Annals Agric. Sci., Ain Shams Univ., Cairo, 50(2), 541-550, 2005

BANANA RIPENING THROUGH ETHYLENE PRODUCTION BY NATURAL SOURCES

[36]

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ABSTRACT

Three activated essential oils of orange, lemon, and garlic in a diluted concentration, 0.05%, were used to stimulate ripening. Five immature banana hands were dipped for 60 minutes in each of the above mentioned solutions (in addition to the control treatment which was dipped in a tap water and left in ambient conditions for 10 days. The treatments were repeated twice every year in both seasons of 2001 and 2002. By the end of 10 days banana treated by all of the stated essential oils reached an acceptable stage of ripening (5.66 and 6.00) when evaluated by Del monte chart, compared to control banana whose ripening stopped at a stage between 2.00 and 2.33. Bananas treated by these essential oils were normally ripened at the end of stay, having high TSS percentage (18.16-22.3 %), compared to control (9-10.33 %), and with acceptable pulp firmness values (from 2.37 to 3.33 lb/in2). In the meantime oils treated bananas lost more of their green color as shown by "a" value measurements, These treated banana had a good or excellent organoleptic note if compared with the control fruits which were unacceptable. It is recommended to use this safe and cheap method to ripen banana and other fruits.

Keywords: Banana, Essential oils, Ethylene

INTRODUCTION

Ethylene (C_2H_4) is a natural product of plant metabolism. It regulates many aspects of plant growth, development and senescence. Ethylene production rates by fruit tissues increased with fruit maturity at harvest and with incidence of physical injuries, diseases incidence - - etc.

Exposure of climacteric fruits to ethylene advanced the onset of an irreversible rise in respiration rate and rapid ripening (**Lincoln and Zeiger, 2002**). Ethylene is used generally in exogenous applications to hasten and hormonize ripening of some important fruits. This is especially the case for banana ripening (100 – 500 ppm), apple and pear complementary ripening, persimmons, sweetening (50 ppm) and for other commodities also (**Hudson *et al* 1988**)

Ethylene gas applications may be carried out through injection from cylinder of compressed gas, into airtight rooms

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(Received June 25, 2005)
(Accepted August 6, 2005)

containing the fruits (bananas in particular) and for a certain time (usually 24 hours). Ethylene may be applied also through releasing liquid agents like ethryl (**Kader *et al* 1985**). This application may be done for example on apple trees one month before harvest to enhance fruit color and sugars formation.

There are some patents concerning small ethylene generators, which use thermal ethanol decomposition to produce ethylene in the presence of some catalysts. There's a real risk concerning the use of ethylene cylinders, as ethylene explodes when it accumulates and constitutes 3% of the enclosed air volume causing serious and lethal danger, (**Seymour *et al* 1993**).

Using safe, cheap and biological or natural substances to generate ethylene either externally or internally for stimulating its synthesis in plants, may help users to avoid disadvantages of recoursing to Ethylene gas cylinders or other expensive patents.

Essential aromatic oils have many useful properties especially as antisceptic agents (**Mishra and Dubey, 1994**), They also may be considered as a natural and safe source to generate ethylene as they've some volatile compounds and monoterpenes with double bond ends like linalool, Geraniol, campene, pinene and limonene which may be decomposed to generate ethylene when these oils are made more reactive and treated properly (**Librando *et al* 2003**).

This research aims to investigate the possibility of using natural essential oils extracted from plants as orange, lemons, and garlic oils in inducing ethylene synthesis and enhancing fruit ripening, especially banana.

MATERIAL AND METHODS

Pure essential oils of orange, lemon, and garlic were purchased from Camena Company (Cairo). After dissolving oils in alcohol, an aqueous solution of each oil was prepared as follows:
2.5 ml. of each of the following essential oils dissolved in about 2ml. of alcohol before being poured in a container having 5 liters of water (constituting a solution of a concentration of 0.05%) and mixed with a tempering pH agent used to accelerate decomposition of these volatile oils, so as the final PH of each oil solution was as follows:-

- PH of orange oil solution → 2.39
- PH of lemon oil solution → 2.51
- PH of garlic oil solution → 2.85

- Banana ripening treatments

Banana hands of magrabi variety (green immature ¾) were purchased from El-Kanater El-Khairia farms, during the years 2001, and 2002.

Each treatment consists of 5 banana hands which subjected to dipping for 60 minutes in each of the following above mentioned oil solutions (orange oil, lemon oil and garlic oil solutions). In addition to the control treatment of dipping in a tap water.

Banana hands were dried, afterwards, and stored in ambient conditions at 20 – 25°C and R.H of about 30% for 10 days. These treatments were repeated twice in every season. The following quality criteria, were evaluated after 5 days and by the end of stay in the ambient conditions (after 10 days):

1. **Ripening degree was estimated at each date according to Delmont scale**

- 1- Full deep green.
- 2- Inception of light green.
- 3- Yellowish green.
- 4- Greenish Yellow.
- 5- Mostly yellow.
- 6- Yellow.
- 7- Yellow with brown spots.

2- Fruit pulp Firmness

Using a fruit pressure tester, mod. FT 327 (3.27 lbs).

3- Peel color

Measured by Hunter colorimeter using "a*" value as a basis for comparison of peel color change.

4- Total soluble solids

Percentage of T.S.S. of the pulp value was evaluated by a digital refractometer "Leica".

5- Acidity of the pulp

It was evaluated by a titration with a Na OH 0.1 Normal solution, (**A.O.A.C. 1985**).

6- Sanitary state and extent of fungal infection

According to this scale: - excellent (10 - 7.6), good (7.5 - 5.5), fairly acceptable (5.4 – 4), poor (high and perceptible decay (>4).

7- Organoleptic note

Taste of pulp was evaluated by a 3-persons panel, and according to 4 grades: - Excellent (10 – 7.6), good (7.5 – 5.5), fairly acceptable (5.4 – 4), and unacceptable (>4).

Ethylene measurement

In the second season only, ethylene emission of the above mentioned essential oil was measured as follows: -

Five ml of each oil (orange, lemon, garlic) were prepared as mentioned before, but dissolved in a 10 ml. only of water and prepared to have the pH values mentioned above, then the container was placed in a closed box, of 0.2 m^3 in volume. Ethylene was measured after 5, 15, 75 minutes and after 24 hours inside the closed box atmosphere. A portable Spanish instrument for ethylene estimation of the model "Bioconservacion" was used to evaluate ethylene concentration.
(For some technical reasons, measurements of ethylene emission from garlic oil were uncomplete).

RESULTS AND DISCUSSION

1- Progress in ripening: (as evaluated by Del Monte color chart)

After 10 days in ambient conditions , it is clear from Table (1), that all the three oil treated bananas achieved a noticeable progress in ripening ,but lemon and orange oil treatments enhanced ripening in both seasons (banana reached a grade of 5.66 or higher), but garlic oil effect was much slower in the first season (4^{th} grade). All the treated bananas were superior to control, which advanced very slowly in maturity to reach only grade 2

Table 1. Progress of ripening stage according to Delmonte chart

Shelf life	After 5 days		After 10 days	
Treatments	1st year	2nd year	1st year	2nd year
Lemon oil	3.33	3.66	6.00	5.66
Orange oil	3.33	4.33	5.33	6.00
Garlic oil	2.33	2.66	4.00	5.66
Control	1.33	1.33	2.33	2.00
Average	2.58	2.99	4.41	4.83
L.S.D. at 5%	0.9989	1.200	0.8800	0.8800

(1st year) and grade 2, 33 in the second year. This indicates a clear stimulation of ripening by all three used essential oils and these results agree with **Watada, (1986).**

2- Sanitary state and fungal infection (like crown rots and anthracnose infections)

As shown in Table (2), after 5 days all treated bananas and control were in good conditions. But with progress in shelf life, after 10 days, garlic oil treated bananas showed little signs of black spot, to be granted a lesser note (6.6 and 5.6 in 1st and 2nd year respectively). These signs may be explained by a certain sensitivity of banana peel to the predominant sulfur compounds in garlic oil especially with advance in ripening. Both orange and lemon oil treated bananas were normally evoluted after 10 days without perceptible signs of decay.

3- Banana pulp firmness

It is clear from Table, (3) that firmness decreased, in a sensible way after treatment by activated essential oils, compared to control treatment, and that in a general accordance with the results of ethylene treated banana by traditional methods **(Kader, 1994).** Control banana didn't ripen normally and kept a high firmness value (12.3 and 12.3 lb/in2 in 1st and 2nd year respectively) owing to a very slow rate of ripening and the high starch content coupled with a great moisture loss. Garlic oil treated bananas had the lowest firmness value by the end of 10 days in both 1st and 2nd season (2.4 and 2.2 lb/in2) compared to both lemon and orange oil treated bananas, which had little firmness values but with no significant differences, (a range of notes 3-3.6). It is evident that ripening operations were well under way and caused disintegration of cellulose and other big molecules by active enzymes such as hydrolases , cellulases and pectinases **(Kays, 1991).**

4- Total soluble solids percentage in banana pulp

From Table (4), it can be concluded that activated essential oils triggered ripening operations in banana, and TSS

Table 2. Sanitary state – Fungal infection

Shelf life	After 5 days		After 10 days	
Treatments	1st year	2nd year	1st year	2nd year
Lemon oil	8.00	7.33	7.33	7.66
Orange oil	8.00	8.00	7.00	7.66
Garlic oil	6.66	6.66	6.66	5.66
Control	6.00	6.00	4.33	3.66
Average	7.16	6.99	6.33	6.16
L.S.D. at 5%	1.153	1.105	1.970	3.052

Table 3. Fruit pulp Firmness (lb/in2)

Shelf life	After 5 days				After 10 days	
Treatments	At start	1st year	At start	2nd year	1st year	2nd year
Lemon oil	19 ± 1	12.33	18± 0.6	13.00	3.33	3.60
Orange oil		9.60		9.80	3.16	3.00
Garlic oil		13.33		12.67	2.37	2.16
Control		15.00		15.33	12.33	12.16
Average		12.56		12.70	5.30	5.23
L.S.D. at 5%		1.091		0.9788	0.9371	1.185

Table 4. Fruit pulp T.S.S. (%)

Shelf life	After 5 days				After 10 days	
Treatments	At start	1st year	At start	2nd year	1st year	2nd year
Lemon oil	3.5±0.2	14.56	4 ± 0.1	19.63	19.26	22.33
Orange oil		14.33		18.66	18.40	18.16
Garlic oil		15.16		13.23	17.33	16.00
Control		3.90		4.60	9.00	10.33
Average		11.95		14.01	16.00	16.70
L.S.D. at 5%		1.424		1.410	2.01	1.77

increased significantly after 5 and 10 days compared to control fruits. Lemon and orange oils caused a pronounced increase in soluble solids by comparison to garlic oil treated fruits (19.26 and 22.33 % 1st and 2nd year for lemon oil treatment and 18.4% in 1st and 18.16% in 2nd year for orange oil treated fruit) ,while control fruits total soluble solids were lagging behind at values of 9% and 10.3% in 1st and 2nd year).These results indicate a clear ripening enhancement effect of essential oil and are in agreement with those mentioned by **Wasef and Khalil (1990).**

5- Color Peel of banana

Bananas were at a deep green color at start of the experiment as expressed by Hunter colorimeter "a" value, with an average of (-13.3), (Table, 5). Treated bananas lost their green color more quicker than the control , especially garlic oil treated fruits after 5 days, recording (-3.4 and –2.9 at 1st and 2nd year compared to control with –8.66 in 1st year and –8.33 in 2nd year) orange and lemon oil treated fruits lost green color in a less noticeable way. After 10 days, garlic treated bananas lost more greenness coloration than other treatments especially in the 2nd year with a value of 5.9 followed by orange oil treated fruits (3.9) whereas lemon oil came at last with (-1.1) but before the control fruits. Control fruits had the slowest rate of greenness loss, even after 10 days. Complete loss of green color or chlorophyll disintegration is a complex ripening operation and to be fully achieved it needs a special thermal treatment, but in this case fruits were simply kept in ambient conditions, and there was a clear ripening stimulating effect of the used essential oils.

6- Acidity percentage

All treated fruits lost acidity in a regular way (Table, 6). Lemon oil treated fruits after 10 days, had a slightly higher acidity (0.3%), in the second year, recording a significant difference if compared with orange oil or garlic oil treated fruits (0.21% and 0.23%), but control fruits had a very slow ripening evolution and by consequence they had the highest acidity values by the end of period in the first and second year (0.56% and 0.4%). These results confirm the ripening stimulating action of the used essential oils, and in agreement with **(Kader, 1994).**

7- Organoleptic note

After five days, (Table, 7), Lemon oil treated fruits had a hardly acceptable note (5), compared to orange oil and garlic oil treated bananas which had a superior note and had an acceptable taste (with notes of 6.66-7.5). After 10 days, all treated bananas had a more advanced ripening rate and acquired a better taste (values ranged from 7.5 to 8) compared to control fruits which were still unripened yet and had unacceptable taste due to their low content of TSS% and high acidity% and higher firmness, and this indicates the importance of an ethylenic treatment to ripen bananas from one hand, and that treating with activated essential oils had succeeded in triggering ripening phenomena in the treated bananas.

8- Ethylene emission

As seen in Table (8), all the tested essential oils produced noticeable quantities of ethylene all over a 24 hours period in the previously stated enclosed space of

Table 5. Fruit pulp Acidity (%)

Shelf life	After 5 days				After 10 days		
Treatments	At start	1st year	At start	2nd year	At start	1st year	2nd year
Lemon oil	0.46 ± 0.05	0.35	0.4 ± 0.03	0.30	0.43	0.20	0.30
Orange oil		0.32		0.28	0.43	0.23	0.21
Garlic oil		0.23		0.20	0.43	0.20	0.23
Control		0.50		0.43	0.43	0.56	0.40
Average		0.35		0.30	0.43	0.29	0.28
L.S.D. at 5%		0.06318		0.08935		0.06318	0.01998

Table 6. Color peel (a* value)

Shelf life	After 5 days				After 10 days	
Treatments	At start	1st year	At start	2nd year	1st year	2nd year
Lemon oil	-13.33 ± 0.05	- 6.10	-13.33 ± 0.05	- 5.33	- 1.06	- 1.10
Orange oil		- 3.50		- 4.63	1.80	3.90
Garlic oil		- 3.40		- 2.90	1.50	5.90
Control		- 8.66		- 8.33	- 2.63	- 2.36
Average		- 5.41		- 5.29	-0.60	2.84
L.S.D. at 5%		3.689		3.895	2.930	3.386

Table 7. Organoleptic note

Shelf life	After 5 days		After 10 days	
Treatments	1st year	2nd year	1st year	2nd year
Lemon oil	5.00	5.00	7.50	7.50
Orange oil	7.50	6.66	8.00	8.00
Garlic oil	6.66	7.50	7.50	8.00
Control	2.00	2.33	2.83	2.66
Average	5.29	5.37	6.45	6.54
L.S.D. at 5%	1.442	2.104	0.9561	1.322

Table 8. Ethylene emission in p.p.m of the enclosed space (0.2 m^3)

2nd year					
Period Ethylene emission	5 min.	15 min.	75 min.	24 hours	Average
Orange oil	18.46 ± 0.05	53.53 ± 0.25	150.33 ± 0.57	175.66 ± 1.15	99.49
Lemon oil	4.00 ± 0.00	52.66 ± 2.51	106.66 ± 2.88	131.66 ± 1.52	73.74
Garlic oil	4.66 ± 0.57	-	184.33 ± 3.21	-	

Note: - For technical reasons ethylene measurement for garlic treatments were not complete

0.2 m3 in volume. Ethylene gas synthesis attained a high value of more than 100 p.p.m for all investigated oils after 75 minutes, and progressed slowly after 24 hours. Garlic oil resulted in the highest ethylene emission after 75 minutes (183 p.p.m) followed by orange oil (150 pp.m) and finally lemon oil (106.6). One of the possible explanation of these oils,is the ability to synthesize ethylene based on their unstable composition (**Guenther, 1948**) and hence the high possibility of the occurrence of a breaking action at their double bond ends of their constituting molecules when treated properly (by a change of pH or of temperature per example) .The obtained results constitute a clear evidence of this synthesis and may explain clearly the ripening function of these essential oils.

Conclusion

Diluted solutions (0.05% by concentration) of each of the essential oils of orange ,lemon, and garlic were effective in inducing ripening in banana fruits, which was reached by the end of 10 days, with good and acceptable levels of eating quality as pulp sugars and organoleptic note, and this was confirmed by their ability to synthesize ethylene. The use of these natural source of ethylene is highly recommended to stimulate ripening in banana and other fruits, especially as an environmentally safe method.

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مجلة حوليات العلوم الزراعية ، كلية الزراعة ، جامعة عين شمس ، القاهرة ، م٥٠ ، ع(٢)، ٥٤١ -٥٥٠ ، ٢٠٠٥

انضاج ثمار الموز من خلال انتاج غاز الإثيلين بطرق طبيعية

[٣٦]

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استخدمت ثلاثة زيوت عطرية منشطة (برتقال - وليمون - وثوم) بتركيزات منخفضة(٠,٠٥٪) لتشجيع النضج . تم غمس كفوف من ثمار الموز لمدة ٦٠ دقيقة في كل محلول زيت عطري من الزيوت الثلاثة المذكورة علاوة علي معاملة المقارنة (الغمس فى ماء الصنبور) . وتركت الثمار في الجو العادي لمدة ١٠ أيام فى درجة حرارة (٢٠ - ٢٥ درجة مئوية) ورطوبة نسبية (٣٠%).

وأجرى ذلك مرتين في كل من عامي ٢٠٠١ ، ٢٠٠٢ وقد وجد ان الثمار المعاملة بالزيوت قد وصلت الي طور نضج مقبول للاستهلاك (٥,٦-٦) حسب الاطوار المبينة في الرسم البياني لشركة ديل مونتي.

بينما توقف موز المقارنة عند طور ٢,٣ -٠٢,- فى حين نضجت ثمار المعاملة بالزيوت بشكل طبيعي واحتوت علي مواد صلبة ذائبة كلية ١٦ إلى ٢٢,٣٪ بينما موز المقارنة يحتوي علي ٩٪ - ١٠,٣٪ من هذه المواد ووصلت صلابه ثمار الموز المعاملة الي حد مناسب للاستهلاك (٢,٣٧ - ٣,٣٣ رطل/بوصة مربعة) وفقدت ثمار الموز المعاملة بالزيوت اللون الاخضر بطريقة اسرع وأشمل بناء علي قيم A بجهاز هانتر لقياس شدة الألوان وكانت درجة الطعم لهذه الثمار المعاملة جيدة أو ممتازة بينما ثمار المقارنة كانت غير مقبولة. ومن ثم يوصي بأستخدام هذه الطريقة الامنة بيئيا والرخيصة لانضاج الموز وثمار الفاكهة الاخرى.

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