	17.0%
Sweetness	2.3	2.9	2.8	0.46	18.5%
Acceptability	1.9	2.8	3.0	0.65	24.5%

Note: Flavour, Sweetness, Acceptability 5 = maximum Score 1 = minimum score.

Table II. Effect of ethylene on the storage life and other quality parameters

Quality parameter	Ethylene			
	0 PPM	100 PPm	LSD (P. 0.05)	C.V
Storage life (days)	14.8	5.8	0.80	9.1
Weight less %	4.4	2.43	0.39	14.2%
Weight less % per day	0.30	0.40	0.027	6.6%
a values (green ness)	-3.46	-1.92	0.33	14.7%
b values (yellowness)	+47.74	+49.28	NS	5.5%
Peel firmness (Nmmt)	3.7	2.7	0.26	9.7%
TSS %	21.7	22.5	0.74	4.0%
Starch %	2.0	1.6	1.8	12.0%
Flavour	1.8	3.6	0.39	17.0%
Sweetness	2.0	3.2	0.37	18.5%
Acceptability	1.9	3.2	0.53	24.5%

for interaction between ethylene treatment and humidity levels at the P = 0.01 level (Table III). Ethylene treated bananas ripened earlier than un-treated bananas. Ethylene treated bananas at different humidity levels ripened at the same time. However, relative humidity had a significant effect on the ripening of bananas, which were not treated with ethylene. Bananas kept at low relative humidity level ripened earlier than those at medium and high humidity levels. Bananas kept at medium and high humidity levels ripened at the same time in statistical terms. There was an interaction between ethylene treatment and humidity levels. The difference in ripening periods of ethylene treated and un-treated bananas was less at the low relative humidity level (7.5 days) but greater at medium and high humidity levels (9.0 - 10.5 days).

Fruits exposed to different levels of relative humidity showed different responses for ripening in ethylene treated and non-treated bananas. The acceleration of ripening at lower humidity levels for un-treated bananas could be related to a higher respiration rate and ethylene production rate at lower humidity levels as perversely reported by George *et al.* (1982) and Burdon *et al.* (1995). In contrast, no statistically variability of ethylene treated bananas at different humidity levels indicated that the respiration and ethylene production were already increased in these bananas

Table III. Interaction between Ethylene and Humidly

Quality parameter	OPPM			100PPM			LSD
	Low	Medium	High	Low	Medium	High	(P=0.05)
Storage life (days)	13.00	15.00	16.5	5.5	6.0	6.0	1.40
Weight less %	8.66	2.55	1.21	4.63	1.61	1.06	0.69
Weight less %Per day	0.66	0.17	0.07	0.77	0.26	0.17	NS
a values (green ness)	-3.29	-3.29	-3.47	-3.63	-1.83	-1.93	NS
b values (yellowness)	48.30	47.88	47.05	50.88	49.72	47.6	NS
Peel firmness (Nmmt)	3.2	3.7	4.1	2.2	3.0	3.0	NS
TSS%	21.6	21.7	21.7	22.3	22.5	22.8	NS
Starch%	20	21	21	15	16	16	NS
Flavour	1.5	2.0	2.0	2.8	4.0	4.0	NS
Sweetness	1.8	2.2	2.0	2.8	3.5	3.3	NS
Acceptability	1.3	2.0	2.5	2.5	3.5	3.5	NS

due to the ethylene treatment so humidity levels could not reduce or increase the influence of ethylene. Thus bananas completed their ripening process in normal time. It can be concluded that low relative humidity (water stress) has the effect of accelerating the ripening processes but this effect could not dominant where ripening was initiated with ethylene. The interaction of ethylene with humidity showed that ethylene had a greater effect at higher humidity levels than at lower humidity levels. The reason for this could be water stress because water stress accelerates ethylene synthesis of fruit (Ben-Yehoshua, 1987). It is because the weight loss % was greater at Due to ethylene synthesis ripening might be initiated faster in un-treated bananas at low humidity levels (65 - 70%) than those, which were kept at higher humidity levels without ethylene treatment. Therefore the difference in ripening period was less in ethylene treated and un-treated bananas at low humidity levels, and was greater at higher humidity levels.

Weight loss %. Ethylene treated bananas at colour stage 6 showed less total weight loss than un-treated bananas (Table I). Weight loss was also reduced for bananas, which were ripened at higher relative humidity levels compared to those, ripened at lower relative humidity levels. The interaction between ethylene and humidity showed that the difference in weight losses between ethylene treated and non-treated bananas was greater at the low humidity level than at the medium and high humidity levels. Ethylene treated bananas showed more weight loss per day than un-treated bananas (Table I). Bananas ripened at lower relative humidity levels showed significantly less weight loss per day than those at higher relative humidity levels.

The weight loss during ripening is an important factor, which adversely affects the appearance, flavour and weight of fruit. The grater weight loss per day at ethylene treatment and at lower humidity levels could be due to the grater respiration and transpiration as previously reported by Burdon *et al.* (1994), who found that respiration of the fruits kept at low humidity was higher than those at high humidity. The interaction of ethylene and humidity showed that un-treated bananas low humidity level lost more weight than ethylene treated bananas due to their longer storage life. Therefore, the difference in weight losses between un-treated and treated bananas was greater at low humidity level.

Peel colour. Analyses of variance showed significant differences at the P = 0.001 level of a * (green-ness) and no significant differences for b * values (yellow-ness) (Table I). Bananas ripened with ethylene treatment were significantly less green than un-treated bananas (Table II). Humidity levels did not show any significant effect on the green-ness values but there was an indication that bananas ripened at higher humidity levels were slightly greener than those, which were ripened at lower humidity levels.

In terms of peel colour development it is clear ethylene effects were more dominants than the effects of humidity level in chlorophyll degradation. However, the results relating to yellow-ness (b*) values did not prove the significant superiority of ethylene treatment over humidity levels. Relative humidity also did not show any significant effect on the green-ness values. This effect has previously been observed that water stress stimulated ethylene production and respiration during the pre-climacteric stage but did not affect the pattern of chlorophyll degradation.

Peel firm-ness. Statistical Analyses showed significant differences for ethylene and humidity at the P = 0.001 level (Table I & II). The interaction between ethylene and humidity showed non-significant results (Table III). Ethylene treated bananas, were softer than un-treated bananas. Bananas kept at higher humidity levels showed greater peel firm-ness values than those at lower humidity levels. Bananas ripened at low humidity (65 - 70%) were softer than those at medium and high humidity (80–85% & 90 - 95%). No significant difference was found between bananas, which were ripened at medium, and high humidity levels.

Ethylene accelerates ripening and starch is converted into sugar during ripening. The similar total soluble solids in bananas at all humidity levels indicated that water stress or water saturation did not affect the process of hydrolysis of starch. This factor has also been reported by Thomson *et al.* (1974). They found that fruits stored al all three humidity levels had similar total soluble solids.

Total soluble solids (T.S.S %). Statistical analysis showed significant difference for ethylene treatment at the P = 0.05 level (Table II). Humidity and interaction of ethylene and

humidity showed non-significant results (Table I & III). Ethylene treated bananas showed a greater percentage of total soluble solids than un-treated bananas. (Table II) There was no significant difference in bananas, which were ripened at the different humidity levels.

Starch percentage. Bananas ripened at different humidity levels showed the same percentage of starch in statistical terms (Table I). Significantly greater starch percentage was recorded in non-treated bananas than in ethylene treated bananas (Table II). There was no interaction between ethylene and humidity levels (Table III).

Sensory evaluation. Bananas ripened at low humidity level showed significantly less flavour than those ripened at medium and high humidity levels (Table I). Bananas ripened at medium and high relative humidity received the same scores for flavour by panelists. Ethylene treated bananas showed better flavour than un-treated bananas (Table II).

Panelists gave maximum scores for sweet-ness to the ethylene treated bananas (Table II). Bananas ripened at medium and high relative humidity levels were sweeter than those ripened at low humidity level (Table I). The interaction between ethylene and humidity showed non-significant results for sweet-ness (Table III). Bananas ripened at medium and high relative humidity received a minimum score for their acceptability.

This greater weight loss showed adverse effects on the eating quality measured by sensory evaluations. The sensory evaluations showed the superiority of ethylene treated bananas over un-treated ones. Bananas ripened at medium and high relative humidity had the same flavour but both were better than those at low humidity probably due to the reduced weight loss. The volatile compounds that give the characteristic flavour of fruit might be not fully developed due to the grater weight loss. This factor was also reported by Ben-Yehoshua (1987), who started that moisture loss affected the flavour of fruit and reduced the activities of different enzymes. The good flavour and sweet-ness in ethylene treated bananas might be due to the increased formation of volatile compounds and grater starch sugar conversion. Panhellists preferred the fruits, which were ripened at medium and high relative humidity. In previous research (Rahman, 1995) it was also mentioned that low humidity causes decline in quality of ripe fruit but he did not mentioned precise reason for this. In contrast, Carvalho *et al*. (1988) reported that the high humidity had no effect on fruit internal quality. It can be concluded from the present research that panelists preferred the quality of bananas, which were ripened at medium and high relative humidity due to their lower weight loss. This is because excess weight loss gives shriveled, blackened appearance at colour stage 6 to the fruits (Thompson *et al*., 1974). The greater weight loss in bananas ripened at low humidity as their lower acceptability by panelists confirmed this.

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