Table I

Effect of dietary biotin on the development, fecundity and fertility of T. granarium

Per cent conc.	No. of larvae treated	No. of adults emerged	No. of days for adult emergence		Sex treated	No. of pairs mated	Total no. of eggs laid	Eggs laid/ female	Total no. of eggs hatched	Per cent hatch
			Average	Range						
0·05	240	187	37·9	29–45	Male	34	332	9·8	238	71·7
					Female	29	275	9·5	99	36·0
					Both	55	396	7·2	149	37·6
0·10	240	162	40·3	30–53	Male	35	397	11·3	262	66·0
					Female	15	70	4·7	14	20·0
					Both	40	245	6·1	54	22·0
0·25	240	59	44·9	31–54	Male	18	314	17·4	169	53·8
					Female	..	..	..	..	..
					Both	11	57	5·2	4	7·0
Control (NaOH)	100	78	33·8	28–43	None	17	87	5·1	66	75·9
Control (Normal diet)	100	96	26·8*	22–32*	None	20	309	15·5	220	71·2

* Agarwal, 1970.

consequently did not hatch. At a biotin level of 0·05%, the sterility was about 62%. This increased to 93% at 0·25% biotin treatment. In the controls, more than 70% of the eggs hatched. This reduced fertility was due to an effect on the female only as can be seen in Table I. The per cent hatch of eggs in crosses between normal females and treated males were almost same as the controls. However, in the reciprocal crosses, the percentage of eggs hatching was identical to the crosses where both the males and females were treated. These results are in conformity with the ones reported so far[2-5] and it appears that induction of sterility may be a general effect of an overdose of biotin in insects. It will be of interest to know the physiological mechanisms involved in such a specific effect on the females.

The authors wish to thank Prof. B. R. Seshachar, Head of the Department of Zoology, University of Delhi, for facilities.

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COMPARATIVE STUDIES ON THE DIFFERENT METHODS OF ARTIFICIAL RIPENING OF BANANA FRUITS

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Introduction

BANANA fruits do not normally attain the ripening stage on the trees and so they are gathered to be ripened artificially. Various chemicals like ethylene, acetylene, coal gas and some growth-regulating substances are usually employed for artificial ripening of fleshy fruits. Banana fruits do not respond to ethylene treatment if they were previously treated with 2, 4-D.[7] The pulp/peel ratio of banana fruits treated with 2, 4-D and 2, 4, 5-T increased gradually until the ripeness condition is attained.[1-3] According to Abd-El-Wahab *et al.*,[1] the total soluble solids increased steadily during the artificial ripening of banana fruits treated with 2, 4-D and the increase began earlier in the treated than in the untreated fruits. The titrable acidity increased when the fruits reached the ripeness condition.[1,2] Kidd and West,[6] Gane,[4] Wardlow and Leonard,[9] working on the respiration of banana fruits, found that the low steady values of carbon dioxide production in the green stage raised sharply to a peak as, or just before, the

first visible signs of ripening appeared, and then declined to a steady level, slightly higher than that found in the green fruits. The sharp rise in respiration rate attained a climacteric peak 2-5 times as great as the previous one.

The purpose of this work is to study the effect of various chemical substances, which are in common use at present, on the quality of banana fruits during the artificial ripening process.

Materials and Methods

Mature branches of "Hindi" banana fruits (*Musa cavendishii* var. *cavendish*) gathered from the plants grown in Barrage were used in the present investigation. A set of three bunches was used for each treatment adopting the following procedure :

(1) In the case of control group, the bunches were dipped for 30 seconds in water.

(2) For treatment with 2, 4-D, the fruits were dipped for 30 seconds in an aqueous solution of this substance at a concentration of 1,000 ppm.

(3) For treatment with acetylene, the bunches were held for three days in a room with acetylene at the rate of 60 cc/cubic meter ; the temperature was kept constant at 60-65° F.

(4) In the case of treatment with coal gas, the fruits were held for three days in a room with coal gas at the rate of one kg. of burning coal per 16 cubic meters of space. The temperature during treatment was also kept constant at 60-65° F.

Following all treatments, the fruits were kept in a room with a temperature ranging from 70-75° F.

Determination of some physical properties of the fruits such as color development, peeling and pulp/peel ratio as well as the chemical properties, such as total soluble solids, titrable acidity and respirational activity, was carried out at three-day interval.

Results and Discussion

1. *Color Development.*—The visual color of banana fruits was estimated according to the color chart of von Loesechke.[8] The data in Table I show a gradual increase in the color development of banana fruits as they approached the ripening condition. This was true in both treated and untreated fruits. The rate of color development was more rapid in fruits treated with 2, 4-D, acetylene and coal gas than in the untreated ones. The fruits treated with 2, 4-D, acetylene or coal gas attained the yellow color (grade 3) after 9, 6 and 9 days respectively, as compared to 21 days in the untreated fruits. Although the 2, 4-D, acetylene or coal gas treatments has a similar trend in inducing the attractive color, the fruits treated with 2, 4-D have a longer marketing time than those treated with either acetylene or coal gas. The fruits treated with 2, 4-D, acetylene or coal gas attained the maximum color (grade 7), 18, 12 and 12 days after treatment respectively as compared to 30 days in the untreated fruits. These results are in agreement with those reported by Abd-El-Wahab and Abou Aziz.[1,2]

Table I

Effect of some chemical treatments on color development during the artificial ripening of banana fruits

Period of ripening (in days)	Grade No. after treatments			
	Control	2, 4-D	Acetylene	Coal gas
0	1	1	1	1
3	2	2	2	2
6	2	2	3	2
9	2	3	4	3
12	2	3	7	7
15	2	4		
18	2	7		
21	3			
24	3			
27	4			
30	7			

2. *Peeling Condition.*—The peeling of banana fruits is a good criterion for evaluating ripening. Data presented in Table II show that

Table II

Effect of some chemical treatments on the peeling condition during the artificial ripening of banana fruits

Period of ripening (in days)	Treatments			
	Control	2, 4-D	Acetylene	Coal gas
0	Unpeeling	Unpeeling	Unpeeling	Unpeeling
3	,,	,,	Hard peeling	Hard peeling
6	,,	Hard peeling	Peeling	Peeling
9	,,	Peeling	Easily peeling	,,
12	,,	,,	,,	Easily peeling
15	Hard peeling	Easily peeling		
18	,,	,,		
21	,,			
24	,,			
27	,,			
30	,,			

fruits were still hard peeling until the first sign of ripening took place. Untreated fruits and fruits treated with 2, 4-D, acetylene or coal gas reached the ripening condition at 27, 9, 6 and 6 days respectively. It may be pointed out that

the trend of peeling did not coincide exactly with the color development during the ripening process. So, the color test is not a good criterion for the artificial ripening of banana fruits.

3. *Pulp/Peel Ratio.*—The pulp/peel ratio is affected by dehydration of the bananas. The peel loses water more easily than the pulp resulting in a modification of pulp/peel ratio during transport and artificial ripening. Data in Table III show that the pulp/peel ratio of banana fruits increased gradually until the fruits reached the over-ripe stage. This was true in both treated and untreated fruits. The treated fruits reflected a high value of pulp/peel ratio earlier than the untreated ones. This may be attributed to the early ripening of the treated fruits. It is also noticeable that 2, 4-D-treated banana fruits reached a higher value of pulp/peel ratio than either the untreated ones or those treated with acetylene or coal gas.

TABLE III

Effect of some chemical treatments on the pulp/peel ratio during artificial ripening of banana fruits

Period of ripening (in days)	Treatments			
	Control	2, 4-D	Acetylene	Coal gas
0	1·03	1·09	1·09	1·09
3	1·09	1·15	1·14	1·15
6	1·13	1·24	1·20	1·35
9	1·14	1·45	1·45	1·68
12	1·18	1·61	1·69	1·95
15	1·26	2·82		
18	1·36	2·86		
21	1·42			
24	2·36			
27	2·35			
30	2·19			

4. *Total Soluble Solids Percentage.*—Data in Table IV show a progressive and consistent increase in the total soluble solids during the ripening of the banana fruits. This was true of both treated and untreated fruits. This increase was faster in the treated than in the untreated fruits. The untreated fruits and fruits treated with 2, 4-D, acetylene and coal gas yielded 18·4, 20·0, 18·0 and 18·4% of total soluble solids upon attaining the ripeness condition, respectively. The untreated fruits, as well as those treated with 2, 4-D, acetylene and coal gas reached the eating stage at 27, 9, 6 and 6 days respectively after the beginning of the ripening period.

The increase of total soluble solids of banana fruits during the ripening process is attributed to the increase of soluble constituents of the fruits, *i.e.*, sugars. These results are in agreement with those reported by Abd El-Wahab *et al.*[1] who found that the total soluble solids increased steadily during the artificial ripening of banana fruits treated with 2, 4-D and that the increase was earlier in the treated than in the untreated ones.

TABLE IV

Effect of some chemical treatments on the total soluble solids percentage during the artificial ripening of banana fruits

Period of ripening (in days)	Treatments			
	Control	2, 4-D	Acetylene	Coal gas
0	4·0	4·0	4·0	4·0
3	4·0	8·6	12·0	11·2
6	4·0	14·0	18·0	18·4
9	4·0	20·0	20·8	20·0
12	4·0	20·8	20·8	20·8
15	4·4	21·0		
18	6·4	21·6		
21	12·8			
24	16·0			
27	18·4			
30	21·4			

5. *Titrable Acidity.*—Titrable acidity is a function of the organic acids in the fruits. The amount of titrable acidity is a resultant of two main factors: the rate of organic acid assimilation and the rate of its oxidation to carbonic acid and water. Table V shows that the titrable acidity in the banana fruits of the control, 2, 4-D, acetylene and coal gas treatments reached its peak at 24, 9, 6 and 6 days, respectively, during the artificial ripening process. This peak coincided with the appearance of the first signs of ripeness. The rate of increase of titrable acidity at the beginning of the ripening period was faster in the treated than in the untreated fruits. There was a decline of titrable acidity in the fruits, after it has reached its maximum peak. This suggests that the biological activities, which favour the formation of acids, are responsible for the increase in titrable acidity. It is also noticeable that the 2, 4-D-treated fruits yielded the least value of titrable acidity, when attaining the eating conditions. This indicates that the 2, 4-D-treated fruits show a more palatable and sweet taste than those of the other treatments. Generally, the titrable acidity showed a progressive and consistent increase until the fruits reached the ripening conditions, followed by a reduction till the end of the ripening period.

6. *Respirational Activity.*—It is obvious from Fig. 1 that the untreated banana fruits showed a low initial value of respirational activity, followed by a period of levelling off. This was

TABLE V
Effect of some chemical treatments on the titrable acidity during the artificial ripening of banana fruits

Period of ripening (in days)	Treatments			
	Control	2, 4–D	Acetylene	Coal gas
0	0·212	0·212	0·212	0·212
3	0·264	0·337	0·443	0·450
6	0·241	0·386	0·468	0·456
9	0·289	0·422	0·323	0·318
12	0·358	0·408	0·288	0·309
15	0·259	0·255		
18	0·330	0·236		
21	0·434			
24	0·456			
27	0·368			
30	0·352			

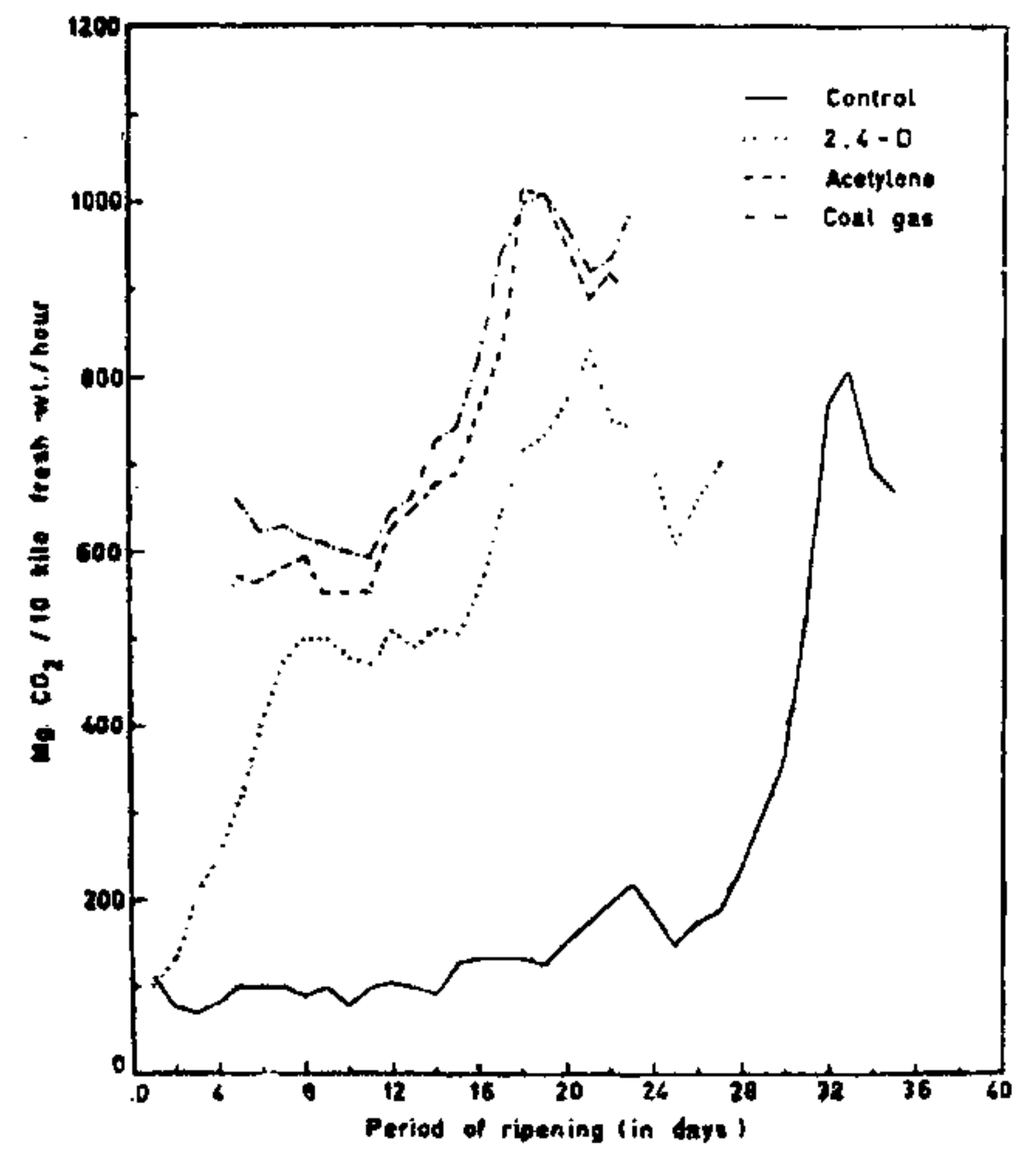

FIG. 1. Effect of some chemical treatments on the respirational activity during the artificial ripening of banana fruits.

followed by a striking increase which attained its peak when the fruits reached the over-ripe stage. On the other hand, the treated fruits reflected a relatively high initial value for respiration, followed by a rapid increase which coincided also with the over-ripe stage. The climacteric rise in treated fruits was attained with the ripeness condition. The 2, 4-D treatment accelerated the respirational activity of the banana fruits, and consequently enhanced the ripening condition. Fruits treated with acetylene and coal gas behaved similarly. The start of increase in the respirational activity coincided with the beginning of the ripening condition and reached its peak with the over-ripe stage. This was true in both the treated and untreated banana fruits. Fruits treated with 2, 4-D have a longer period of marketability than either the untreated fruits or those treated with coal gas and acetylene.

SUMMARY

Mature banana fruits were subjected to three different treatments, *i.e.*, 2, 4-D, acetylene and coal gas for the induction of artificial ripening. Although the color development was faster in fruits exposed to acetylene than those of the other treatments, 2, 4-D-treated fruits showed a longer marketing time. Peeling of fruits was enhanced with all treatments earlier in acetylene treatment. Compared with the untreated fruits, the treated ones reached the highest attainable pulp/peel ratio in a much shorter time. The total soluble solids of treated fruits increased at a much faster rate and reached the highest attainable values in a shorter time than in the untreated ones. No difference was found between different treatments in this respect. The rate of increase of titrable acidity was faster in treated than in the untreated fruits, and the peak was attained after 6, 6 and 9 days for treatments with acetylene, coal gas and 2, 4-D, respectively, as compared to 24 days for the untreated fruits. Treatments with 2, 4-D, acetylene and coal gas accelerated the respirational activity of the fruits and consequently enhanced the ripening process. Generally, it may be concluded that the application of 2, 4-D for the artificial ripening of banana fruits is much cheaper, and surpassed the other treatments with acetylene or coal gas in extending the marketing period of the fruits.

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